



## NO WASTE ECONOMY

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Don't expect the Earth to produce more.  
Expect humans to do more with what the Earth produces.  
This is the second Green revolution.

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AT THIS MOMENT in time the world of industry is not responding to the basic needs of our society. Some people may say, oh, yes, we just need to have population control and everything will be all right. Other people say, we just have to become more productive. Whatever options they may favour, everyone agrees that with 5.5 billion people in the world, with 1 billion people looking for jobs, with 800 million living in absolute poverty, the present system is not right.

Within industry, there is a lot of fascination with the first Green revolution. Through the mechanisms of irrigation, of massive water use, through seed selection, through fertilizers, herbicides and pesticides, we were able to achieve seven times more output of rice per acre than we had forty years ago. This is not a bad result! Yet it's not sustainable. It is not possible to continue with such use of water. We're depleting the aquifers.

Scientists around the world agree that we're never going to succeed in doubling or tripling the output of grain, let alone increasing it five-fold. At the present stage, with all the fascination with the manipulation of genes, all the biotechnology scientists say that we may be able to improve output by a factor of 20% to 50%. No one today dares to advance the figure that we could have another five-fold increase of output. We know that we had a dramatic increase of industrial and agricultural output, but with 94 million people being added to the planet every year, we can't keep up.

THERE IS A FIGURE that is much more important than the 94 million people who are added to the world every year. In

Asia we now have 400 million people who are going to join the middle class by the year 2000. Middle class means simply that 400 million people will be drinking a pint of beer a day. They will read a newspaper. Just by having 400 million new people with the purchasing power to buy a beer a day will force the Green revolution into bankruptcy. Not the 94 million new people, because they don't have enough purchasing power. But the 400 million new middle-class consumers entering the market will have purchasing power comparable to the United States and Canada.

This is really where the pressure will be. Today, we already have 400 million middle class consumers, so this will effectively be doubled, having a much more dramatic impact than the 94 million new people every year.

Therefore, we need a second Green revolution. But this does not require the Earth to produce more. It requires humans to do more with whatever it produces. For example, there is a plant in Mexico called the sisal plant. It looks like a cactus. The sisal plant is the number one crop in Tanzania. It's a main crop in Mexico, in Colombia and in Brazil. The sisal plant is used for its fibre, mostly to make ropes. Ships still have sisal rope. No synthetic rope has the strength of a sisal rope.

But the sisal fibre is only 2% of the plant. 98% is waste. This means that Tanzania has 11.8 million tons of biomass waste a year dumped into the river. As long as you think in linear ways, you can't do anything with that waste.

My colleagues and I have been studying what else you can do with sisal fibres. We learned that you can ferment citric acid and lactic acid out of the bole of the sisal plant. I looked at the market and saw that citric acid is \$3,000 a ton. This is a very valuable product. Sisal fibre will get you only about \$200 a ton.

Citric acid is a main product in the food industry. It's an excellent component, a natural one, as is lactic acid. So, when you can get 10% out of the weight of the sisal plant converted into citric acid, I'm telling Tanzanians that they can become the world's leading producer of citric acid. I ask them, why do you struggle and try to get subsidies from the Commission of the European Union to subsidize your fibre production, when you should be producing citric acid? Of course, the European Union is not interested, because Austria is the largest producer of citric acid in Europe, and Pfizer, an American company, is the second largest producer. They have no interest in seeing Tanzania being able to put citric acid on the market.

But the reality today is that we have a linear production system for sisal plants, which makes the industry uncompetitive. If we were able to apply systems thinking to sisal plants and extract all the great things the plant is making, including the wax (it has an excellent wax), then we could make this into a very sustainable industry.

There is also more to the sisal fibre. We use only the long fibres; the shorter fibres are not used. Now, who can use the short fibres? Which enzymes can use lignin cellulose? There's basically only one enzyme, from mushrooms, which can break down the lignin cellulose of the fibre structure. That is why we're now growing mushrooms on the sisal fibres, and that is 35% of the biomass. Then, of course, the mushrooms break down the lignin cellulose and partly convert it into carbohydrates. This gives you excellent cattle food! All this makes economic sense.

LET ME GIVE YOU another example

- cellulose. The cellulose case is a pervasive one. We all agree that we shouldn't be cutting primary forests. But cutting primary forests and then only using 25% of the tree, that is a crime. It's a crime for us to cut it, and it's an even greater crime

to use only 25%. We extract only cellulose, and the 75% - the lignin, the hemi-cellulose, the waxes and the proteins - is discarded. That is again the result of linear thinking in industry. When industry cuts the tree, it is interested in the cellulose - not in the other products.

Another case is beer; which is a typical middle-class drink around the world. When you produce beer; you have a fermentation process, of either barley, or rice, or whatever you ferment. But you extract only 8% of the nutrients from the cereal. 92% is discarded. It's given to cattle. People say, "Oh, cattle can eat it," but cattle cannot eat it, because 70% is fibre, and the stomachs of the cattle cannot digest it. There is an enormous amount of methane generated by cattle, and it's partly because of the food we give to them. We know that when our stomach is upset, when we ate something bad, we have too much gas in our intestines. Well, that's what we're doing to the cattle all the time.

We always give the cattle something bad to eat, and then we complain that the farmers are generating too much methane gas! Using only 8% of the nutrients from beer is sheer madness.

Another case is the palm tree. The fatty acids of palm oil are only 4% of the biomass. 96% of the biomass of the palm tree is burnt, worldwide. Every twenty years they have to clear the palm plantations and what do they do with the wood? They just burn it. They consider it not good enough for furniture, not good enough to be transported for cellulose, so they burn it.

Here we have an effective palm oil industry which is perfectly competitive in the world, yet it has self-defeating aspects. Today, we have a \$65 million budget for research in Malaysia to study how to increase palm oil from 4% to 5%. I'm saying, why don't we take about 10% of that budget to do something with 96% of the biomass?

Linear thinking is very much ingrained, not just in the industry, but also in the research. Researchers are, in general, linear thinkers. They get a message from industry:

"Increase this to 5%. Let us know how you can genetically engineer this to get it to 5%, 6%, 7%." What I have proposed is a new research agenda. The message is simple: "Don't expect the Earth to produce more. Expect humans to do more with what the Earth produces."

**PRODUCTIVITY IS VERY** important in industry. The problem is that industry has looked at only two out of three key input factors.

One is labour - how to produce more with less people. Very popular, but self-defeating. Developing countries thought for decades that their low labour costs would give them a competitive advantage in the markets. Yet the North has replaced low labour costs with no labour costs. We just don't have labour any more. We just tax people enough so that we can support 40% unemployment in the labour market.

Since we've no labour costs, we don't care if Third World countries pay \$5 or \$50 to a labourer; because we don't have labourers any more. This is a shift we've seen, for example, in the textile industries. We've noticed that all carpet-making has moved back to the North. The largest exporters of carpets in the world are Europeans and Americans, not Persians or Pakistanis - because technology has shifted, and we can now make carpets basically without people. Machines are doing it very effectively, with high-tech software.

In addition to labour productivity, industry looks at the productivity of capital. This basically means that we get more return with less risk. Industry has been very clever at that. But industry has not looked at the productivity of raw materials. The three basic input factors in the economy are labour; capital, and raw materials. How come our economists have been focussing on only two of them?

The reason is very simple. In dollar terms, the average raw material prices have been decreasing for the past thirty years, until two years ago.

Industry never looked at raw material productivity, because there was an abundance of raw materials in the market. But after 1994 all that has changed.

Across the board, all prices are now rising. For example, polyethylene is double the price of two years ago; copper is 26% more; petroleum prices are double what they were two years ago. The price for malt, which is a key ingredient for beer-making, is triple the price of three years ago. That is a fascinating development. It is the needed signal from the market for industry to wake up.

A KEY ARGUMENT here is that, for the first time, there is the opportunity to increase not only productivity, but also employment. This is news for politicians. A new economy is emerging where you can have a rise in productivity and a rise in employment.

How does this work? There are two ways. One way is by achieving total throughput, which means that all raw materials that you buy are really used in the process. If you reach 100% throughput, then you've re-used everything, except for energy. One industry that claims to have succeeded in doing that is cement. Everything that goes in comes out on the other side, except the energy. The cement industry is one that claims to work with a total throughput.

Food-processing, on the other hand, is the most wasteful. For example, in Brazil, citrus fruit growers only grow lemon for the perfume. They throw everything else away. Meanwhile, the juice-makers throw all the peels away and don't process them. That is typical linear thinking in food-processing.

The second way to increase productivity is through industrial clusters. We know that one industry cannot find all the solutions within itself. For about thirty years, business schools have been teaching that you have to focus on the "core business strategy". You have to do what you're best at; forget everything else; focus on one great product. The "core business strategy" is the main culprit of linear thinking. The financial markets force business to adhere to a single core business strategy.

To increase raw-materials productivity, we need to cluster different industries, so that they can work together. The concept is not entirely new. There is the concept of 'just-in-time'. It is, basically, a way of manufacturing that reduces inventory, because the various items in the inventory are delivered by the suppliers 'just in time'. In order to pursue this strategy, industry used the clustering principle. For example, in the car industry 600 suppliers had to relocate around a Toyota factory in order to deliver their products 'just in time'. The result was that inventory supply time could be slashed from three months to thirty minutes. Thus a lot of capital that had been locked up got released. It took twenty years for Toyota to relocate its 600 suppliers, but today they're operating at a much higher level of efficiency.

LET ME NOW illustrate the details of industrial clustering with the concrete example of a beer brewery. To introduce the idea of industrial clustering, I began to promote the zero- emissions concept, which is closely associated with the clustering of industries. Zero emissions means that we don't have waste any more. We eliminate the concept of waste. We know from nature that this can be done. What is waste for one species in an ecosystem is food for another. So, when one industry produces waste, it has to look for someone else who knows how to use it.

This is not just theory; it's what we've put in practice in three breweries: one in Fiji, one in Tanzania and one in Namibia. When you make beer you have solid waste, CO2 waste, heat waste and liquid waste. In solid barley waste you have 70% fibre and 26% protein, plus a few other things.

In our three breweries we're growing mushrooms on the fibres. In collaboration with the Chinese Academy of Sciences and the Hong Kong Chinese University, we've developed a system to grow mushrooms on the spent grain. You can have up to five harvests of mushrooms in one batch of spent grain, and we've even succeeded in producing high-priced mushroom delicacies like shiitake and miyatake.

None of the mushroom experts around the world ever thought of growing them on beer. As a systems thinker; I asked: what can we do with the fibres? We discovered that fibre is a mushroom feed, and so we use our fibre as mushroom feed.

Now, with the 26% protein waste, we're cultivating earthworms. Earthworms like hot, sticky, wet environments, in which they convert vegetable proteins into animal proteins. To give you a figure, a middle-sized brewery with an annual production of 100,000 litres of beer will give you 10 tons of solid waste a day. 70% of that you can use to grow mushrooms.

But what I found even more interesting is that with one ton of solid waste, you can produce about 130 kilos of earthworms. Therefore, a mid-sized brewery will produce about 1.3 tons of earthworms a day. That's a lot of earthworms. We feed them to chickens. So now we also have a chicken farm linked to our brewery.

What this means is that there's no need to have any aid programmes for food in Tanzania. Just convert the sixteen breweries into chicken farms, and mushroom farms. You can create massive amounts of food. On top of it, the food is extremely healthy.

In addition, the mushrooms convert lignin cellulose into carbohydrates. These carbohydrates, the waste from the mushroom farm, are given to the cattle. The cattle used to get food that had only 2% carbohydrates; now their food has 45% carbohydrates, thanks to the good work done by the mushrooms. So now we have a 45% carbohydrate feed stock for cattle, which is high quality feed.

The cattle and the chicken produce much less methane with this type of feed, but they still do produce a lot. We catch all their droppings in a digester, which then generates steam. The largest digester we have is in Beijing, in a brewery that produces 800,000 litres of beer a year. It's one of the largest breweries in China. All the steam they need in the brewery comes from the digester; from the waste of the chickens and cattle. It's a very efficient process.

So our chickens and cattle become a source of energy. We are not used to looking at a chicken as a source of energy; we look at it as the source of eggs and food. But a chicken is also one of the most efficient methane generators in the world. With

three chickens and one cow, you can have electric light all evening in your home.

Now, the digester also generates waste, called slurry, which has a very high BOD (biological oxygen demand). This is considered a problem by environmentalists, because of the large amount of oxygen that has to be added. The Chinese and the Vietnamese have worked with very high BOO slurries before.

They put them into fish ponds on which they have floating gardens, so the roots of the flowers and ryes and tomatoes extract all the food. It's like floating hydroponics. Within twenty- four hours, the BOO of 1,000 (which is what our digesters give us) is broken down to a BOO of 25, without adding oxygen. So we have floating gardens and seven kinds of fish are bred in the ponds, which is the traditional Chinese way of dealing with slurries. This is nothing new; it's what the Chinese have been doing for thousands of years. We are now applying this at our industrial site which means that we have six or seven ponds the size of a hectare, one next to another, and we treat all our slurry that way.

So, I'm asking my beer brewers, "In which business are you? Are you in the hydroponics business, the fishpond business, the chicken-farming business, or the mushroom business, while you happen to make some beer on the side?" From a systems point of view, it doesn't really matter. Nobody tries to maximize anything here; this is all optimization. That's the beauty of industrial clustering. The principle of the natural cycle is applied here as an industrial cycle. No more linear thinking.

Let me summarize our results. First of all, in terms of output of nutrients, of fertilizer and of energy, we're doing seven times more than a brewery. This is the second Green revolution! We're producing seven times more food, fuel, and fertilizer. This means we've completely changed the economics of a brewery. It is also important to realize that you can't do this with a two-million-litre- a-year brewery. You can only do it with a small brewery.

The second result is that we generate four times more jobs than in a normal brewery. We have four times more people employed, because all that clustering requires workers. However; every single component of the cluster is tested against the market. Our great advantage is that every resource comes free, because it is what was considered waste. From the brewery's point of view, everything is waste. Our additional expense is on the infrastructure, all of which is located around the brewery. That means we have eliminated transportation costs completely, which is a major advantage. The brewery is always located close to a consumption centre, which means the mushrooms are sold, the chickens are sold and the fish are sold locally.

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