[SQUEAKING]

[RUSTLING]

[CLICKING]

PROFESSOR ISLAM: All right, so what we're calling this, the enabling conditions hypothesis. I did send you an op ed that was published, I think, about two years ago in a newspaper in Bangladesh called "Neither necessary nor sufficient." So this is what the idea was. "Neither necessary not sufficient-- three enabling conditions for effective transboundary water management."

So I started with this idea that does life cause death? Does oxygen cause fire? Does rain cause flood?

What it means, essentially, then, if you look at these three questions going from very philosophical point of view, that life cause death, of course, you need life before you can die. Just because if you are not alive, you cannot die, but does it cause it? The same thing with oxygen. Will oxygen-- does it cause fire?

Why is this important? Because right now, I'm sitting in my room. I have oxygen, but there's no fire. But think about the situation really about maybe 5,000 years ago, when we did not know about all of this, and we had a lot of fire in many different places.

Then you are a scientifically minded individual, you went and measure everywhere, and you find that, in every place there is a fire, there is oxygen. So then you have a theory now. That theory tells you oxygen cause fire.

It's a good theory because I don't think-- basically, think about it 5,000 years ago. I did not know any of this chemistry. I did not know oxygen. But I found out certain things are present in all situations when there is fire.

So now, I am basically very brilliant. I came up with the theory-- oxygen cause fire. So this is the fundamental problem of cause and effect, or observing certain things by observing certain other things and trying to link them.

So what I argue that this is really fundamentally what scientific methods are all about. You take observations, then you formulate a hypothesis, and then you test it, and then you refine it. So now, if you are 5,000 years ago, then how do you know that oxygen is not causing the fire? What do you have to do?

This is where this idea of necessary sufficient conditions become extremely problematic. In this particular case, now you know that, for example, in my room right now, I'm sitting here, there is oxygen, but there's no fire. So that means, why it's not there?

[INAUDIBLE] is necessary, but not sufficient. What is sufficient, then? You need to have some trigger. If you have a trigger, then it will start fires.

We will now start basically-- put some fire here, maybe with a candle or something that makes my house may get into fire. So there's the distinction we need to make, but this is, right now, may seem very obvious. But when you get into the messiness of the transboundary water management or other complex problems, there are many, many causes can create an outcome.

Many, many causes can create something that you see. So fire is what you see. Then you try to attribute some cause, and then you get into this idea of necessary and sufficient conditions.

What we are arguing really, in complexity, that no, in complexity, problems are the problems which are complex, where many, many variables and actors and institutions are interacting with each other. You simply cannot isolate cause and effect very cleanly. There are causes, of course, but those are not easily identifiable. As a result, you get into trouble.

What happens, really? You may identify something as cause, then very quickly you find out that is not the case. And you are seeing this with COVID-19 over the last 14 months. We have attributed to many, many things there's a causal conditions, then later on, we found out they may not be.

And we even found out that all kinds of solutions, starting from using bleach from our president, but these are all essentially just trying to relate some arbitrarily linked things. And in the simplest case, people would say that there are some correlation maybe. And you know the correlation is not causation, but that's-- we said this is very cliche. We're not interested.

We are fundamentally challenging this idea of cause and effect, that you simply cannot identify cause and effect very cleanly as you can in some other cases. Even in the simplest case, does rain cause flood? And one of us said, yes. Yes, it does. In most cases, it does, but in many cases, it do not.

So think of, really, in Boston, it was not raining for the last several days. Now, if it rains one inch, there'll be no flood because most of the water will essentially infiltrate and go to the ground. Now, if it rains for three days in a row, yes, basically, soil will get saturated. You'll get flood.

So that means you need some conditions. So here, rain is a necessary condition, but it's not a sufficient condition. The problem of this type of analysis really came if you go back now. Where is this idea of necessary and sufficient came?

So I did dig basically deeper into this. It came from geometry. In geometry, it is very precise because I need to have four sides to have a rectangle, and with 90 degree angle. I need to have three sides to have a triangle. There is no way around it.

So I can explicitly say, what are the necessary and sufficient conditions for something to be considered a triangle? That is not the case for many physical systems. More importantly, many coupled systems, like where you have natural systems and human systems, like our transboundary water problem, where you have natural systems, so water is getting coupled with the human systems of managing it and governing it.

When they're coupled, the systems become complex. This notion of necessary and sufficient conditions are not good enough. So I'll stop here just to give you pause. See what you think about this distinction between necessary sufficient conditions. Then we'll go into enabling conditions.

PROFESSOR SUSSKIND: I presume we don't have to wait 5,000 years to make judgments about such things, and I'm interested in how you think we know enough to say that's only correlation, that's not causation. And is it really-- could it be a function of time and perspective and experience, and that there's not really a method to know that quickly?

PROFESSOR ISLAM: Yes, we'll get into something. Basically, I did not have a chance to discuss this with you. So we are basically making distinctions now between two types of facts, and this is part of the discussion that we have today.

So one thing that, over time, that we have learned this idea of scientific method and scientific facts. Another thing that basically we are [INAUDIBLE] has been used in social science for quite some time called social facts. And we are making a sharper distinction between these two right now, so what I argue really in this particular case, that scientific facts are basically a particular type of facts.

Those facts are verifiable, reproducible, replicable. Those will not depend on daily perspective or notion. They may depend on matters over time, but there is a way to get around this. That's the whole idea of scientific method, so we'll talk about that.

Social fact, on the other hand, does not have to be true. Does not even have to be verifiable. It's just, we believe. It's just that we accept it as reality. And that is fine, too, and we have done many of these.

For example, this whole idea of currency is a social fact. We give tremendous amount of value now to this something green called dollar, and whether I'm in Bangladesh or in Boston doesn't matter. Everybody accepts it. Whether they believe in me, whether I am a atheist or I'm agnostic or I am Muslim does not matter. You accept it that this is something that everybody thinks is good.

And now, think about what is happening with the Iranian currency. It has been significantly devalued because of all this embargo that we have created. So that is really a paper, and that paper has certain value because everybody in the world thinks the dollar is very valuable.

This is social fact, and there is no way to justify whether this is true or not. It is true right now. I can use it anywhere I want, but I do not know what will happen to this really 10 years from now.

So those are the distinctions we need to make, and we will make those distinctions when we are talking about scientific fact and social fact. In this particular case of your fire can be basically determined by scientific method because what can we do really? Even 5,000 years, we didn't have to go that far. We can find out really that, although oxygen is necessary, it does not create fire everywhere. So that means something else has to happen, so that is a systematic way of doing experiments and then to find that out.

But I have seen few places where there is fire there is oxygen, so my immediate conclusion could be that oxygen causes fire. Then there has to be question, and we find over time. So let's go with this enabling.

So what we are saying here, that we need three enabling conditions, and I was careful not to use this idea of necessary and sufficient anymore. So three enabling conditions are needed for any boundary crossing complex water agreement to be initiated, implemented, and sustained. So this is a very big claim we're making here.

So whether you are working with the Indus treaty or you are working with Ganges, what we are saying then, Mashroof, if you want to be basically writing your Ganges treaty for 2026, yeah, we want to do it. We need to be very careful about these three conditions. You may say no, no, I need something else. Then we'll talk about this. But what I am saying that, at least these three are needed.

So what are these three? The first one is there has to be an active recognition of interdependencies, meaning that if you need to sign a Ganges treaty between India and Bangladesh, they have to actively recognize interdependencies. India has to recognize that Bangladesh exists, and they need them. Just saying that because India is upstream, Bangladesh is downstream. Of course, there is already interdependency there, but that's not good enough.

What is happening right now, if you think about it, like Animesh, and we worked on a little bit with Brahmaputra, Brahmaputra is creating serious problems between China and India, but there is no active recognition right now. China, India, although they're independent, is saying that you are using our water, and we are in serious trouble. But they have never, so far, actively recognized this.

As a result, really, what we argued that, no, I don't think they're going to go to any treaty. And they are not right now, although there is a lot of noise, a lot of discussion, a lot of international forum, international funding agency trying to find out what is going on in Brahmaputra. What I'm arguing that I'm yet to see anything that is tangible happening in the Brahmaputra, so if you have to ask me, these are dangerous game to play.

In terms of prediction, there would not be a Brahmaputra treaty signed unless this recognition is active between China and India, and that is exactly what happened really if you look at Indus Water Treaty. Indus Water Treaty was signed in 1960 between Pakistan and India because they actively recognized that this is important.

About the same time, President Johnson from the US sent another envoy to Israel and Palistine to have Jordan treaty. Jordan treaty was not signed until 1994. So why one was signed in 1969, another was in 1994? In both cases, US was basically a significant player.

So you need to think about those treaty. Then I say, yeah, look, at that time, they did not recognize. Jordan did not recognize Israel is important or vice versa.

So as a result, it took a long time. In 1994, they came, and basically, they signed the peace treaty. Part of that was a water treaty, too. So you just think about those two cases between Indus and Jordan, then you get some clue really what this enabling condition 1 means.

Second one is that, I'm sure you've talked about this, mutual value creation. So just because you've recognized the problem, and you have a conflict, is not good enough. Now, you have to see, really, can you create some mutual value through negotiation that both parties will benefit?

Because otherwise, you have limited amount of water, and you have no way to divide this. And your actual need is much more than what is actually available, then how do you get around this? So only way then you can get around this, if you create some mutual value, and then you can do it many different ways, I'm sure Larry and Animesh has given you ideas of, really, how to create mutual values. How do you connect different type of sectors and different resources, and so on?

You don't have to talk about water only. You can bring in food. You can bring in energy.

You can bring in security. You can bring in military power. All kinds of things can be done.

DR. GAIN: So to discuss these things, if we consider this Ganges example, we already had the Ganges treaty, but in my view, this mutual value creation didn't happen until now. But already the treaty has been signed. So what do you say about that? Although this enabling condition didn't meet, but there is a treaty or negotiation?

PROFESSOR ISLAM: Notice the EC here, we said the initiative implemented and sustained.

DR. GAIN: Yeah.

PROFESSOR ISLAM: : So yes, you can have it because you have it for-- basically, all the mutual value fully was not done, but it was done partly. There were certain things done. For example, Bangladesh could have told India that, look, if we want to have this treaty now, you want transit, we'll give you transit. So India wanted transit really from, basically, to go through Bangladesh to Tripura.

See, they want to do this, said let's do this. The Bangladesh trying to do this Ganges barrage now, so for Ganges barrage, India may get flooded a little bit. Can that be brought into the picture?

So the issue is that basically you have to bring in other issues. Those are now basically being discussed in Bangladesh right now. If you think about what is the particular problem with the Ganges, Ganges is not a problem for the flood season. The problem is really the dry season. See, in the dry season, the flow goes down so low that we have serious issues of water shortage.

So take a hypothetical example-- if you take the entire water, basically during the dry season, it's about 4,000 [INAUDIBLE]. Still, it would not be good enough to keep the Kolkata port navigable. One of the primary reasons that India wanted to build the Farakka barrage was to keep Kolkata port navigable, but in the dry season, the flow goes so low, it still cannot-- even they have taken all the water. So that means they have to come up with alternative sources.

Can they use ground water? Can this basically store water during the flood season over extended period of the river? That is what Bangladesh proposed in the Ganges barrage. So this is a over 50 mile river that will be using as a storage device. Because Bangladesh is a very flat country, we cannot create another dam. So that's another mutual value creation option can be explored.

AUDIENCE: Let me ask you a question, professor.

PROFESSOR: Please.

AUDIENCE: So you said something very interesting, that creating mutual values. From what I understood-- I might be wrong-- that anything goes. So one of the tension between Bangladesh and India is Bangladesh being used as a vessel to create trouble in its Seven Sisters, which is why it is of India's interest to maintain the security in Bangladesh. So I'm wondering if that sort of value can be created even-- I mean, can this be used as a bargaining chip? So that is what I want to know.

PROFESSOR: Definitely, yes. I'll tell you something that is-- I think you hit it exactly right. So about three years ago, when we have our water diplomacy workshop, and Larry may remember, we have four individuals from Bangladesh foreign ministry came from foreign ministry really to learn about water diplomacy in our workshop. And their primary concern was that they want to work on the water treaty, what would they do?

So we discuss the Seven Sisters issue, and we discussed that this is an issue that, yeah, this is a security problem for India. Can that be used, that Bangladesh will create opportunity for that, so that these insurgencies do not create problem for India? Yes, this is open for discussion. You can link that with basically water.

AUDIENCE: In that case, so I can actually bring security where I work [INAUDIBLE]?

PROFESSOR ISLAM: Yes, you can. You can-- and then definitely, and this is a relevant problem for India to basically keep taking care of those Seven Sisters and this insurgency is a serious security problem. And Bangladesh can help.

And also, Bangladesh can be used as a transit. But then, Bangladesh has to ask something else in return. That is why the discussion must go on. This is a discussion I had with the foreign minister. And even after that, so I went to Bangladesh and we did have a workshop on water diplomacy within the Foreign, basically, Ministry.

And then pandemic started. Of course, then we got stuck. The difficulty, I'll tell you, this is just not to be shared with Bangladesh government. So I think the difficulty that we have in Bangladesh-- many of these ministries are extremely, I think I would say, progressive. But there is no system memory.

Meaning that water secretary is water secretary right now. Suddenly, he gets transferred to transportation. That memory doesn't exist, that basically he needs to do certain things. And that does not continue to the next secretary. So as a result, really, you reinvent everything every time. And that's a problem.

AUDIENCE: And then the lack of institutional memory is like, it's a serious issue in developing countries like Bangladesh. I completely agree. I work for the government so I understand.

PROFESSOR ISLAM: So that's a different problem. So that's the way we'll go later, maybe. So the third one that we're seeing, this adaptive regime of governance. And that is also very important because you need to anticipate.

I think, Hossain, you are saying that, yes, in industry there is no climate change dimension. Because in 1960, we did not know even climate existed, let alone climate change. So we have no idea about this.

So but, they did not put any provision. But they did put some other provision though. If you look at the industry, they had a technical provision that they said that if there is a technical problem, that Pakistan and India cannot resolve, somebody else should come into the picture. You know what that somebody else was?

PROFESSOR SUSSKIND: I have mentioned it already.

PROFESSOR ISLAM: Oh, you did? OK. All right, so that was brilliant. That was brilliant.

The question is basically, why there might be precedent has to be basically somebody has to come in and then appoint a body. Because they thought MIT is a good technical institution. They may still exist for 50, 60 years from now. And they will have no interest in India and Pakistan.

So this was brilliant. So when you are trying to design this treaty for Indus or for the Ganges, you need to be also thinking forward. Basically, you don't know what will happen, whether climate change will come. What will happen if another COVID-22 comes in, who knows?

But there has to be some provisions so that this can be used. What we are doing in this enabling condition hypothesis is this-- if they are not in place, your treaty is not going to be basically implemented well. It cannot be sustained very well. That's a big claim.

So I want to hear or maybe you can do it later as well that, find out a treaty that was initiated, implemented, and sustained for a long period of time. But one of these conditions were missing. That would be a good exercise. I could not find one yet.

But are these going to guarantee success? No. They're not going to guarantee success. But you can see, these are minimum subset.

The one example I usually give to make it simpler is that if you want to get a PhD, what are the enabling conditions. Number 1 is obvious, I think, that you have to be alive. Otherwise, you cannot do it. So fine.

Number 2 is that you need to have a bachelor's. Unless you are getting an honorary degree-- we're not talking about honorary degree. If you said earn PhD, you need to have a bachelor's.

So which bachelor's, I do not know. It could be in political science. It could be in hydrology, could be in computer science. Does not matter. But you need to have a bachelor's, at least.

Everything else are situational. You need to have an advisor. You need to have funding. You need to have a topic. All kinds of things will be needed.

And then, of course, you have to pass the qualifying exam. A department has different requirements. You have to take this course, that course. Those are called situational conditions.

If first two enabling conditions are not there, you're not getting. But just because you have those first two doesn't mean that you'll get PhD. No. So that's what the difference is.

So when you're thinking about this, you're thinking along those lines. So these are not necessary and sufficient conditions. I'm not telling you what will be necessary to get a PhD, what will be sufficient to get a PhD. But I'm just telling you that you need these two enabling conditions. Then, you need many, many situational conditions.

And those situational conditions are context dependent. It will depend whether it is at MIT or Tufts or somewhere else, whether you're in engineering versus in urban planning. They have different requirements.

DR. GAIN: But then, what is the difference between a necessary condition and enabling condition?

PROFESSOR ISLAM: Oh no, necessary conditions could be many. I'm telling you that you don't need more than these three. I can come up with many necessary conditions that may not still satisfy all.

And see, the reason I think I want to get away from this necessary and sufficient, as we mentioned, this really came from a very structured discipline called geometry. So I'm trying to solve a geometric problem. Now I want to apply it to my messy transboundary water management problem.

That's the reason I want to make the distinction. Because here, if you look at the news and look at writings, you'll see that, yeah, this was not a necessary condition. We did not satisfy necessary conditions. Then you ask them, OK, so what are the necessary conditions.

So to give you a simple example, I tell you that I want to go from here to New York. So what are the necessary and sufficient conditions? Can you exhaustively write this?

AUDIENCE: No, there would be thousands. So it is not possible to cover them all.

PROFESSOR ISLAM: You got it. So this is basically a very large space. I may decide to walk. I may decide to take a plane. I'll take a bike. I'll take a bike and then I will take a boat. Or I have a donkey.

So I essentially cannot exhaustively write down all the conditions. That's what the difficulty is. So that brings us to something else that I want to start maybe our talk. So let's start there.

AUDIENCE: Legal language sometimes like try to, I mean, make conditions that are exhaustive. For example, if the corporate of a chocolate is asked by a lawyer, then he would write that this chocolate has to be from this particular tree. And it cannot be consumed by any other party without paying the money to the original company in any form.

So in this way, they can probably minimize-- I don't know whether I could make sense or not. But the legal language sometimes tries to cover all those conditions that you say, that there are so many conditions.

PROFESSOR ISLAM: Sure. So this is where essentially now I think you got it exactly right. So this is what basically-- although we don't want to talk about our previous procedures. So now if you come into the problem, really, if you want to define really what the presidency should entail, does president have to really file taxes and make it clear. This was not explicit. It was not explicitly he has to file taxes and make it public. So he decided not to do it.

Now the question is, how many things can you write down explicitly the president has to do. Then I have to even tell you, when he goes to the bathroom, this is what he has to use just to make it--

AUDIENCE: [INAUDIBLE].

PROFESSOR ISLAM: So--

AUDIENCE: [INAUDIBLE]

PROFESSOR ISLAM: The problem is, so this is exactly the point. So for the presidents of the United States, how many things you can explicitly write what he or she does really as a president. We cannot do this.

So we are assuming that certain things, they will do because they are morally responsible individuals. I cannot be explicit about them. Because if I make it explicit, then it becomes essentially routine. As you said, [INAUDIBLE], you can write it down, this particular chocolate came from this particular tree and this can be eaten by only this particular individual. Fine.

But then how many of them you write? That is where essential and necessary sufficient conditions miserably fail, particularly in the system when those are coupled.

It can be fine. Right now, if you have asked me, the best law that we have is Newton's laws of gravity. What is it that basically apple fall? An apple was falling before Newton.

We just did not understand this. He was brilliant to find out a particular law that applies everywhere right now. Whether I'm in Bangladesh or in Boston, apple falls. And I know that I can explain it by gravity.

So that's the law which is, I would say, the physical law that is replicable, verifiable, everywhere you go. Now to take an example for water that I use is that water flows usually downhill because of the energy gradient. That's the physical law.

But water also flows uphill. For example, water flows uphill in the American west to money. In my home on the second floor, because I put a pump. Otherwise, water cannot go to my second floor.

By gravity, it should go down. How could I get water in my second floor bathroom? I get it because the water is pressurized. So I can create conditions that things can also violate the physical laws.

Now when those physical laws are violated by human intentions, then you have a problem. Like, for example, Ganges was flowing fine. India decided to build a barrage. Barrage was not there. Now they can control it.

So that's a physical control of water, which is violating the physical principles. And that's when our natural systems and human systems are coupled, and then it becomes a complex problem. Is it making sense?

AUDIENCE: Yes, professor.

PROFESSOR ISLAM: All right. So here I think I'll give you a quiz. And then we'll continue. So how many colors do you see here? Water diplomacy-- A Principled Pragmatic Approach to Govern and Manage Complex Societal Problems. How many colors?

AUDIENCE: Three.

PROFESSOR ISLAM: Three. Good. So remember three, three is important here. Then I will tell you something else. So water, diplomacy, principled, pragmatic, govern, complex, problems. So put all kinds of words-- and I'm sure you have heard many of these words many, many times in this class.

So how many colors are here?

AUDIENCE: Seven.

AUDIENCE: Seven.

PROFESSOR ISLAM: Seven. Good.

AUDIENCE: Seven.

PROFESSOR ISLAM: So you have three and then you have seven. So I'll just give you one basically clue. And then we'll discuss this at the end of the class.

So if you really want to be very scientific about this, there are only three colors-- RBG, red, blue, and green. Then, everywhere you go, this seven color comes in. There are seven colors of rainbow. There are seven heavens.

There are all kinds of seven came into the picture. Where did this three and seven then came from? I have only three color. Why do I have seven?

Why do people say that there are seven colors in rainbow? In reality, if you go to the fundamental color, there are only three. Now if you go to your computer, and if you have a 24-bit machine, you probably have about on the order of eight million colors based on this three combination of RBG.

So I can go from three to eight million. And now if you just give you a color palette and I tell you that, fine detail, what color is this, there is simply no way you can fine detail unless I tell you what those are.

So what is my point here? The point is that you can take three things and put it in different ways and you can get millions and millions of combinations.

Same thing is true for this necessary and sufficient conditions. I can take three variables, or three situations in a particular water conflict, and arrange it in different ways. I can get many, many combinations. So in this particular from three to seven to millions, that is the case, that means my necessary and sufficient conditions will never be able to be exhaustive. I cannot do it.

Although, fundamentally, they are related maybe to only three. But I cannot come to that three level. If I come to that three level, it's too abstract.

So that's why I put this basically mumbo jumbo stuff here. That basically you have only 26 letters, but you can create a Shakespeare to water diplomacy book and everything else in between by different combinations of letters. That is exactly the point with this interconnected systems.

Your building blocks may be very few. But the way those building blocks are interconnected and interdependent may create different situations. And that has serious implications in the way we think about water. So let's go there here.

So I'll start with this many faces of water crisis. If you think about it, what is water crisis? Water crisis, if you think about, they'll tell you that if you have 20 liters of water per person per day from an improved source, you have access to water.

Just an estimate definition, and that definition is used globally. Based on that definition, there are about 760 million people who does not have access to water. So this is what we're trying to do-- these are our SDG.

Now if you think about this, this is really not true. This 760 million is not true. Why it's not true? There are about two billion people lives in slums across the globe, from Dakar slum to Bombay slum to Nairobi slums, and from Brazil. And these people are not even counted.

Why are not they counted? Because most of them are in illegal government land. So government does not provide them water. So they are not even counted. They don't have access to water or access to-- doesn't matter.

So who are these 760 million people? These people are essentially people in rural villages in Africa and Asia. So this is one problem with access to water, definition of water crisis.

On the other hand, when they talk about water scarcity, they have a different definition. What is this? This is fewer than 1,000 cubic meters of water per person per year.

So if you're in the US, if you have 1,000 cubic meters of water per person per year, you are not water scarce. So Boston, for example, is not water scarce, but Nevada is.

But as a whole, US is not. That translates to 2,740 liters per person per day. Look at the difference between 20 and 2,740-- huge difference.

Do you have access to water, versus, are you water scarce. These are two different things. And we often then get confused which are you trying to address.

If you go to SDG, it's not clear what they want to do. They have that thing is goal seven, I think, is related to water. And they have all kinds of things there. But it's so, I would say, nebulous that it's not clear exactly how they're going to measure this and how they're going to implement this.

So access to water is not necessarily constrained by availability to water, really. It is something else. So when you want to talk about water crises, and your objective is to provide water to a slum in Bangladesh, it's a very different problem than saying that I want to have water for agriculture production in Bangladesh. These are two different problems. And oftentimes, we confuse them.

And let's go to the next one. So what are the scientific facts versus societal problem here? More people die from unsafe water than from all forms of violence, including war. So these are statistical facts.

There are also economic analysis. Every dollar invested in safe water and sanitation yields anywhere between $5 to $27 in economic benefits. You don't have to agree with that 5 or 27-- it's more than $1. We're not going to the economic argument here for now.

But at least there are many, many studies that has done this. That if I invest $1 right now, I can get $5 to $27. So that means I can make more money. Instead, I'm not doing it. So what is the problem?

And then I say, OK, 768 million people lack access to water. Two billion people are living in high water scarcity region. So how come we're not doing anything about this?

And this is the statistics I had when I was a graduate student many, many years ago. How could you have a crisis, then you're not resolving this crisis? So that means it's not a crisis.

So why it's not? Let's say that I am generous. I want to make 50 liters, not 20-- 50 per person per day. Give me $120 billion, I can do it for everyone in the globe.

Look at the global GDP-- $85 trillion. Only 0.14% of global GDP. So how come us as a global community, we're so much basically benevolent, so much generous, we cannot spend even 0.14% of our GDP to give water to everyone? So the problem is not economic. Problem is not that we don't have the technology.

So how do I go then? So this is where I think maybe you can be a little bit more creative as water diplomats, that these are not really the argument that people are making. We need to make different types of arguments.

So then it comes to, basically, this is the cover page of our book. So we are saying that, look, I think when you look at this problem, you need to look at this-- there are natural domain problem, there are societal domain problem. These have been studied forever, but they also happen in a politically real world.

So in water diplomacy, what we are arguing for last several years that, look, you need to understand the natural problem, you need to understand the societal problem. You need to also understand that this is happening in a politically real world.

So how do I combine these scientific knowledge and social knowledge in a politically real world where things will have some way to at least have some traction? I don't have to discuss this idea of, look, I only need 0.14% of GDP. Still, people do not have access to water. 768 million people do not have access to water.

These are all known problems. Go to any water literature right now, any water crisis, you'll see these statistics given everywhere. So nothing is being done then.

Those are the type of questions we want to raise. And hopefully, you guys will have some clue when you are in your organization to have some impact.

So the reason I think what we argue that is happening, that there are differences in political boundaries, knowledge, know-how, management. These are all basically happening at multiple scales. And these choices are particularly problematic because they cross boundaries. They have uncertainty. They have multiplicity of values.

So these are not basically unknown. What we are basically hoping do it with our water diplomacy framework is that we want to explicitly recognize this and see how to at least adjust some of it so that we can be a little bit better than what we were yesterday.

See, I may not be here for another 30 years. So I could not see this changing very much in 30 years. In 30 years, we still had the same number of people dying out of this lack of sanitation and water across the globe. So are we basically dumb or we are just too insensitive?

So this is where essentially we are standing here. And in a present, we came from past, but we don't know exactly where we came because past is-- although it came, happened once, the interpretation of past could be quite different because, for example, if you think about how I came, where I am right now, if you ask my mother or my wife or my daughter, they'll have different stories.

And some of these stories will be probably similar, but it cannot be exactly the same. So that means our understanding of the past is also really colored by our own experience, our own perspectives, and the way we have seen it.

The problem, even, is that future could be even more unknown because we have no clue how it will happen. But only thing we have is past. So how do I create water management situations by looking at the past, knowing that future is unknown?

So this is the fundamental puzzle. It's a scientific puzzle, as well as social puzzle. This is where you need to basically-- the question you are raising. OK, in 1960, they didn't know about climate change. I don't know what will happen next 50 years?

We did not know that COVID-19 will come in 2020. It did and it changed the life significantly. So those are unknown. And then we need to have somewhere to essentially deal with it. What is the next COVID going to come? We don't know.

So what does that tell you? What tells you, most of our understanding from science is from physics. So what physics tells us that with classical physics, I can essentially describe the world in a very interesting and very predictable way.

But the problem with complex system is that they are not easily describable by classical physics or quantum mechanics. World is not deterministic, world is also not random. It is somewhere in between.

That's what the complex system is. Complex systems argues that this is not a purely predictable system. At the same time, it is not a random system either.

So everything that you've learned in school, now is really not becoming very useful, because everything you learned is essentially either based on some classical physics, which is deterministic equations, or statistics. But we're arguing that for complex system, neither would work. You need a combination of these two.

Then you come with this. Basically, two scientists in 1973, they were telling you "The search for scientific basis for confronting problems of social policy is bound to fail." And this is a very classical paper written in 1973, cited over 10,000 times now.

DR. GAIN: Is this "wicked" problem?

PROFESSOR ISLAM: Yeah, it is same thing, same group. So they were very brilliant, two young assistant professor from Berkeley in 1973. So what they were telling me, when you are confronted with complex problems-- we do not talk "wicked" because "wicked," I don't like this word. But they use "wicked."

But "wicked" essentially in their term is very similar to what we call "complex." And these are interconnected problems. These are interdependent problems. There is simply no way to do cause and effect, and particularly when there are social policy involved.

Then came this lady from here, Wellesley. She was an economics professor and chair. She said, you can't take politics out of this analysis.

Now you have three things. You have physical systems, your social system, your political systems. And what we argue in water diplomacy, we try to mix them up. And we say that all three are important. And you need to be careful about all three. You just cannot take one or the other. And then your solution is not going to be very sustainable.

DR. GAIN: So here, how is the difference between the social system and the political system? Sometimes--

PROFESSOR ISLAM: Yeah, that is a good point. You have to go then to our diagram here. Let me see if I can go back. So I did not use "social." I said "societal," so societal we are saying that there are only three things, because we want to make life simpler.

We said we put governance, assets, and norms and values as societal. We are keeping political as a different entity. So this separation in many places you may find to be not really that clean. You can put politics also in societal domain. That would be fine.

But then you need to be explicit. But here we are explicit. We are saying that for us, when we talk about natural systems, we are talking about quality, quantity, and ecosystems-- measurable, quantifiable, more or less.

When we talk about societal systems, we talk about governance and we are keeping it broad. Governance could be your NGO to your government to basically your water board in Pakistan or Bangladesh.

Norms and values could be also quite broad. It could be your cultural values. It could be religious values of water. So we are keeping them broad. Assets, it's not only money. It could be human assets too.

So we are being very careful when we coin these terms, we spend a lot of time thinking about those. So we kept them in a way that we don't need any more than these six. And we have asked this question to many of these water diplomacy workshop attendees that, look, do I need anything else. Have we missed anything? Tell us something that we missed?

So maybe we will ask you the same question. Have we missed any variables that you need to include to talk about water conflicts? Those are not there in this particular figure.

Think of a variable or an actor or an institution. We are saying that everything is included here. Maybe think about it. Maybe before the end of the semester, you can let Animesh know.

Because these are big claims we're making. Look, I think you don't do anything else. These six are good enough, because we have defined this sufficiently broad so that you can go and dig deeper into this. All right.

So those essentially six now, we are saying that we can basically even write it down in a little bit more systematic way. We're talking about variables and processes that will come from the natural domain. Actors and institutions will come from societal domain.

And then you have values, interests, and tools. And we go in that particular order. So values, so this you need to be very, very careful. Because what ends up happening in most cases, since I came from a totally different domain-- when I was doing my engineering stuff, we were particularly interested in tools.

And then we basically started working with Larry. And we found out that there is something called interests and positions. And then we need to talk about values. So now we get into really entangled mess.

Then you have problems, policies, and politics. What we argue that these things have to come into place. You have a problem, you have policies, you have politics. Unless these three are aligned properly, you're not going to get a solution that will be basically resilient and sustainable.

Just think about what happened, really. Between January 20 and then today's April 27-- just three months. In three months, we have already vaccinated about 200 million people.

That was not the case in December/January. What happened? Nothing much changed in the US. Few people change in White House. Other than that, most of the actors and institutions are the same.

So some of the problems, policies, and politics need to align properly. If it does, things can explode or things can get totally basically out of control. So big-time thinking about is basically just the difference between January 20 and, say, April 27.

So this multiplicity of choices, then, what it does really, this essentially fundamentally challenged this idea of finding optimal solutions. This is what basically Rittel and Webber found in 1973. They were talking about that when you have a social problem-- we are calling them now coupled natural human system problem. To look for optimal solution is impossible.

So that's the recognition we must have, because this is the recognition. At least, oftentimes, we do not have when we are coming from a technical domain. From a technical domain, we want to find an optimal solution very quickly.

And optimal solutions are possible for well-structured systems. I can find the optimal temperature for my room. There's no problem, because I can put enough basically heating and air conditioning and thermometer to get it done.

But if I want to do optimal temperature for city of Boston, it cannot be done, because city of Boston is open. Now things are coming back and forth from all kinds-- maybe from Connecticut or from Maine or from Canada, where the cold air is coming in. So I cannot make this.

But on the other hand, in my room, I can do it because the room is bounded. So basically it has boundaries. It can be insulated. It can be done.

So if the system is bounded, system is well-structured, system is well-defined, optimal solutions are OK. But in most natural systems, they are not. In almost all coupled systems, it's impossible.

When the natural systems and human systems are coupled, then you cannot find it. Then you need to be contingent in context. Then you say, fine, then what did I learn. If everything depends on the context and everything is contingent, then why come to school? Just go and do it. That's where I think will give you some clue with maybe water diplomacy and principled pragmatism, how that can be done, although they're contingent, although they're contextual.

So water diplomacy, then, what is it? So scientific method, I said that, in general, it's objective. So we'll talk about a little bit more closely. So policy and decision-making is subjective. Whether you like it or not, that's what it is. So whether your political bias is Biden versus Trump [INAUDIBLE], you're seeing that policy-making and decision-making. So this is going to be subjective, whether we like it or not.

Then we are seeing the scientific facts are objective. Maybe, I think there are nuances that we don't want to get into right now. Social facts are subjective.

So I'm making a sharp distinction between these two things. So there is a scientific fact and there is a social fact. When we talked about this idea of alternative facts, where people got confused is that they were mixing it up. Social facts are, basically, there are alternative facts.

Scientific fact, there is no alternative facts. If I take my temperature, if I find it to be 98.4, it is 98.4. Maybe with another thermometer, you can get 98.5. It cannot be 200 degrees. So that's a scientific fact. And I said, this is objective, replicable, reproducible.

Social fact would be how I feel about the temperature. I may feel perfectly fine. And Larry may feel perfectly hot with the same temperature. But the thermometer is measuring same temperature.

How both of us feels is quite different. That's the social fact. That simply cannot be objectively defined. And you don't have to.

But in decision-making, both are important. I just cannot use scientific fact to make decisions which will affect human beings. I can do this for machines. But when I bring in human beings, when they have emotions, they have agencies, they have temptations, I cannot use just scientific facts and assume that it will work.

As a result, now, water diplomacy is both subjective and objective. So this is essentially very problematic in terms of implementation. But this is also very good because this is the way you'll keep your job for the next 50 years, because not anybody can do it that well.

So that's the reason I think-- so Larry is doing for 50 years. I hope I can do it too. For another 20 years, I'll tell you what to do. And that is exactly where I think the brilliance and the ingenuity will come in.

That this is not easily separable. I cannot just take objective facts and claim that I'll be able to do water management very well. Neither can I do subjectively. So if you can combine these two in some creative ways, you'll have credibility and you'll be able to do it.

AUDIENCE: Professor Shafik.

PROFESSOR ISLAM: Yeah, please.

AUDIENCE: Can you repeat again the example of the temperature, which is to illustrate the difference between the subjective and objective?

PROFESSOR ISLAM: OK, so just one second here. Let me see here. So objective facts would be, I would say-- we will go this into a little bit more detail [INAUDIBLE]. So objective fact, I am defining it very sharply.

So in my definition, objective fact is based on scientific matters which are observable. It has to be observable. If it is not observable, so observable by how. So then basically if you really want to be very sure, you said we have five senses.

If these are not sensed by your five senses, it doesn't exist. So I'll tell you, although I don't want to basically make our friend Pinker in other school on the Red Line. He's a cognitive psychologist at Harvard. So he would tell you really everything else that you cannot sense or can't observe doesn't exist. So trust-- it doesn't exist. Trust simply is not measurable.

He has a whole book called "Enlightenment." 700 pages with hundreds of thousands of graphs. And he's showing that with enlightenment we have basically done remarkably well. Because in all measures that he shows-- of course, he's very selective in showing that everything has improved.

Like, our infant mortality has improved. Our war has gone down. People dying from war has gone down. People dying out of hunger has gone down. So we are doing well.

But in that book, trust was not even mentioned once. Because he doesn't care really about trust. So for him, it's a scientific fact. Unless it is observable, it's not scientific.

Social fact now, I feel bad. And we have too many people suffering from mental disease right now. Mental disease will become the most pandemic really in the next 20 years, he doesn't want to talk about this. So funny, those are subjective judgment. You figure it out.

So that's the difference. He thinks those are not observable-- doesn't exist. So that's a very sharp, it's a very crude definition, but that's the way I try to do this also. So I say subjective is meaning that these are not easily verifiable.

But I do disagree with him that, no, they exist. I may not be able to measure them, but they're real. He will say that they're not even real. They're just a fiction of your imagination.

AUDIENCE: Thank you very much. Thank you.

PROFESSOR ISLAM: So that brings us to this. I think this you will like now. So here, I want you to look at these two pictures. And I thought it was very nice. So there is a difference between myth and fact.

Look at this first figure. And then remember what this individual is doing. This individual now remembers myths. Although you have given him 12 facts.

So what is the problem? The problem is that our cognitive ability to process information is not really very good. So if you give me a lot of information-- it's happening with COVID. If you think about COVID clearly, people are so confused. It's not that people are confused. People just simply cannot separate it out, because you are giving me so many facts and so many conflicting facts, so ultimately you remember the myth that most likely I'll die. Although the probability of you dying is extremely low, even if you get it.

On the other hand, if you can give myth with some carefully constructed facts, you do remember the fact. So the argument that I'll make here is that our challenge is to essentially, when I'm trying to debunk some of this myth or some of the social facts, to create scientific facts. Those are easily digestible to the audience that I'm giving it to.

But that's very, very powerful. Because otherwise, I can keep talking about this climate change. In general, public does not understand what I'm talking about. As a result, they think it's a hoax.

So what does that mean really is this. When you're trying to replace a myth from somebody's mind, you need to replace it by some facts. Otherwise, it will get replaced by another myth.

So the question is basically and the politicians are extremely powerful really in basically replacing myths. And myth are not really easily discounted. I don't believe that myth can be easily taken out. They will be there.

The challenge is to create myth those are little bit more scientifically valid. If you can do this, then I think you have an alternative narrative. Otherwise, you don't have an alternative narrative. You have no way to make any influence in the policy-making and the decision-making.

So that brings us to something that I like is that-- you remember when you talk about water diplomacy framework, we did not say that this is model. It is not even a theory right now.

So what is a framework? Framework is something that is it's some general ideas and general relationships that gives you to address a particular problem in a particular way. So that is the framework.

When the framework get tested over time, so we are doing it for many, many years right now, gradually it will become a theory. Eventually it will become a model and predictable.

So right now, we'll put on water diplomacy-- principled pragmatism as framework. This framework allows us to explain those things in certain ways. It allows us to intervene in certain ways. When it becomes a theory, then you just basically like evolution. Evolution is a theory.

Newton's law is a law. Newton's law is not a theory, it's not a framework. So there is a distinction between framework, theory, and model. So model is at the level that you are the Newton's law.

So things doesn't matter really whether I'm in Boston or I'm in Brazil. Newton's laws applies. So that is what the difference is. So if you can develop certain law, those are context-independent, then you have a law.

So do I have a law for water? No I don't. I don't have a water diplomacy law. We have a water diplomacy framework. And that framework with time will probably get tested, refined, and get into theory and hopefully into model some day.

So what are the principles? The principle that we are trying to use here in principled pragmatic framework is this objective scientific method. So we said that there is an objective scientific method, these five senses. It allows me to do certain things in certain ways. Those will be independent of context.

Giving out example of taking temperature-- so a temperature with a thermometer is a measurable thing. I can easily validate this. There is no ambiguity there.

Pragmatism comes in this subjective interpretation now. Because the example that I was giving that how I feel about temperature is a subjective interpretation. That interpretation should not be confused with scientific methods.

But I need both. I need scientific method. I need also subjective interpretation. This is exactly where water diplomacy comes in, that we just don't need scientific methods. We also need subjective interpretation of the local values, local context.

Then if I can combine these two, you get principled pragmatism. That is subjective and objective. The same thing that we talked about our water diplomacy.

Then we said, OK, like, I think, I don't know, you have talked about this. We look at the world in various, I would say, the simple way. So we said that there are only three types of systems.

And our first job is to identify that problem. And that's the diagnosis and characterization. So with simple problems, but this causal relationships are well-understood-- complicated, it's often ambiguous, but-- not easily identified, but you can still identify this.

Then you have complex problems-- not easily identifiable, only perceivable in retrospect. So a good example of this would be like flushing your toilet. You can go and buy basically a toilet system from Home Depot for $100. It would work out very nicely. No problem.

Bringing water to your home from Quabbin, like about 50 miles away, and taking the water on the 16th floor of your room. And you get out, you get warm water, that's a complicated system. I need lots of pumps and pipes and then chlorination and heating and so on.

Complex problem is the one that when we created this global reservoir, we have also eliminated four villages from Quabbin because we wanted to create a large reservoir. A lot of people has lost their homes and they had to be bought out.

So was this right to do? Because you are basically removing human beings from four towns for 200 years, because Boston has to grow. Boston needed more water. They needed to create the Quabbin Reserve in 1920s. So they created this by eliminating four villages. And there is still people complaining that that was not the right thing to do.

So that's a complex problem where you have basically coupled a natural system with the human systems. Now the system is, in this case, is knowable and predictable. So flushing a toilet is more or less predictable.

This is complicated, but it's still more or less predictable. Not always, but this one is most of the time unpredictable and emergent. Meaning, that things will just emerge that you had no idea that it was going to come.

And from your arsenic problem, you have seen some of this emergence. We'll talk about a little bit more. If you are to intervene in these systems, this will work with best practices.

And this is where I think most of the people got it wrong. And I think we want you to be very careful. What we are saying here is that, your best practices will apply very well for simple systems.

If you go into a complicated system, you need some expert knowledge now and some contextual knowledge. If you go into complex system, now you need something totally different. You need a synthesis of scientific facts and social facts.

You simply cannot use best practices. Because there is no best practices for complex systems. And although you will hear this term often, "give me a roadmap," no, I cannot give you a roadmap. The roadmap assumes that I know the road. So how do I know the road? I know the road because I've seen it in the past.

So that means I'm assuming the past will essentially be similar in the future as well. If the future is a little bit different than the past, my past knowledge is not going to be very useful. So I cannot have a roadmap.

So to hope for a roadmap, to hope for a best practices is an illusion we must abandon to deal with complex problems. Is it making sense? But this is very important because we need to make a distinction between these three colossal problems.

Your first job would be to essentially decide which one is simple, which is complicated, which is complex. And then you cannot use the tool, those that will be applicable for simple system, when the problem is actually complex, or vice versa.

PROFESSOR SUSSKIND: Shafik, assume that everybody is working on very complex problems. Each of the cases you heard about, the beginning that people describe, they're all complex. They may have simple components within them, but basically the conflicts and what's at the heart of the conflicts are complex.

It sounds from your description like it's not really possible to be usefully prescriptive in a situation in which the problems you're dealing with are highly complex. You think that's right? Or do we--

PROFESSOR ISLAM: No, then we're in trouble. At some level it is, but at some level it is not. So let me see what I can explain. So the story that what has to happen then is, when you are confronted with a problem like solicited, we are confronted with the problem of Ganges Water Treaty.

So let's take this as an example. Then, we have to decide, when we talk about Ganges Water Treaty, what are we talking about. So if you ask me right now, so I'll say, Ganges Water Treaty should primarily focus on the dry season flow.

So now I'm trying to make the problem a little bit sharper. Why dry season flow? In the wet season, I have about 70 to 80,000 cubic meters per second of water flow. That is a flood season. Flood season lasts for a few weeks. But it clears the problem, but that is a recurring phenomenon.

Then in the dry season, it's almost about eight to nine months. That creates significant problem, both from water availability for ecosystems to irrigation to navigability, so many, many things. So I will focus on that part.

Then my question will be, so OK, so given that dry season flow is only 4,000 as opposed to 80,000, now what can I do. How do I basically resolve this complexity of the problem? Now we have to come up with deal with India and sit down and see what adoptions can I have.

What adoption those are possible so that we both can come up with some options where we know we're not going to get 80,000. We need clearly actually 20,000. We only have four.

Now how do we solve this problem? It's not easily resolvable. Then, where essentially this whole idea of mutual value creation, negotiation, and discussion has to come in, rooted in scientific facts. That's basically where I think you can think of really how do I get around this mess, because otherwise it becomes such a complex problem that nothing can be done.

PROFESSOR SUSSKIND: So are you saying that when you face a complex problem, try to only work on part of it?

PROFESSOR ISLAM: No. What I would say, that the approach should be problem-driven. Meaning, that you have to define a particular problem that you want to solve. So here I have defined the problem that I want to resolve the dry season flow in the Ganges. That is my problem.

PROFESSOR SUSSKIND: Right. But isn't that really a part of the larger problem of trying to managing the Ganges?

PROFESSOR ISLAM: It is, it is, no question about it. No question about it. And I don't think there is any way to disentangle this. Can you take it all separately? No, you cannot.

So then what do you do? So at one extreme, then you can think of really, everything is interconnected with everything else. If that is the case, then you are in a mess. That mess simply cannot be untangled.

PROFESSOR SUSSKIND: Right.

PROFESSOR ISLAM: Then, you can argue that, no, no, you are essentially being reductionist, because you are trying to reduce the problem to something that is simpler. To some extent, yes. But what we want to be careful really when I'm defining the problem for the dry season, I don't want it to be a reductionist problem that basically we do not get affected by flood.

So I need to be careful really-- the rest of the dry season is eight months. These eight months will affect the other four months too. How? That is the question.

If they are cleanly separable, then it's easy. But they are not cleanly separable, they will not be. So this is what the complexity will come. I don't think how hard we try you will be able to go in.

That's the reason scientific method is important, because you need to keep this idea of experimentation valid. So you observe, you ask questions, you hypothesize your experiment, analyze, conclude, and keep doing this.

Then you go here. So I think that this I don't think we need to call this because this is more into-- recognize that basically there is no panacea here. See, if there is no panacea, then what is there?

What I am saying that we need to be precise in diagnosing the problem. So here the whole approach that we are trying to take is that this is a problem-driven approach. It is not a theory-driven approach.

So I have a problem. That problem is to solve dry season water problem in Bangladesh or in India. Now to do this, so that is my diagnosis of the problem. Now what are the facets of the diagnosis? What aspect do I need to do?

Is it really to keep Kolkata port navigable? Or is it really to stop saltwater [INAUDIBLE] in Bangladesh? Or both are important. If both are important, then how do I try to see, given the limited amount of water that I have, can I do both?

If I cannot, then do I have other options? What if I use ground water? Can I use groundwater in a year and next year basically I have more rain it gets filled. With the groundwater, I cannot use it forever, because it will get depleted.

So those are the type of discussion that has to happen. So precisely the point with complex system is that complex systems will not allow you to give a solution that is static. It will give you a solution given that particular problem, given that time and space scale.

Then what we need to be careful is that we monitor and we keep adapting to the changing situations. So that being said, we have to embrace complexity with humility then. That is not basically I'm going to give you a solution, that you have it. There is no prescription that is universal. I cannot do it. I'm just being very honest and blunt.

But at the same time, I'm giving you a framework. That framework would allow you to do things in certain ways. Then you think in a systematic way.

What does that mean? That means that you try to define what your system boundary is. What are the nodes and links in that system? So that when you get this spaghetti diagram, what are the nodes and links that create this spaghetti diagram and that is understandable and systematically manageable?

Then you say, OK, I diagnose and prescribe. So I'm saying that you need to prescribe. So how do you prescribe then? The way you prescribe by understanding the capacity of the system, as well as the constraint that system imposes on you.

What that means, really, the capacity and constraints for the Ganges between Bangladesh and India will be quite different, if you are trying to do it for the Nile between Egypt and Ethiopia. So the challenge here is that you have diagnosed the problem. Now you have to give some prescription. That prescription must be consistent with the capacity that your system has. And that capacity can involve basically from human capital to basically actual assets of money to cultural values and everything else.

But not all of them are important at any given time. The challenge for us as a water diplomat is to find out what those are and try to define that subset.

Otherwise, this set is very large. You can go to the Ganges and assume that, look, Ganges water is probably one of the most polluted water in the world. But it is the most holy water for Hindus in India.

So I cannot basically start questioning the cultural value. That has to be taken into account. So that is the capacity and constraint the system is imposing on me.

Then I said that there is no panacea. So let's be clear about this, that there is no simple, generalizable best practices. Then I said, OK--

PROFESSOR SUSSKIND: Excuse me, Shafik. When you say diagnose and prescribe, using capacity and constraints, you don't mean that you can't enhance the capacity.

PROFESSOR ISLAM: You can, you can.

PROFESSOR SUSSKIND: With resources from outside the system, right?

PROFESSOR ISLAM: No, I don't. I think very good point, no question. Exactly. I think we need to bring in other-- capacity is not fixed. Capacity can be enhanced, capacity can be reinforced, even I think can be built, and even can be taken as an outside energy.

So World Bank can create more-- basically can put in money. Absolutely. I think I need to be a little bit more careful there. No let's not assume that the system capacity and constraints are fixed. OK.

So the question is, basically, do we need anything else. Because I'm also teaching a similar class at Tufts. So we need to pose this question. So I'm asking maybe you guys also that.

OK, is this more or less general abstract level of things that we need to do to start addressing the problem? Then we'll get into very quickly our arsenic problem, then how this can be applied in real-time. I don't know-- how much time do we have, Animesh?

PROFESSOR SUSSKIND: We have about 10 or 15 minutes.

PROFESSOR ISLAM: OK. So, all right. So let's do the thing. Maybe I'll just go into this.

PROFESSOR SUSSKIND: Could you just go back one for a minute to the diagram, to the list you had? You said, in the question marks at the end, is that sufficient. Is that complete?

PROFESSOR ISLAM: Do we need anything else. It's like one question you raised, I think I need to use this [INAUDIBLE]--

PROFESSOR SUSSKIND: My uneasiness with that list is that, if you're going to act adaptively, if you're going to continue to review and change what you are doing, you need to have the institutional capacity to do that.

PROFESSOR ISLAM: Sure.

PROFESSOR SUSSKIND: To build the institutional capacity to think and act systematically to build the capacity, to act adaptively. And so the person who's talking about taking action, I think, needs to think about the institutional design for the process that makes this list possible. And that itself becomes an item on the list.

PROFESSOR ISLAM: Sure. Good point. Any other thoughts? All right, let's see whether we can-- so essentially that what we are arguing-- so I hope I convinced you-- that there is no established methodology exist to resolve complex problem, because these problems are not deterministic nor random.

So that means you cannot use classical physics or you cannot use statistical mechanics to do this. Then, at the same time, these problems can neither be fully explored by the positivist, meaning this hypothesis testing type of framework that I was arguing that with five senses. So you cannot just use scientific methods.

Nor can you use just interpretations. So it's not that basically you can use either/or methods. So you cannot use purely scientific method. You cannot use purely subjective, ethnographic methods to address these problems.

What then you have to do really is somewhere to basically combine your scientific facts and social facts. So that's what it's all about. And if you look at the paper that I sent you to read, the arsenic contamination problem essentially tries to do this, is to explain the problem from a scientific facts perspective, then use the understanding-- meaning the social facts-- to actually address the problem. So what that means to you is-- so let's go back and visiting your [INAUDIBLE]. I don't go here. So I go here.

So I use an illustrative case. Illustrative case is that it can support a theory. So the arsenic contamination problem is used here as an illustrative case. Meaning that if you illustrate that, it's a complex problem. But it does not really provide any validation of the theory.

But we've also used it as an extended case. Meaning that if I take this case and I look at all the features, what I see really here is this is a couple natural and human system problem. In this couple of natural and human system problem, when I intervene, it gives rise to emergent properties.

And then it becomes a complex problem. So that means I can use this to show really when you have this type of coupling, you will expect these type of things to happen.

So now if you take, actually what happened then. So basically Bangladesh has decided that they will promote groundwater use as a case study that we are using it here. There are two policy goals. They want to increase agricultural productivity and reduce infant mortality. So these were the policy goals they wanted to do-- very sharp, very well-defined, easily measurable.

And then you go and then you see this. So this is where essentially-- now if you try to re-link all these different components, different variables, processes, now you see this is a mess. And this mess really is not new. And this is not even our mess. I think many people have created this type of mess. They call this system diagram, an interaction diagram, whatever.

And we are seeing that this is really so old, basically it doesn't allow me to do anything. I just totally get paralyzed. So it's not going to work, because things are interconnected. We understand that part.

The question then becomes, how do you diagnose or sharply define the problem that not all of these links and nodes are equally important. Only some are. The question is, which are.

So in the case of dry seasonal flow, we gave you an example relief. That is what we want to do. So that's a much simpler definition of the problem with the interconnections and interdependencies. Those will be needed.

Once you have that, then you can go here. So if you look at what Bangladesh has done, they wanted to have two policy goals. And these were achieved really with tremendous success. It has increased agricultural productivity, decreased infant mortality.

Agricultural productivity has gone up by almost 100%. Infant mortality was the lowest in South Asia. So in those terms, it was very good really, very basically successful story from 1960 to almost 1980s.

Then what you started seeing, the arsenic contamination emerges now. In 1960, they did not expect that arsenic contamination would come. The difficulty they have created they have not measured so they are not following it. So they were not really monitoring the progress. They are not being adaptive. They did not care.

So as a result, it emerges. Even that emergence did not really lead to any action. It took another 15 years. On the day first the arsenic was detected in water, then to actually create something at the government level, it took 15 years. Why did it take that long? So that's where basically the system failed.

Then you have taken interventions which led to even more unintended emergence. If you remember, really, you looked at this. Basically, they put red and green wells. Now the villages that had red wells now have problems with basically girls getting married because they have a stigma. So you have created a social stigma by creating a solution that you wanted to do because you wanted to let people know that there is this well is red, meaning it has high arsenic concentration.

So where did that come from? What we learn from this, this was a theory-driven, causality-based reasoning. What did that come from?

So that really came from if you know the story of cholera in London in 1854. And John Snow found out that-- he was an epidemiologist-- he found out that there is a cholera outbreak in London and they cannot find out what is going on. So he did a very systematic way of finding out who has cholera, where the drinking water is coming from. And he found out the well.

And he went and basically shut that well down. Cholera went away. So that is basically my theory, or by basically scientific knowledge that I used in Bangladesh also, without understanding anything else.

So I basically went and start painting everything red, because Snow did it and it stopped cholera. So if I do this, arsenic will be stopped. Yes, it will be.

The only difficulty there is that this is rural Bangladesh. Number 1, I have over 10 million wells right now and not one. So as a result, my theory doesn't go with actually what is happening on the ground. So we got into serious mess. And that took another 20 years to unfold.

So what would happen, in a principled pragmatic approach, what you want to do, you want to find out the problem-driven question. So the question was that, OK, so I have infant mortality problem in Bangladesh.

So to solve that infant mortality problem, I found out the quickest solution. What is the quickest solution? Dig some shallow wells. It's cheaper, it's quicker. Fine. And we've done that.

And that is perfectly fine. What was missing there is that they did not monitor really the progression of this. They just assumed that it's a simple solution. It'll stay forever. If they have monitored this, they would have found out long ago.

That's why we're seeing this problem-driven question with hypotheses consistent with observed signals. I need to keep observing the system as it evolves. If I can do this, then I have an approach that is more or less functional.

So to summarize then, basically, what we need to do, we need to first find out a very sharp definition of the problem that we want to address. Then find out whether is this is a simple problem, complicated problem, or a complex problem.

Then find out, if it is a complex problem, then what is the complexity coming from. Is the complexity coming from the scientific unknown or is it coming from the social fact? Those are alternatives.

Then try to synthesize these two. Then design an intervention with some basically targeted metric, that this is what I want to do. And then monitor this as you go along. Then you could be adaptive and find a solution that will basically be resilient and changes over time.

There is no universal solution. So if have you one message you want to take, I think that will be that there is no universal generalizable solution for complex systems. Complex systems will bring even more problems once you try to solve them. By the time you have solved them, you have given rise to another set of problems.

And this is also nothing new really. This has been done with Larry's department for many years, from like Sean to other people. They have talked about these problems almost 50 years ago, that the idea of when you're trying to do these social problems, by the time you solve the problem, you have given rise to another set of problems.

So the challenge is to essentially be very aware of that problem nature will change. And if it does, how do I detect them early on so that I can be adaptive and act accordingly? We'll stop here.

DR. GAIN: So do you have any final question for Shafik?

AUDIENCE: What are your thoughts about the enabling conditions between India and Pakistan on taking up the divisions in Ganges Water Treaty?

PROFESSOR ISLAM: Enabling conditions should be-- those will remain three. What you want to do, hopefully, I think, is that what are the main issues of contention right now. That needs to be discussed, because I have not following recently about the industry.

So what would be good I think for if you can identify one or two things that both countries are in disagreement with. What is that really? So I can give you one example. For example, for Brahmaputra is that what I followed recently is, say, for example, India is claiming that China is holding all the water and then it will create problem.

Physically, that is not true. Because the amount of water that is coming from Burma for China, even if China-- we did this study with domination, with another Chinese student we had. Even if they decide to keep all the waters in China, it will have no impact in India, although they are making that claim. So this is essentially a social myth they want to create, that the Chinese are creating problem. But these are not based on facts.

So what you want to do within this, to find out is it possible to find some very sharp scientific facts-- those are observable. Like one example I use with Bangladesh in India for the Ganges, even if I give all the water to India in the dry season, India will still not be able to basically make their Kolkata port navigable during the dry season.

So that means this is a non-starter. Why are we start fighting this? Try to find something else then. Although, of course, it was scarcest problem if India keeps all the water in the dry season. But even if Bangladesh decides I'll give you everything, still it will not solve the problem. So that means you need alternative sources now. That part has not been explored.

PROFESSOR SUSSKIND: Before we finish, I just want to thank Shafik again. He and I worked together a long time on this. And I'm always learning something new each time I hear him present this material. So thank you for taking the time, Shafik, to meet with the class and for sharing your ideas. And thank you for having such good ideas.

DR. GAIN: Yeah, so.

PROFESSOR ISLAM: No, thank you very much. No, I think, No, I don't want to embarrass Larry. Larry has been an inspirational mentor. So because many of the things that I discussed today I did not know about maybe 15 years ago when I started out. So we have been talking for a long time now.

So yeah, if you look at this guy, you said that you need 10,000 hours to develop any expertise. So between both of us, we probably spend more than 10,000 hours now.

PROFESSOR SUSSKIND: Oh yeah.

PROFESSOR ISLAM: So hopefully we have some level of at least understanding in for expertise.

DR. GAIN: But also, yeah from our side, yeah.

PROFESSOR SUSSKIND: Everybody in the class, right, the other people in this class are potentially the person you'll find yourself coming back to and working with. Shafik and I, we did not know each other when we first encountered some overlap in our interests. And we just kept creating opportunities to exchange our thoughts, and Animesh then gets added to the mix and now extends both of our ideas and our work and his own work.

So everybody in the class should imagine that it's through these interactions with your colleagues that you shape and sharpen your ideas. So Shafik, thank you.

DR. GAIN: Yeah.

PROFESSOR ISLAM: So for the class, I think I have a challenge for you. So since you did not share much of your thoughts, maybe you're too shy. So think about the arsenic paper that you read. I want you to find out at least one hole, the one thing that you found that this is really outrageously stupid, it's not going to work. So I gave the same challenge to my students also.

So there are a few things that I have issues. I did not share those with you. But I will not tell you right now. But I want you to see really-- Larry raised something very interesting here, that if the institutional mechanism is not there, if the capacity is constant, it's not going to work. So we need to refine that.

But are there anything else you see in terms of making it operational? See, at one point I said the complex systems, you don't have generalizable solutions. You don't have any prescription. But then we are giving you prescription too.

So the line is very subtle here. But at the same time, I don't see a way around it. So the question is basically how do I bring in these ideas of principles of scientific methods which are more replicable, more reproducible with the social effects which are going to be continuously subjective, continuously contentious. But at the same time, decision has to be made.

So that's where basically, where are the hiccups or where are the binding constant that will essentially let it fail? If you can think of one or two ideas, that would be good, or maybe an example that you have seen in your real life where you try to apply this and see, did not work.

PROFESSOR SUSSKIND: He wants you to be a white hat hacker of his work.

PROFESSOR ISLAM: Yup, that'd be good.

PROFESSOR SUSSKIND: Find programming problems.

PROFESSOR ISLAM: Exactly. So find a hole and then that will be very nice. That's the way ideas gets challenged. Otherwise, because you will stagnate.

DR. GAIN: And also, apart from that, even if you have your own specific issue regarding water diplomacy that can be related to the theory that Shafik mentioned, you can also write him an email so that, yeah.

PROFESSOR ISLAM: Sure, please. Please feel free.

PROFESSOR SUSSKIND: All right, I'm going to disappear. But thank you so much.

PROFESSOR ISLAM: Thank you very much, Larry.

PROFESSOR SUSSKIND: I look forward to the presentation starting next week. OK. Bye-bye.

PROFESSOR ISLAM: All right. bye-bye.

DR. GAIN: Yeah, thank you, thank you.

AUDIENCE: Thank you.