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Introduction by Professor Nolon:

Dr. Alistair Hanna is Director of McKinsey and Company, international business consultants. He received his Ph.D. in Nuclear Physics from Orange University in Belfast. At McKinsey, Dr. Hanna consults with high-technology clients in various aspects of their business systems and adapts them to changing market and technological conditions. He and other consultants in the Stamford office of McKinsey, which he directs, conducted an extensive opinion survey of the workings of the land use system in New York State in conjunction with the Land Use Law Center. We are indebted to him for his interest in this field and for his presence today.

Dr. Hanna:

We have defined the "land use system" as that body of laws and governmental programs that influence or react to the use of the land or its resources. Environmental protection laws are included, since they react to uses of land and resources that are negative from the environmental point of view. Also included are economic development programs and infrastructure development that encourage particular land uses. It is a broad topic. The laws that create the incentives and regulations that constitute the land use system are important. Whether or not they constitute a legal "system" is the question we have been exploring with the Land Use Law Center of Pace University School of Law.

My comments today include three topics. The first discusses an extensive survey we did with the Land Use Law Center two years ago in New York State concerning the workings of the land use system. The results of that survey indicate that the people who are most closely involved with the land use system in New York find the system to be overburdened and unable to manage many of the issues that it was created to handle. The second topic I will discuss deals with science and how our understanding of the way the world works has changed in the last ninety years. This is important because many of our systems today are based on an earlier understanding, more a nineteenth century than a twentieth century understanding, of the world around us. This explains why some of our systems are unable to cope with the highly complex and dramatically different world in which we live. The third topic deals with the current cost of environmental regulations and evaluates our system of environmental laws from that perspective. In the United States, we find that huge sums of money are being spent to resolve problems that we never expected to confront. Stockholder wealth in major companies is being destroyed at a rapid rate. This could have been avoided if we had set up a system that was much more integrated from top to bottom, one that understood at the grass roots level what the issues were and one that was flexible and responsive. If such a system had been created in the first place, we would be doing much better today. So, our goal should be to see that current laws are integrated into an efficient system of laws and that those countries that are adopting new laws today establish workable systems to avoid the problems we have encountered.

The Land Use Survey:

In 1993, we tabulated the results of over 2000 surveys that we received from the 10,000 we sent out in New York State. These respondents ranged from people who were involved in state land regulation and planning, to local regulators and planners, to those who are involved in property development, the environment, banking, commerce and the whole range of areas in which people in the land use system work. The results of the survey show that 58% of the respondents considered the land use system today to be operating at either a very poor, poor or fair level of performance. Of those surveyed, 26% fell in the middle, with neither a positive nor negative opinion of the system. Another 16% thought it functioned at a very good, excellent or outstanding level.

Our principal observation about these results is that the ratio of respondents viewing the system as negative was three to each one who viewed its performance as positive, a three to one vote against the system. Now, this is not a very good result. If we were thinking of introducing a new product into the marketplace, we would want the results to be exactly the opposite. Instead of a ratio of more than three to one against, we would look for a ratio of three to one in favor. We apply this same standard to our performance as a company, as well as that of our clients, when we survey opinions to find out how we are doing. So here we can see a system that, according to the people who have to live with it and use it, is just not working.

This is particularly alarming in view of how important the land use system is. According to our survey, it has important work to do. A significant number of our respondents listed eight objectives as important for the land use system to achieve:

1. Protect the natural environment - 66%
2. Use infrastructure dollars efficiently - 63%
3. Protect community character - 60%
4. Locate and support business activity - 53%
5. Protect agricultural lands - 42%
6. Protect existing property values - 42%
7. Provide affordable housing - 37%
8. Protect developers' rights - 21%

Here we see a critical public system not able to accomplish the goals that those who know it best think it was designed to achieve. So why is this system not working? I believe that by understanding how systems have been influenced by thinking in the scientific world we can understand not only why this system is not working well, but, also, how it can be repaired.

Using Science to Understand System Behavior:

One of the earliest systems that scholars tried to explain was the planetary system of stars, the planets, and the Earth. Aristotle came up with a very fine way of thinking about that. Insofar as he was able to explain the movement of Mars across the night sky over time, he had to put in place a series of wheels. He thought of the planets as fixed to some of these wheels and the stars fixed to others. This machine moved in such a way that allowed Aristotle to explain the movement of the planets, a very difficult mathematical exercise, indeed.

Aristotle believed that the natural action of a physical body, such as a stone or the moon, or a planet, was to come to rest, unless a force is working on it. This approach seems reasonable. If you are in an automobile driving down the road and you turn the engine off, the car will gradually coast to a stop because the forces of friction are stopping it. So, Aristotle concluded that if the natural thing for a body is to be at rest, then all bodies would likely be at rest at the center of the Earth. Thus, he concluded, all planetary bodies revolve around the center of the Earth.

Aristotle's views were well thought through and were accepted for over 2000 years before Galileo and Newton introduced a different explanation of how this planetary system works. What Newton said was that a body moving in a straight line will continue to move in a straight line. Therefore, if we know where a body is today and how fast it is going, we will be able to predict at any time in the future where it will be and how fast it will be going then. This was a major change from the way people thought in the past. It completely reversed Aristotle's notion of everything being at rest and coming to rest at the center of the Earth. And, of course, with the work of Galileo and Copernicus, we realized that, in fact, the Earth was not the center of the universe and that the planets turned around the sun and that the stars moved within different systems altogether.

We see here a complete paradigm shift that had to take place in people's minds in the seventeenth century. People who had been used to the Aristotelian system, to the Earth being at the center of everything, now had to come to grips with a system of thought in which the Earth was just another of the planets. Naturally, this took some time, but eventually philosophers and theologians began to incorporate it into their thinking. Descartes viewed the universe based on the mechanics advanced by Newton; he saw the universe as having two aspects: mind and matter. This allowed him to view the mind as thoughtful and creative, and matter as bodies that can be understood mechanically. These bodies, then, operate in mechanical ways which are very predictable and can be investigated by the separate mind. There is no connection between the mind and physical bodies, so the mind can observe the bodies from afar and not interact with them. This led to the concept of determinism. Charlie Chaplin's interpretation of determinism is that there is a huge machine and once this machine starts in motion, it just runs according to a certain set of laws and there is nothing you can do to prevent it.

By the mid-twentieth century, determinism remained the last secure conceptual foothold of classical physics. That is to say, we still believed that if you know the position and speed of a body that starts in motion, you can determine where it will be at any future point in time. In the late nineteenth century, Laplace said that we will soon be able to predict all of human behavior because, if we know the laws of human behavior and we know the condition of a person today, we will be able to predict what that person will do in the future. He was among many who believed that we understood nearly everything and very soon we would know and be able to predict all.

Determinism, as the reigning approach to systems theory, took a terrible hit in the early twentieth century. In 1905, Einstein taught us that the speed of light is constant. A beam of light, whether aimed toward or away from an object in motion, will always be seen as travelling the same speed, relative to that object. If you shoot light towards something that is moving, it will seem to be going three times ten to the 10th centimeter per second and, if you shoot it from something that is stationary, the light will go at the same speed. This was a paradox; it said that our normal understanding of the world does not work for light. Other scientists then observed various particles that were not known to exist and science began to realize that the atom was not the smallest unit of particle matter, that there were things called electrons. Very quickly quantum mechanics evolved and soon we were given the Heisenberg Uncertainty Principle, which taught us that, in fact, we cannot know both the position and momentum of any particle exactly.

At the most elemental level of matter, we began to accept probability and reject certainty in observation and prediction. A new paradigm emerged which we are still having trouble accepting. As Stephen Hawking recently wrote:

> The uncertainty principle had profound implications for the way in which we view the world. Even after more than fifty years they have not been fully appreciated by many philosophers, and are still the subject of much controversy. The uncertainty principle signaled an end to Laplace's dream theory of science, a model of the universe that can be completely deterministic. One certainly cannot predict future events exactly if one cannot even measure the present state of the universe precisely![1]

Through quantum mechanics, we have begun to discuss new theories of chaos, rather than determinism. One theory is our classical approach, where the complexity of inputs on one axis ranges from simple to complex and the complexity of outputs on the other ranges from simple to complex. Classical physics dealt mainly with what happens when you have simple inputs and simple outputs or complex inputs and complex outputs. In quantum mechanics, we began to discover that very small changes in an input could cause tremendously complex results; this is at odds with the classical understanding.

1. Stephen W. Hawking, A Brief History in Time: From the Big Bang to Black Holes 55 (1988).

Conversely, population biology is an example of a simple system. In a simple system, a classical system, population changes are regulated by deterministic mechanisms. Certain increases in inputs have predictable effects on outputs, such as the population's growth or decline. If the inputs are complex, we could say the population changes were randomized by unpredictable environmental factors. But, what we see is something very different. We see that, in fact, complex outputs can result from very simple changes in inputs, such as the food supply.

To illustrate, there is a very simple relationship between the increases in food supply and the increases in the total population. As we increase the food supply, the number of people in the population increases, nice and smoothly, until we come to a certain point. Then, unpredictability sets in; we move into a very unstable period where an increase in food supply can actually increase, or decrease, the population in seemingly random ways. Then, as we continue to increase the food supply, we get to even more complex situations where the population can be oscillating back and forth between four different possible levels for the same increase in the amount of food.

So, by changing a very simple variable, the food supply, and changing it by very small amounts, we suddenly get into a realm where the population that results jumps about dramatically between one level and another. Taken to another level, we start to move from the four possible populations to thousands of possible population levels. This demonstrates the area of chaos. Our equation, our understanding of the system, begins to break down in the chaos area.

Interestingly enough, if we continue to increase the food supply, we actually come to another area where there are relatively few possible outputs, and we have a reappearance of order. In a very simple system, where we are changing one variable by very small amounts, we see dramatically different results for the same approximate amount of increase in food. So, we have a system that we thought we could predict very finely but that, in fact, produces outcomes that are beyond our ability to understand. As we increase the magnification of this system in change, we observe this same movement from order to chaos and we see it in ever-increasing patterns.

The startling revelation of chaos theory is the acute dependence of systems on their initial conditions. Unlike our classical theory, where a small change in initial condition led to a small change in output, we now understand that very small changes in initial conditions can lead to wildly fluctuating results in outputs.

But, there is an even more important observation provided by chaos theory. Notice that we see something else in this chaotic quadrant that we call self-organization. This is where, in fact, order can emerge from chaos. This happens within the system where, through some sort of mutual interaction, the system moves into a period where outputs are complex but orderly. Systems achieve self-actualization through this process and arrive at levels where they operate productively and successfully. So what we want for our systems is that they function in a manner that gives them this same self-organizing capability to achieve order and efficiency out of chaos.

The reason, I believe, that today's land use system is failing is that it is not a self-organizing system. This was told to us by our survey respondents, as I will explain in a moment. The system of environmental laws, particularly, is a centralized, rigid, top down, command and control system. The other parts of the system, that determine where and how quickly resources are used and that provide incentives for their use, are not connected to one another and operate independently of the system of environmental regulation. This overall "system" cannot self-actualize by reacting swiftly and capably to a dramatically changing world. When chaos sets in, it lacks the ability to self-organize in response. As a result, quite often, the wrong action is taken which may yield even more chaotic and unproductive results.

Environmental Regulations and Economic Costs:

But what does all this have to do with environmental issues? This is the third part of our discussion today. Well, of course, everybody is aware that we have serious environmental problems to address. We have emissions to air, emissions to water, and we have all sorts of hazardous waste being produced on the land that has to be taken care of. And, we all know that environmental compliance is costing a lot of money in the United States today. Let's take a look at how much it's costing and then look at why it's costing so much.

Today, it is costing over $125 billion a year in the United States to protect the environment. This is a result of a position that we have gotten ourselves into throughout our long period of industrialization. We have built plants, developed utilities, and used the land, doing things to the environment that we never intended, the results of which we did not foresee. Now, we have to do something about the environmental degradation that has resulted. And, as usual, solving a problem costs a lot more than initially protecting against it. A $20 seat belt in a car installed when you buy the car may save the system hundreds of thousands of dollars in future medical costs if the driver or the passenger is saved from a serious accident. Prevention, we know, costs a lot less than curing.

The costs some of our U.S. companies are incurring are enormous as they attempt to deal with environmental issues. In 1987, for example, Monsanto spent about $200 million a year, and by 1990, spent $350 million. Texaco spent just under $200 million in 1990, and by 1994, spent almost $450 million. And, Florida Power and Light is currently spending $15 million and is expecting that to double to almost $30 million in the next year. So here are companies in the chemical industry, the oil industry and the utility industry spending so much more than just a few years ago on trying to solve these problems of the environment.

If we compare the growth in environmental costs to growth of other costs of doing business from 1987 to 1990, we see that they have been growing at a much faster rate: 13% a year. Compare this to benefit costs for workers which, during that same time, increased only 7%. The crude products that go into production increased only 5%. Labor costs increased only 2.7% and the cost of capital has been growing very slowly in comparison.

We see companies like Texaco having to spend $1.5 billion to comply with a certain set of regulations. For Allegheny Power Systems, its largest capital project in the United States is an acid rain scrubber. In BMW, one-third of its $845 million research and development budget today goes toward creating cleaner processes. Chevron is planning $700 million for the redesign of a refinery to reduce pollution.

In the utility sector, there are expected costs to take care of some major issues like acid rain, toxins, greenhouse effect and thermal water discharge. Billions of dollars per year through the 1990's will be spent to deal with these issues. These are huge costs by any standards. If we think in terms of the year 2000, we anticipate that energy companies will be spending over 5% of their revenues on environmental issues. Chemical companies will be spending 4%, paper and products almost 5%. So here we see a situation where more money is being spent on environmental issues than is being spent on research and development or than is being realized by shareholders in terms of profit.

What are the driving forces that are pushing these costs up so quickly? The principal one is regulation. In the United States, over the last 30 years, we have put a series of regulations in place that have forced a certain type of compliance on these industries. The industries have resisted this type of regulation and have had little to do in creating the system that generates one of their biggest costs. As a result, we have missed a chance for regulators and industry leaders to cooperate in developing the most productive and effective system.

We talked about chaos, the idea that small changes in the input can result in huge changes in the output. Well, that is environmental protection in a nutshell. We are finding that to take a few particles out of a stream from a pipe is costing billions of dollars. We are finding that once you have polluted a piece of land with oils or chemicals, to get those chemicals out costs enormous amounts of money. We are finding that the interconnections between the environment and the pollutants are hugely complex. We now know that the production of soot in one part of Europe results in the killing of forests in another and the killing of the trout in the streams of yet another. The interconnections in these systems are so complex that taking care of all of them is leading to exponential increases in costs. So, complexity is a major driving force and all of the intelligence in the entire system is needed to address the problem.

Another recent observation is that, as environmental regulation progresses, the standards for compliance increase and the costs imposed on polluters rise exponentially. One of the ways to understand this is to see that, as the standard of pollution allowed goes from 0.5 pounds per million of pollutants in each British Thermal Unit (BTU) to 0.2 pounds, the cost of removal goes from about $200 million per ton of pollution removed to almost $3 billion. So here we see this exponential effect: as we try to do a little better, the costs are not going up linearly, they are going up exponentially.

What can we do about these forces that are driving our environmental costs up? Well, one thing we can do is institute new types of regulation that promote choice and flexibility on the part of the polluter. Instead of having regulation where the central nerve center says do "X," we can have regulation that is much more flexible, that produces goals, and allows the corporations and the public entities to achieve those goals in the ways that make the most sense for them, as they interact with one another. But this takes cooperation between the regulator and the private sector, which can lead to better solutions and even prevent the need for certain types of regulations altogether.

Perhaps, if our corporations move effectively in a proactive manner, we can even prevent the need for much regulation. By reducing scrap and waste, we can actually find markets for some of that byproduct. By instilling in our corporations a conservation ethic, perhaps expenses in general can be reduced, remembering that small changes in inputs can effect large changes in outputs, in positive as well as negative ways. So, perhaps if we take a different attitude toward the environment from the beginning, we can have a very different outcome as we move through the process of industrialization. If we design our systems to recognize the complexity and potential chaos that can result from putting the wrong system in place, perhaps we can do better than our predecessors.

We talked about Monsanto earlier. Recently its share price was about $64. About half of that equity, almost $30 per share, is tied up potentially in regulatory or environmental compliance issues of one sort or another. That is to say, the value of Monsanto could more or less be halved if it does not do a good job of taking care of the environmental issues that face the company. If we look at the same sort of issues for three industries - the electric utility industry, the chemicals industry, and the paper and products industry - what we see is that the amount of stockholder wealth that can be wasted is potentially $168 billion. And in each of those industries, we are talking about something on the order of 25% to almost 40% of the total shareholder value potentially wasted if we don't do the right thing in the environmental arena.

Creating Self-Actualizing Systems:

Now how can we respond to these issues? Let's begin by thinking in terms of two dimensions: the financial impact on the private sector and the environmental impact of various solutions. We can develop solutions where neither consideration does well, such as the lose/lose approach where private costs are high and the environment continues to degrade. So we want to try to avoid this quadrant where environmental gains are low and private costs are high.

The exact opposite quadrant to that is what we call the win/win, or "virtuous" quadrant, where the financial impact is low and the environmental impact is good. And believe it or not, programs that achieve this virtuous result are known and are being followed by some companies. Under our system, however, we tend to operate in a third quadrant: the trade-off zone, where we improve the environmental impact, but the costs to industry are extremely high.

The fourth quadrant is the environmental exploitation quadrant which is probably where industry operates in the absence of any regulation or threat of regulation. This happens when we exploit resources unthinkingly and the results are very negative from the environmental perspective, although we may, in the short-term, have excellent financial results. But, as we have seen, in the long-term, the costs to society finally have to be paid and the final accounting for the private sector is negative, as well.

The 3M company has managed to operate in the virtuous quadrant, where they can actually improve the environmental impact by reducing the emissions that they are producing and at the same time achieve substantial financial improvement in the company's operations. There are other ways to accomplish this win/win result. We can identify efficiency improvements where we reduce waste and costs at the same time, or, find markets for by-products that previously were discarded, or, be on the cutting edge of environmental compliance and achieve a competitive advantage over other companies that, later, have to pay the higher costs of clean-up and compliance. Or, we can take environmentalism seriously and, by so doing, win greater market share among consumers who are increasingly environmentally aware.

There is an example involving a Los Angeles refinery that shows the wisdom of seeking solutions in the virtuous quadrant instead of operating in the trade-off zone. The refinery, in order to meet the emissions standards that are being applied in Los Angeles County, was going to have to spend about $60 million in order to manufacture cleaner fuel to improve the emission from the cars using its fuels. Through a negotiated approach to achieving the same level of emission reduction, it was discovered that the refinery could achieve the same environmental benefit by purchasing 8,500 old vehicles and taking them off the road at a cost of only $25 million. Here, the private sector beat the regulators, so to speak, by working with, and ahead of them.

We can respond more intelligently, as we see illustrated in this example, avoiding such enormous costs and decline of stockholder equity while protecting the environment just as effectively. This requires, however, fully engaging corporate leaders and researchers at the outset to develop long-term environmental protection plans. DuPont incurred enormous costs as it tried to improve the environmental impact of chlorofluorocarbons (CFCs). The situation improved, ultimately, with the introduction of hydrochlorofluorocarbons (HCFCs), but the point is that with some foresight and planning, great private costs could have been avoided by going to HCFCs in the first place. This requires that we anticipate rather than respond to environmental events. This, quite obviously, cannot be done through a system that is not integrated; it requires one in which all levels of government and both the private and public sector work together to identify problems and seek solutions.

Conclusion:

We have discussed three issues today. We have talked about the fact that those people who use the land use system in New York find it is not able to meet all of the priorities that they had hoped it would. We see that science is telling us that the world is a very complex place, that we cannot hope to be able to see the end of the road from the beginning, and that, in complex systems, very minor changes in the inputs can cause chaotic results. To avoid such results, we have to have systems that are capable of coping with complexity by being able to maneuver and self-regulate so that order and efficiency emerge. Finally, we talked about how the environmental system, which does not have this ability, is imposing huge costs to achieve increasing environmental standards.

Our land use systems are breaking down because they cannot handle complexity. They tend to be command and control structures where standards and procedures are centrally determined and compliance is enforced upon other parts of the system. Other important public land use influences are uncoordinated altogether with this centralized process. In a highly complex world, this doesn't work. Science is telling us these systems do not produce efficiency. The private sector has realized this in the way it has changed its business systems themselves. If you think of some of the programs that companies like General Electric with its workout program, or the defense industry with its quality programs, have instituted, you understand that each of them is designed to capture the knowledge at all the levels in the organization and to introduce flexibility and responsiveness into the business system. Private sector systems are changing to integrate that knowledge, to bring it together to set goals and objectives, to define strategies and a vision for the organization, and to ensure that the organization is highly responsive and wastes nothing.

If this can be done in business, it surely can be done with our critical public systems as well. We have seen from the U.S. situation that once you get behind the power curve in environmental issues, the costs are horrendous; therefore, we have got to think proactively. We have to begin to get ahead of the technology. If we allow industrial technology to get ahead of us, then we are going to be cleaning rivers, cleaning rain, we are going to be doing the things that cost a lot of money. If we think prevention instead of cure, we are going to be a great deal better off.

When we did the survey in New York, we asked the respondents what an effective land use system would do, in their opinion. The results showed that these respondents wanted an integrated system; 88% of them wanted comprehensive, integrated planning to precede land use regulation; 70% agree that local plans and regulations should be consistent with plans at higher levels of government; 81% of them thought that these plans should define geographical areas where growth and development should be concentrated while designating other areas for environmental conservation; 82% said that the capital infrastructure budgets of the federal, state, county and local governments should be coordinated with one another to realize these development and conservation goals.

These suggestions are very close to the ideas advanced by Senator Henry Jackson in the early 1970s who wanted to design an integrated system using federal incentives to do so, before the Congress adopted stringent environmental rules and regulations. Senator Jackson's National Land Use Policy Act would have integrated local, state and federal systems.

Planning would have emerged from the local level to be memorialized in the state plan which was under constant review. The federal role was to provide financing, data, assistance and training to encourage and assist the states in their coordinating role and to spend federal resources and direct federal regulatory pressures to help implement the state plans.

This may not be the perfect system; I don't know. But it's an attempt to achieve a much more effective system that integrates from the top to the bottom, that uses grass roots knowledge and aligns it with the goals and objectives of the overall system. It is consistent with our message today that, as science and the business communities are teaching us, we must design a system for the important job of land use regulation that is integrated across all the levels of government and between the public and private sectors. Senator Jackson thought of this type of system in the 1970s. Perhaps, we can design one at least as good today.