Back to Adam Smith

There is Light at the End of the Tunnel

article by Gunter Pauli
July 1999

Introduction to the Re-Publication 21 years later

When this article caught my eyes in this period of lockdowns, I realized what a methodological approach can teach us about envisioning the future. Here were my observations over two decades ago when I was preparing the present the concept of the Blue Economy and the standard where zero emissions and zero waste is the starting point - not an end objective.

1. Economics is not a science. Unfortunately now I have to conclude that many of the traditional sciences like biology and chemistry are in urgent need of a fundamental revision. As I have stated, most diplomas that are more than 20 years old have surpassed their expiration date. There is a need for a fundamental overhaul of what we teach our children.

2. Pollution as a parameter of success. Amazing we have exploited the Commons to the point of its collapse and the few pockets of Nature left are threatened because our goal was to protect, and we never had a standard requiring to regenerate.

3. Go Beyond Reduction. Indeed we need a business model that regenerates, uses what is locally available and ensures the resilience in communities to respond to all basic needs.

So I invite you to read this article and perhaps pay special attention to the section on page 16, dedicated to infectious diseases. The text in blue are my updates.

Bogotá, 2nd of April 2020

In a magnificent, informative, to the point and relevant publication "Beyond Malthus", Lester Brown and his colleagues from the Worldwatch Institute provide a stunning summary of 20 challenges the world has to face since population will continue to grow for at least half a century. The projections are grim, the basis for hope is limited, especially when one realizes that whatever we do today is insufficient to alleviate the critical conditions of the billions who live in poverty, lacking the most basic provisions of water, food, health care, shelter, energy and jobs.

Nothing has changed! We only changed the objectives from Millennium Development Goals into Sustainable Development Goals after failing to change the reality for the majority of the poor. We do know the richer got much richer and the gap between rich and poor is increasing.

The production and consumption model which prevails clearly is not capable of responding to the needs of all communities in the world. It does not seem to be a matter of inequity by design, but rather a case of ignorance how to do better. The ways and means that have been implemented to produce goods and services are profoundly wasteful, and have not yet succeeded to incorporate the inherent efficiencies nature displays. Worse, the production engineers are confident of their success in productivity which they consider better than nature. The desire to produce more faster has lead to a processing system whereby chemicals, pressure and temperature is used to isolate one component, considering the rest as waste. The stress to consume more, more often, has lead to a wasteful society which is drowning in its own waste.

The capacity to produce much more with less is the basis of the *homo economicus*, and represents the heart and soul of economics. While all agree that the main objective and contribution of economics is its drive towards productivity and efficiency, responding to the needs on the market, it clearly has a long way to go before it can pretend to even have come close to that goal. Economics is a science which still operates in Stone Age, at a time when humanity has already entered Space Age.

If economists were to search for a new production model which is based on systems, inspired by nature, which emulate nature and which operate in harmony

with nature, then this science is likely to succeed in providing the minimum of goods and services to all on the globe without exhausting the Earth's limited resources, without engendering a collapse of the ecosystem on which we are dependent.

The main reason why the present economic model is incapable of doing exactly that is that it does not apply the most basic rules provided by its own theory: implement an always more productive way to combine labor, capital and raw materials through the continuous introduction of innovations which relies on a unique human characteristic - creativity.

This article, inspired by and a reaction to the analysis of Lester Brown who has motivated me for so many years, takes the assessments of the Worldwatch Institute, and indicates how some of the trends could change if economists were to apply their own theory. Since the Worldwatch Institute is dedicated to fostering the evolution of an environmentally sustainable society, the analyses outlined here could perhaps contribute to these objectives in a novel manner.

The key to change the macro-economic framework is to design new business models that shy away from everything that the MBA's are taught.

Economic Theory

Economics is hardly considered a science by physicist, biologist, chemists, even engineers have their doubts. These reservations are well-founded. There is no science which demonstrates in its practical implementation such a discrepancy between what it does and what it prescribes and teaches. Worse, while all sciences from psychology to biology have evolved to a systems approach, economists remain in practice at micro-economic level, generically called management science, impressively linear. It is therefore all the more surprising to see the magnitude of influence economics and management have acquired in our society.

The first shortcoming of economics in practice is its focus on only two of the three main input factors. Economic theory prescribes that the *homo economicus* searches for the most efficient combination of three input factors : labor, capital and raw materials. But, analyzing what business schools teach, and verifying what companies do, it is clear that the search for productivity only focuses on labor

(producing more with less people) and capital (obtaining better returns with less risk). There is hardly any interest in the notion of material productivity. The result of such an incomplete approach is that the economy is generating more value added per employee, securing better returns for capital, slashing jobs. This leads to the false axiom that an increase in productivity goes hand in hand with an increase in unemployment.

It is quite amazing that this positive correlation between better productivity and higher unemployment has become a widely accepted phenomena. Economists hope that over time, new innovations and the identification of new business opportunities will secure a slow but certain absorption of a major share of the population into the work force. Reality is quite different indeed. While never in history so many people have had a job, never in history, so many people are desperately looking for a job.

While in Europe and Japan one could hope that the negative population growth will eventually solve the problem in one generation or so, economists seem to neglect that such a *laissez-faire/laissez-passer* attitude sends a most dramatic message to 20% of the world population and about 40% of youth : society does not need you! Rich nations can indeed afford such an attitude. Transfer of purchasing power through taxation can alleviate difficulties created by such an insensitive approach to joblessness. Developing nations on the other hand know all too well, that high rates of unemployment amongst the young generation which can represent up to 60% of society, is guaranteeing a road towards violence, insurgency and even disintegration of civil society.

Nothing has chan.The hard reality is that high rates of unemployment, combined with environmental degradation beyond repaid, and the disintegration of civil society (war) leads to an exodus that translates in large scale exodus where people risk everything to reach “the other side”.

Pollution as a parameter of success

The focus on productivity of labor and capital not only leads to high levels of unemployment, it is also the main reason that the present production model pollutes, and that consumption of products generates so much waste. The fact that economics and management is capable, but not prepared to respond to the needs in society through a systems design, results in a massive loss of resources, which

become apparent under the form of waste, water and air pollution, landfills, incinerators and illegal dumps.

In the 1950s success was measured by the number of smoke stack chimneys, the brownish color of the local river, and the grin on the black faces of workers. Industrial success today is projected to society by trees and flowers, animals and blue skies. We know that the truth is different indeed. Over 100,000 synthetic products offer on one hand great comfort and luxury, but on the other hand generate problems we have not yet started to understand. Packaging outweighs increasingly the content of its product, and more energy is spent on transporting food than this nutrient could ever offer to its consumer. This is not a simple criticism of the present economic model, this is only an indication that we are far from applying what we have proposed as the final objective: doing more with less.

In a systems design, we can imagine how waste of one process can evolve into a source for other processes. We only have to observe a tree to know that it never could survive without mushrooms and earthworms converting its wasted leaves into humus, and how the excreta of the birds feeding on its fruits mineralizes the water providing additional nutrients. The linear and over-simplified modern industrial version of the tree would prescribe that all leaves from the forest would be gathered at a central point, where all the mushrooms and earthworms gather, after which one tries to make new leaves ... which would never work. Each tree has its own ecosystem which leads to the recovery of all the nutrients and energy, through a complex system, which ultimately permits the tree to continue to grow and procreate. This lesson from nature shows all too clearly that a recycling society, or a closed-loop economy, has no chance to clean up the environment, generate the value added needed, thus will never survive the test of time. The permanent recycling of nutrients in a closed-loop creates “mad cow disease” in animals, and incest leads to degeneration of humans. Why do we try to recycle through a closed system, feeding off our own tail?

There is a need for a (1) complex; and, (2) open systems design, which does not have to be difficult. The result will be a dramatic improvement of efficiency, one which permits to introduce the 10/60 rule, substituting the traditional 80/20 rule of thumb which has dominated economic thinking for the past century. The 10/90 rule prescribes that by merely using 10 percent of available space one can

process all waste of one process, and generate 90 percent of total revenues. This capacity to generate value added from "nothing" using little space, permits the creation of jobs, thus securing a simple logic for ***a basic economic rule : increase of productivity generates more jobs***, and is only possible when we use all materials. Once we have succeeded to fully use all matter and energy, the production model will have reached its optimum. If the production model has reached its optimum, then there will be no more pollution and we have reached the objective of zero emissions and zero waste. It will be an effort that will never end.

Beyond reducing waste and pollution

The major advantage of this production model based on what Adam Smith taught us two centuries ago, is not a mere elimination of waste, and the generation of jobs. The major breakthrough of this approach is that it permits us to envision how society can respond to the needs in society: water, food, shelter, health care, and energy. If economist evolve towards system thinking, managers can become systems practitioners, and society will harness this tremendous human energy embedded in its creativity, crystallizing its desire to provide a better future for future generations.

The focus on total productivity, one that reserves equal attention to labor, capital and raw materials, leads to a synergy which surpasses the possible achievements of a productivity program focusing on one or two of the three key components. But, one has to keep in mind that whereas it is possible to develop productivity programs for capital and labor within the industry or agroprocess itself, it is impossible to do so with raw materials, waste, weeds. ***One has to search for opportunities outside the core business.***

A productivity program which targets raw materials, waste, and weed goes beyond the mere recovery and recycling. The search for productivity implies a search for value added, and optimizing the multiple outputs of a complete system with a given input. This is more than the recovery of heavy metals after consumption; this is more than the extraction of more cellulose from an existing tree; this goes beyond organic farming, eliminating chemicals. It is a production process which targets the full use of all components, time and time again so that nothing will be lost. And this can only be achieved when one operates in clusters of industries.

Whereas recycling programs are well known, the design of a system which permits the full use of all inputs is surprisingly only applied in the petroleum industry. There is no other industry which cracks molecules in such a precise manner that in the end nearly all is used. Interestingly enough, the petroleum and petrochemical industry is the only one which continuously searchers for new uses for its outstanding product, and continues to add value to its cracking of molecules. No surprise thus that is can be so much more competitive than similar products made from renewable sources. The natural products are always more expensive because one typically only focuses on one component, considering the rest as waste.

The application of system design in economics and management, the introduction of productivity for raw materials, waste and weed can help us see the light at the end of the tunnel which is dark and without promise. Here are some reflections on these points using the treatise of Lester Brown “Beyond Malthus” as reference. The 19 areas of for consideration are :

1. grain production
2. fresh water
3. biodiversity
4. energy
5. fish catch
6. jobs
7. infectious diseases
8. crop land
9. forests
10. housing
11. climate change
12. materials
13. urbanization
14. protected natural areas
15. education
16. waste
17. conflict
18. meat production
19. income

1. Grain production

> *"From 1950 to 1984, growth in grain harvest easily exceeded that of population, raising harvest per person from 247 kilograms to 342. During the 14 years since then, growth in the grain harvest has fallen behind that of population, dropping output per person from this historic high in 1984 to an estimated 312 kilograms in 1998 - a decline of 9 percent." (p.33)*

Since grain, rice, corn and other major crops suffer from a per capita decrease in production, and since there seems to be no chance to increase access to new land, irrigation and fertilizer, we have to search for alternative ways of increasing production of nutrients. Since each crop mentioned produces a ***multiple of 10*** in terms of straw, husks, cobs and the like, which are nearly always left to rot on the field, incinerated, generating carbon dioxide, or simply used to clean up cattle barns, their productive value extremely underexploited.

If we were to operate in clusters of production, then we can imagine how all this agro-industrial waste can -for example- be converted into substrates for mushrooms. Straw *(Volvariella volvacae)* and oyster mushrooms *(Pleurotus spp.)* fruit under ambient environment, especially in hot and humid climate, exactly the regions where demand for food is falling short of needs. Since the amount of straw is minimum 10 times the amount of grain, we could estimate that there is a potential 18.5 billion tons of straw. If a biological conversion rate of 50 percent is achieved, then this would lead to 9.25 billion tons of mushrooms (at 90 percent moisture content), or an additional 1.5 billion tons dry. And the spent substrate is an excellent feed for chickens.

Since the two mushroom species mentioned would fruit within weeks after inoculation, the nutrients would be available for immediate distribution and consumption. The additional land use could be limited to 10 percent of the land available for farming, generating a multiple of revenues. The mushrooms can be dried and kept for consumption for 2 to 3 years without any preservation agents.

Whereas Latin America does not have a culture of eating mushrooms, Africa and Asia both have a long tradition of harvesting and cooking mushrooms. The rich

biodiversity of fungus, which is yet to be discovered and understood is one of the greatest potential areas for expansion of food.

The agrowaste to mushroom program counts today an estimated 5,000 initiatives worldwide. This is a success … and a failure. The potential is at least one million production units and this can turn into a major engine of jobs and health in local communities.

2. Fresh Water

> *"Wherever population is growing, the supply of fresh water per person is declining. As a result of population growth, the amount of water available per person from the hydrological cycle will fall by 73 percent between 1950 and 2050. Worldwide, some 70 percent of the water pumped from underground or diverted from rivers is used for irrigation, 20 percent is used for industrial purposes." (p. 37)*

The main use of water for agriculture can be classified as highly inefficient. Studying the use of water in harsh conditions, such as the Namib Desert, offers a basis of inspiration on how it could be done differently, obtaining the same results using only a fraction of water. The *Welwitschia mirabilis*, the oldest living plant on Earth, survives in the Namib Desert for over 2,000 years, permitting ruminants to chew off its leaves as a source of moisture. This plant and insects from the same ecosystem are experts in the harvesting of moisture from the air. Whatever part of the world, there is always humidity in the air. The harvesting of fog has become a necessity for survival in Namibia and northern Chile, but is an unexploited opportunity everywhere else. When water was abundant there was no need to be creative, when water is scarce, one has no choice but to become ingenuous.

Somehow, when humans search for water, facing a lack of rivers and creeks flowing nearby, the only option considered is digging a hole. The air around them, even when there has not been any rain for weeks or months, is rich in moisture, seldom dropping below 15 percent. Even in these dry circumstances, moisture will rise every morning, declining to a minimum in the afternoon. Technologies can be developed inspired by nature's response to the need to survive in the driest parts of the world.

The application of granulated dried seaweed can be applied as a soil component, offering a first concrete example of how nature can be used to reverse some of the climatological conditions which at first sight are without future. Since seaweed absorbs water up to ten times its weight, it represents an exceptional sources for water retention. In the morning, when moisture in the air is high, the soil is replenished with water captured in these granules of seaweed, while it is released slowly during the day.

Seaweed is one of the least exploited resources. The coastal zones in Latin America and Africa, where major concentrations of people emerge, are also the areas where high unemployment affects poor communities. It is therefore critical to see how the need to dramatically increase efficiency in water consumption for agriculture, could stimulate coastal industries, first cleaning up beaches, then planting, harvesting and transforming seaweed. The result is most beneficial for soil and crops, but even more important perhaps, one will be able to increase the absorption of trace minerals such as iodine, which are today lacking in the food cycle.

Industry has a second challenge. Since it is the second largest consumer of water, the linear thinking of water consumption imposed by law has emerged as a major obstacle. Food, wood and fiber processing industries are large consumers of water. Each liter of beer requires ten liters of water; each ton of cellulose requires 20 tons of water; each ton of recycled cellulose needs 40 tons of water; each ton of sisal fiber is produced with 30 tons of water. Each kilo of coffee required 35 liters of water .... . The conclusion is clear, there is a tremendous room for improvement in water consumption on the condition one is prepared to introduce new process technologies.

Coffee washing has slashed waster consumption from 40 liters to 0.2 per kilo. All waste water from a brewery should be used for fish and algae farming on site, without the neutralization of pH as is prescribed by law. The production of one ton cellulose from trees can be obtained using only 2 tons of water, introducing the steam explosion technology. It is perfectly possible to dramatically slash water consumption in industry IF one makes it a priority.

The introduction of stone paper cut water consumption per ton of paper to virtually zero, with no need to recycle water. Five factories have been built. The introduction of farming tomatoes with condensation water has resulted in a farming technique that produces water, while growing tomatoes. The first three mega farms are operational. Seaweeds have converted into agents of change, not the least through the capturing of microplastics and the generation of biogas while creating a refuge for juveniles regenerating biodiversity …

3. Biodiversity

"We live amid the greatest extinction of plant and animal life since the dinosaurs disappeared some 65 million years ago, with species losses at 100 to 1,000 times the natural rate. The leading sources of today's species loss are all a function of human activities." (p. 41)

While on one hand there is a massive loss of species, there is also a large amount of species which remains unknown. The second largest kingdom of nature mushrooms, has an estimated 1.5 million species of which only a mere 5 percent has been described taxonomically. And of these 80,000 species, scientists only succeeded in distinguishing male from female in about 15 percent. There seems to be a need to secure survival what we have, but there is an as urgent need to understand what we still have and put this to a productive use. Whereas there are germoplasm banks for seeds of crops, there are no germoplasm banks for mushrooms in Africa and Latin America, two continents which represent an estimated 45 percent of biodiversity. Scientists rightfully request a better seed bank for plant and crop varieties, while fungal species should be urgently added to the wish list.

There is a need to better understand the generative capacity of nature. As the Environmental Research Center Las Gaviotas (Colombia) has demonstrated, there is a unique capacity to create bridges between desolate regions where the environment has degraded, even where life is threatened, and the bustling zones of biodiversity. This unique dynamic reproductive model deserves more detailed attention. While this permits us to imagine how to protect nature, it also permits the regeneration of environments which could house and duplicate the unique reserves that remain available to us. What Las Gaviotas succeeded in Vichada, Colombia in an area of 11,000 HA, could be duplicated in the same part of the world covering some 6 million HA.

The attractive point of this exercise is that the recovery of biodiversity is self-sustaining. It only requires a start-up capital equivalent to one million dollar per 1,500 HA. The further financing is possible through the generation of drinking water, a challenge which was clearly identified in the previous chapter. If forestation and water management is effectively combined, then one can address two key issues at once. It is possible to find ways out of this challenge.

Las Gaviotas was the first to demonstrate how to regenerate biodiversity - giving nature a chance. Thanks to the popularization of farming techniques like agro-forestry and permaculture there is a broader understanding of how to invite all five kingdoms of nature to contribute to the productivity of food, nutrition and material cycling. Today we witness the regeneration of biodiversity of the forests of the seas (seaweed curtains and forests) and the forests on land.

4. Energy

> *"In the past half century, global demand for energy multiplied more than five times - over twice as fast as population. Over the next half century, world energy demand is projected to continue expanding well beyond population growth, as developing nations try to catch up with industrial nations." (p. 45)*

There are numerous renewable energies which have been studied, though one remains largely unexploited both in developing and industrial nations alike: biogas from animal and plants waste. We could single out intensive piggeries as a major problem in terms of health hazards, nitrification of ground water, its opportunity for the generation of energy is largely neglected.

For every 1,000 pigs, one generates biogas equivalent to 100 liters of petroleum, or some 36.5 tons of petroleum equivalent per year. Several countries and regions are the home to millions of pigs. These regions can easily convert this waste issue into a major source of energy. In the case of Curitiba, a city proud of its environmental design, there are sufficient pigs to power all the buses in the state with biogas. At present the State is negotiating the construction of a 90 million dollar gas pipeline from Bolivia, it could actually put a pipeline to the piggeries instead.

Pigs are not the only source of biogas, water hyacinth, largely considered a

pest in Africa, is another important potential source largely neglected. One kilogram of water hyacinth is capable of generating one cubic meter of methane gas. Considering that there are millions of tons of decomposing water hyacinth in African, Latin American and Asian lakes, there is a huge potential to harness this form of energy.

The digesters needed to convert this manure and plant pests into an energy source are cheap and easy to install. Designs are available for as little as 20 dollar a unit, but could also cost 2 million dollars for an industrial application in Japan. Benin was the first country to adopt the option of biogas from water hyacinth at the Songhai Centre in Porto Novo. This digester not only provides a great source of energy, but also provides a quality fertilizer. Since water hyacinth recovers all trace minerals and nutrients which washed off into rivers through soil erosion, it provides a chance to reapply to the soil what inadequate agriculture had taken off.

The transportation of numerous small producers of biogas to a central processing is considered the major challenge, but quite possible to solve. Just like a milk truck will collect cows' output each day, so will a tank truck collect biogas generated the previous day. A daily collection and a daily revenue will secure daily maintenance. Unless there is income, there is no maintenance, a problem which was often lead in the past to a lackluster performance of digesters in rural areas.The gas is used in a limited form on the farm, since it would require double energy systems. It is in some circumstances better made available to the public transportation system at a competitive price. Simulating the potential in Latin America and Africa based on piggeries and water hyacinth offers us a real light at the end of the tunnel.

Then we discovered the seaweed forests which produce massive biogas as well. We can supply all energy needs of the USA with only 3.3 million square kilometers while increasing the livelihood of billions of fishes …

5. Fish Catch

> *"From 1950 to 1988, the oceanic fish catch soared from 19 million to 88 million tons, expanding much faster than population. The per capita catch increased from less than 8 kilograms in 1950 to the*

historic peak of 17 kilograms in 1988, more than doubling. Since 1988, however, growth in the catch has slowed, falling behind that of population. Between 1988 and 1997, the catch per person declined to just over 16 kilograms, a drop of some 4 percent." (p. 49)

The Earth's water bodies have a tremendous capacity to produce fish protein. Unfortunately, the fishing method used at high sea and the farming methods on land are largely neglecting the concepts of productivity in a systems context.

A modern fish farm will typically cultivate cat fish (North America) or tilapia, where genetically modified and manipulated native African fish species are hormonically treated in order to secure that no energy and feed is wasted on the production of eggs. This male and/or neutered mix of fish is farmed in shallow ponds, fed with special feed, laced with antibiotics to boost growth as well as fight potential diseases. The polluted water is continuously short of dissolved oxygen, requiring additional input of energy. This program offers not only a questionable result in term of quality of food and limited margins to the farmers, it does not celebrate the potential of local biodiversity.

The integrated fish farming concept, developed in China over the past 400 years permits the use of 4 to 6 local fish species which each feeds on different nutrients at their ideal trophic level. The art of Chinese fish farming is that no one feeds the fish, the system secures feed to the feed of the fish. This offers a highly efficient conversion of inputs into fish protein, reaching up to 15 tons of fish per hectare without having to buy fish feed. Marshlands, often ecologically degraded, offer a first unique opportunity to apply these concepts.

Many agro-industries, which generate both massive amounts of excess water are a second target to give a second use to their residual waters. In addition to their quality water, they often also have nutrients which are of direct interest to fish farming. The piggeries have been discussed before, the breweries fall into the same category but the most attractive may be the milk powder production units, like the ones in Scandinavia where one can even imagine cultivating tropical species using all their wastes, including the dried milk which does not meet the standards for human consumption and are discarded in warm process water sent to the treatment plant.

While we succeeded on the mushroom farming on agrowaste worldwide, we only have isolated examples in China and Brazil where the integrated biosystems have been successfully implemented. It is one of the areas where we have not advanced as we envisaged.

6. Jobs

> *Since mid-century, the world's labor force has more than doubled- from 1.2 billion people to 2.7 billion, outstripping the growth in job creation. As a result, the United Nations International Labour Organization estimates that nearly one billion people, approximately one third of the global working force, are unemployed or underemployed. Over the next half century, the world will need to create more than 1.7 billion jobs just to maintain current levels of employment" (p. 53)*

The challenge of massive job creation is impossible to overcome if one maintains the present production model dominated by core business strategy and productivity of labor and capital only. If one is prepared to apply the basics of economics and pursue as vigorously productivity of raw materials as labor, then a massive shift in the generation of employment can be expected. The ZERI concept leads to believe that it is perfectly possible to generate more jobs, while increasing productivity of raw materials.

The logic has been tested at micro-economic scale. It needs to be developed further at macro level, but the case is clear. If a beer brewer were to use all spent grain to bake bread, more jobs are being generated and sustained with the generation of value added, than if the spent grain were simply shipped off by truck to a landfill or a cattle farm. This bread competes and substitutes bread baking from freshly imported grain, but on the other hand, its overall production especially in Africa and Latin America will be available at lower cost with greater efficiency, thus bread will now be available to people who could not afford the price of imported grain.

How many jobs would be generated when all breweries in Africa were to apply the concept? How many jobs would be generated if all reforestation projects would also foresee the production and bottling of drinking water? How many

additional jobs are feasible if coffee waste is used as substrate for farming? How many people can have work and get paid because social and sustainable housing is guaranteed with local construction materials?

The challenge of 1.7 billion additional jobs is massive, but the opportunities that emerge converting waste and weed into new productive inputs is easily understood.

Since "The Blue Economy" was launched in 2009, ten years after this article, another decade has gone by and just through the initiatives that we monitor an estimated 3 million jobs have been created. We are from from our goal, but we have succeeded in doing better than was expected by everyone else.

7. Infectious Disease

> *"The last half century has witnessed substantial worldwide success in combating many past scourges. The prevailing demographic trends continue to create a crowded human "medium" that both invites and is vulnerable to infection." (p. 57)*

Modern medicine is focusing on killing the bad. As long as medicine has this clearly defined target, it will fail to stem the inroads of infectious diseases. ***Time has come to shift from killing the bad to strengthening the good***. There are few programs which secure that the immune system which suffers from malnutrition, stress, burnout, tainted water, polluted air etc. can be strengthened. One of the problems is our diet. A second problem is the increasing reliance on antibiotics which over time are decreasing the capacity of our immune system to respond.

Our food intake has an insufficient component of immune modulating biochemicals which are found in mushrooms (triterpines, protein-carbohydrates), algae (betacarotene, iodine), vegetable oils (Vitamin E). Our high reliance on animal and fish protein does not offer us access to many of these valuable components. Worse, excessive processing of food and its preservation for long shelf life eliminates healthy and indispensable nutrients which are later added-in again at a premium price. The initiative to cultivate immune system modulating mushroom varieties (*Lentinula edodes*, *Ganoderma lucidum*) on agro-industrial

waste streams provides an opportunity to increase natural substances which could even offer hope to the HIV infected orphans living in colonies in Southern Africa. They have a job, they have a purpose, they have nutrition which is key since the anti-viral drugs in undernourished body have fewer chances to succeed.

A balanced nutrient base enlarged with mushrooms, algae and vegetable oils not only strengthens the system, it is likely to reduce the dependence on antibiotics. One of the disadvantages of a regular use of antibiotics is the reduction and even the elimination of intestinal flora, up to the point that a large number of adults does not have the flora anymore to secure a good digestion. Especially the lack of *bifidus* and *acydophyllus* creates room for proliferation of *E.colli* and *salmonella*, two strains which cannot be completely killed by antibiotics.

The present scheme of providing health care is certainly well-intentioned, but carries with it a series of limitations which need to be overcome if a reversal of the present trends is to be expected.

We are subjecting our body, and the immune system to more and more stress of all types. And while air and water pollution, as well as malnutrition have been clearly described as causes of illnesses, there are numerous additional man-made shifts in living conditions which include radio wave and electromagnetic fields from high tension electric transmission to wireless communications. Science has not yet established cause and effect, but the correlations are increasingly evidenced. That is the reason why we have worked for the past decade on better communication, data transmission and GPS networks that use the infrastructure that is already available. We apply not just the cautionary principle, we point to better solutions!

8. Cropland

> *"Since mid-century, global population has grown much faster than the cropland area. Grain area has increased by some 19 percent, but global population has grown 132 percent, seven times faster. The trend is likely to continue in the next century, dropping cropland per person to historically low levels. In crowded industrial countries such as Japan, Taiwan and Korea, grain area per capita today is smaller than the area of a tennis court." (p.61-62)*

The focus on cropland is limited. It needs to be enlarged to a broader food

production system which goes beyond the mere availability of land. Since crops represent only a fraction of the total biomass, its residues, especially straw, offer unique and proven opportunities for the generation of proteins and nutrients, using the integrated biosystem widely applied in China. The case of some 10 million Chinese farmers teaches us that it is possible to use 10 percent of cropland to generate 60 percent of revenues. Though, the additional revenues would not be created if straw was not available in the first place.

The degradation of cropland through soil erosion is adversely affecting productivity of land. The use of fertilizers does not reverse the trend of decreased productivity. On the contrary, the overuse of non-soluble fertilizers seems to aggravate the situation. There are solutions to this problem. The water hyacinth accompanied by fast growing giant grasses and girasols can secure a recovery of the nutrients. Water hyacinth is an aquatic weed which thrives on water bodies with accumulated nutrients mainly from untreated organic waste or soil erosion. A continuous harvesting, chopping and inoculation of water hyacinth offers the chance to reapply a mixture of the trace minerals and nutrients to the soil, complemented with mycelia and bacteria.

The recovery of degraded land could also be achieved through temporary planting of degraded cropland with bamboo, which has a rich foliage could convert this into an improved soil, while providing construction material for social and sustainable housing. The complementary benefit is that bamboo secures the sequestration of 40 times more carbon dioxide per square meter per annum than a pine tree. This systems approach is likely to offer good results for degraded farm land in the tropics.

A sustainable world will replenish top soil all the time. It is part of the overall strategy from the production of food to the development of renewable chemicals and the treatment of organic solid and liquid waste. The priority is the design of a cycle of production and consumption especially in cities that permit to close this loop that has escaped the present economic model.

9. Forests

"Global losses of forest area have marched in step with population growth for much of human history. Indeed, 75 percent of

the historical growth in global population and an estimated 75 percent of the loss in global forested area occurred in the 20th century. Deforestation is created by demand for forest products tracks closely with rising per capita consumption. Global use of paper and paperboard per person has double since 1961." (p. 65)

If we consider a production system for paper and cardboard which remains centered around cellulose from wood, it is certain to fail to respond to demand, even when the most successful gene manipulation promoting tree growth has been successfully implemented. The use of cellulose from trees is inefficient. Cellulose from sugar cane (bagasse), banana trees and bamboo grows faster and is superior to what can be obtained from trees. The only problem is that those who control the world market for cellulose and the related process technologies have evolved their business over the past 100 years in a temperate climate. The most productive sources of cellulose are found in the tropics.

A bamboo has per square meter per year approximately 40 times more cellulose than a genetically manipulated fast growing pine or eucalyptus tree. It does not make sense to search for sustainable forestry when readily available cellulose is not even considered seriously. Today, bagasse (48% fibers) is incinerated; bamboo, growing up to 25 meters per year is simply not harvested. The availability of 8 millions of hectares of sugar cane, a sector in crisis due to a dwindling demand for sugar (for obvious reasons since it creates plaque on teeth and is therefore substituted by synthetic sweeteners) would offer a new chance for farmers if the same price were paid for bagasse as for eucalyptus fibers (+400 dollars per ton) which exceeds the going market rate for sugar.

Cellulose of giant grasses can be used in large quantities for the production of paper, but one cannot use the same separation technologies which have been developed for soft and hardwood. It does not take an industrial engineer to realize that the giant grasses like sugar cane and bamboo have a fundamentally different structure than trees, and therefore are much better subjected to separation techniques which are appropriate to the tropics and to the grasses.

There are numerous initiatives to use all these biomasses for paper production but unfortunately few have succeeded. The reason is that the majority

opted for the use of same chemical and mechanical separation processes which are used in temperate climate. The provision of paper and cardboard is not a problem on the condition that one is prepared to think in terms of the most efficient provider of the material. If one sticks at all cost to the production of paper using cellulose from pine trees, then one is bound to fail. The only one to gain is the forestry company which will see prices for cellulose rise.

If in addition to the production of the cellulose, other by-products could be extracted from either the tree, the sugar cane or the bamboo, then we are in an ideal situation. The production of lignin is an obvious choice since it is easily obtained and a rich source of energy. Now we can imagine an overall increase of productivity of the system which will make the process more efficient, generate income and jobs.

Stone paper offers an interesting complement to the market, but it does not absorb humidity. Therefore there is a need for more than just re-using waste. Our search for the past decades has always included multiple options and bamboo has emerged as a gift from Nature. The construction of the Bamboo Pavilion at the World Expo 2000 in Germany marked a shift not only for the use of bamboo as a core ingredient for paper but also as a construction material that outperforms any alternative. This is the new era of the vegetable steel.

10. Housing

> *"Over the past half century, the world's housing stock has grown roughly in step with population. Without renewed government commitments to provide housing, this situation stands to worsen, for housing needs worldwide are projected to nearly double over the next 50 years, housing in Africa and the Middle East are expected to increase more than threefold." (p. 69-70)*

If the present housing concept is maintained then indeed demand will be difficult to respond to. Though, if one introduces the concept of "grow your own house", then there is a chance to succeed. Unfortunately housing construction around the world is exceedingly inspired by construction systems which dominate the regions of the world characterized by temperate climate. Unfortunately, these construction systems have served as models for the developing world, leading to an

excessive consumption of steel, glass and cement.

The concept introduced by ZERI offers the chance to build a social and sustainable house using bamboo. Bamboo is widely available, there are over 1,000 species. The design by Colombian architect Simon Velez permits us to offer a cheap, functional and beautiful house of 65 square meters, using no more than 150 bamboos. The growing of one's own house thus requires no more than 75 square meters. The harvesting can be done after 12 months, depending on the type of bamboo used. The preservation of bamboo can be secured with pyrolytic acid from the same bamboo, which is a stimulus to entrepreneurship, and which eliminates (imported) toxic substances against fungus and insects, used to protect tropical materials. Bamboo, and other tropical materials, treated with its own acids is not only beautiful in color, strengthens in structure, it carries a guarantee of over 50 years. The Japanese even offer a one hundred year guarantee.

The shift from steel, cement, asbestos and glass to a building dominated by tropical construction materials which grow rapidly on degraded soils offers a glimpse on how one could respond to the millions of homes without having to spend the money and the energy in non-tropical materials. The experience in Latin America, which is being repeated in Africa provides a good basis. The amount of bamboo needed can easily be supplied as part of recovery programs for degraded and contaminated land.

Bamboo offers a unique option, and this has been deployed throughout the world, generating thousands of jobs.

11. Climate Change

> *"Over the last half century, carbon emissions from fossil fuel burning expanded fourfold, boosting atmospheric concentrations of carbon dioxide by 30 percent over preindustrial levels. The 15 warmest years on record have all occurred since 1979." (p. 73)*

The reversal of the risk of climate change accompanied by intense heat waves, more severe droughts and floods, more destructive storms, more extensive forest fires requires an innovative portfolio of 'productive ways' to massively sequester and/or reuse greenhouse gases.

The recovery of methane gas, 21 times worse than carbon dioxide as a greenhouse gas, through the piggery digesters described before is a first step. Animal husbandry is recognized as the second largest source of methane gas. First, we seem to blame the wrong species. It is in the first place up to the human beings to provide better feed which does not generate such high amount of gas. A lot of waste material from industrial processes such as spent grain, leads to higher gas production. If we change food or include healthy ingredients like seaweeds, then cows and pigs do not have the same amount of methane. Second if gas is produced, we should find ways to capture and use it, giving it value instead of merely letting it evaporate in the air.

The sequestration of carbon dioxide has been debated at length. It resulted in reforestation programs around the world. But when one realizes that giant grasses such as bamboo on land and kelp in the sea, which used to form massive forests in Africa, Asia and Latin America, sequester up to 40 times more carbon dioxide per square meter per annum than trees. One wonders why these fast growing biota have not been the trend. Whenever energy companies announce a reforestation program to offset their excessive emissions, all they can think of is a pine tree and an eucalyptus. One reason may be mere ignorance about nature's biodiversity, thus decision makers are guided by what they know from their own temperate climate. Another reason seems that there is a well known economic use for wood, but that those who live in the parts of the world subject to four seasons are not aware of the massive and long life uses for bamboo fibers, neither of kelp forests.

Brazil is after China and Russia, the third largest consumer of asbestos in the world. Asbestos has not been substituted for synthetic alternatives, as these are more expensive. Since asbestos is widely used in social housing, no political leadership has been found to impose a more expensive roof in return for a healthier living environment. If all asbestos in Brazil were substituted by bamboo fibers, then Brazil would need to forestate and harvest annually a roughly estimated 4 million hectares of bamboo. This would sequester the equivalent of 160 million hectares of fast growing pine forests. If Colombia were to substitute its asbestos - imported from Canada- then it would require thanks to its most efficient *guadua* species, an estimated 100,000 HA, or 4 million HA tree equivalent. China, a bamboo country by excellence would absorb all the carbon dioxide it emits to

respond to the energy needs if this option would be taken.

Bamboo forests used to cover major parts of Asia, Africa and Latin America. When the Spanish colonizers arrived in the South American highlands, they found huge bamboo forests. Actually the regions known today for coffee, once were bamboo covered. Bamboo fibers as a strengthening material in cement have a long economic life, securing that the carbon is not immediately released into the atmosphere. Everyone agrees that asbestos must be eliminated for health reasons, but Latin America, Africa and Asia continue to use this toxic mineral, or its expensive synthetic substitute, then we have a fine opportunity to reverse climate change.

Bamboo is not the only species that can be promoted, but since there are some 1,200 bamboo species of bamboo, one could be identified for nearly each type of climate, except temperate and cold ones. All the key areas of the world were asbestos is used, local species of bamboo available. Perhaps the most attractive element is that bamboo species do not need rich soil and would therefore not compete with agriculture. Steep hills, eroded land, brown fields laced with heavy metals, one can identify the main areas of the world which are of no economic use. Bamboo not only recovers the land through the creation of a new humus cap, it also assists in the recovery of the hydrological cycle, reintroducing ground water which had been debilitated due to top soil and vegetation mismanagement.

None of the goals established in all the possible agreements have been achieved. We refrain from participating in the large meetings and focus on the implementation of projects that are always based on the principle of zero emissions. By 2001, it was decided to release the trademark and have it available for free use by anyone.

12. Materials

> *"In this century, prosperity and one time use of most materials have been strong drivers of materials consumption. In the United States construction materials accounted for 72 percent of total material use in 1995. The environmental damage per ton of material used can sometimes be greater later in the extraction process than it was in the*

early stages." (p. 77-79)

Since the present production and consumption model only uses a small fraction of each of the materials produced by or extracted from the Earth, there is little chance to ever respond to the needs of the people, let alone tackle the massive waste production. When the soluble part of the coffee bush which ends up in a cup of coffee, represents no more than 0.2 percent, it is not a surprise that the coffee farmer has a hard time making ends meet. Farmers are subjected to volatile changes in international market prices. When the long fibers of sisal and fique only represent 2 percent and the rest is wasted, it is no surprise that the synthetic alternative quickly takes over the market. The list of massive generation of waste is long.

The use of bamboo for construction in the tropical highlands offers a very different perspective: a 20 meter long bamboo can be used nearly 100 percent. The main part of the stem -some 9 meters long- is used as (1) a structural building material, (2) the archlike roots are used as a support, (3) the top of the bamboo serves for smaller decorations, (4) the left-over of the stem is to be used as fuel for the immunization process, (5) the leaves are used for mushroom farming, and (6) the twigs also end up in the smoldering fire of the immunization. It has been estimated that wood used in a construction of an American home seldom represents more than 20 percent of the biomass originally generated by the tree. The complete use of material using tropical materials offers a clear view on how the production model of the future will be much better placed to respond to the urgent needs of the people.

The same logic goes for beer, typically produced in urban centers. The spent grain is today shipped off to cattle farmers hundred kilometers away, or simply landfilled or even incinerated. This option is not ideal. One could simply add a bakery to the brewery and then recover all the protein which otherwise would be lost. The book "UpSizing" (Pauli, 1998) offers hundreds of examples how our present inefficient use of materials can be reversed, leading to a new economy where the productive utilization of all components is certain to lead to a fundamental reversal of the present trends.

This crystallized in the core principle: use what you have, and generate value.

13. Urbanization

> *"The world's cities are growing faster than its population. In 1950, 760 million of the world's people lived in cities. By 1998, this had at least tripled, to more than 2.7 billion. The number projected to live in cities by 2050, some 6.2 billion people, exceeds world population today." (p. 81)*

The major reversal to be designed is the reversal of the present rural push towards cities, to first a rural freeze and eventually a return to the rural areas. The present push out of the rural areas is the result of a lack of visible opportunities in the countryside as already small plots of land are divided and then divided again with each passing generation, until they become so small that people can no longer imagine how to make a living for them with the present production model, which only focuses on one materials and discards all the rest as waste. There are few cases which demonstrate that the trend can be reversed.

The average size of a Colombian coffee farm has dropped to 1.6 HA, from some 4.5 HA only 25 years ago. It is hard to survive with a family on such a small plot of land, only cultivating coffee. But, if one can grow mushrooms on the leaves, twigs and cases of coffee, a first and immediate additional revenue stream can be generated. If in addition, one can give value to the bamboos growing along the creeks in the steep hills were no coffee can be farmed, adding value through a simple immunization technique, yet another revenue can be secured. Soil erosion can be combated planting lemongrass along the roots, which is a popular essential oil with a global demand. One member of the family could become an expert in bamboo constructions, another in immunization, another in mushrooms, another one in essential oils and of course one maintains the expertise in coffee. The integrated coffee farm will look quite different from the present fazenda where the farmer has a hard time imagining how to survive. The family is not expanding land, or diversifying into new areas. It is merely using what it has available and what can be put to productive use. Time has come for humankind to become real "*homo sapiens*".

The development of Las Gaviotas in the Colombian Llanos created a

sustainable community of 11,000 HA out of nothing. If the same were achieved in 6 million HA of the Colombian and Venezuelan savanna, which faces the same challenge, then it will be possible to create some 120,000 jobs while massively forestating the region. The development of Northern and Amazon regions of Brazil along the similar principles is not only technically feasible, it has even a strong economic logic to underpin it. If the creation of jobs and value added is sufficiently demonstrated through the sustainable use of all resources, then it will be possible to not only keep people happy in the countryside, it will attract more families to establish a sustainable livelihood, instead of facing a bleak future in overcrowded cities.

The search for ever higher productivity in the State of Para lead to the closure of some 11 wood mills. Since the mills were located in the heart of the forest, it is difficult to imagine alternative job creation to this unsustainable use of an internationally protected natural resources. Though, the reuse of the water hyacinth as a soil replenisher, the harvesting of tropical/medicinal mushrooms, the processing of cultivated mushrooms using parts of the defunct woodmill, offers a clear idea how not only jobs can be created, but more important how it is possible to secure a recovery of the environment which has suffered from human intrusion.

While this approach is not feasible overnight, and may take decades to proof its viability as in the case of Las Gaviotas, it are these pioneering efforts that permits new vision to emerge.

This is why the new projects like El Hierro discuss the power of re-ruralization, instead of studying urbanization and the effects of life and communities. There is a need to strengthen the livelihood of the rural communities.

14. Protected Natural Areas

> *"Population growth during the past 50 years has made it difficult to set aside and conserve natural areas. Another half-century of growth will put even more pressure on protected areas as formerly small, distant settlements encroach on these sites and as the number of people who use the sites explodes." (p. 85)*

The main setback of protected natural areas is that these have been closed to human activity. Worse, the only economic initiative that has been permitted is the introduction of tourism, which in many cases offers the highest and fastest economic returns, but on the other hand has a negative impact as well.

The sustainable economic use of protected natural areas is a necessity. Whereas the omnipresence of man is not to be promoted, selective and well targeted activities can be undertaken which are designed to secure the long term viability of these areas. The Natural Park of the Sierra Nevada of Santa Martha, home of the highest coastal mountain range in the world, which rises some 5,900 meters from the seashore, is home to one of the wealthiest biodiversities on the globe thanks to its multiple microclimates. It is also home to the Lost City. Though, the park and the archeological sites are closed to the public. While security reasons related to the illicit drugs has to be recognized, it is on the other hand the home of a unique collection of orchids which could be propagated and sold at very high premium prices on international markets. It is also home of medicinal mushrooms which can be harvested without any risk of damage to the environment.

Outstanding initiatives of UNESCO related to the Man and Biosphere and the World Cultural Heritage offers an insight in both the problems that are created as well as the opportunities which are missed. There should be no doubt, the mere preservation of these areas does not offer a guarantee for its survival. A targeted strategy for sustainable economic activities can relieve the pressure through the generation of revenues, while providing the funds for a real preservation of the areas.

We evolved from protecting to regenerating nature reserves, designing ways to put Nature back on its evolutionary path.

15. Education

> *"The global need for teachers and classrooms will rise very slowly in the next quarter century, and decline thereafter. At the global level, total population is projected to increase by 47 percent between 2000 and 2050, but the number of children under the age of 15 will actually decline by about 3 percent." (p. 89)*

The teaching methods today are clearly insufficient to equip people with the tools to become self-sufficient in their daily needs. The educational system which "exposes but does not impose", which "reaches but not teaches" as applied by the ZERI Foundation (and others) offers a chance to reverse the present trends leading to insufficiency of self-reliance. The exercise at the Montfort Boys Town in Fiji indicates that when children not only learn a profession, but also acquire the capacity to provide their own food and energy after graduating and returning to any of the 600 inhabited islands of Fiji, that there is a chance for them to find comfort and quality of life in their remote areas on the globe.

The same approach has recently been introduced in the HIV infected orphan colonies in Mutare, Zimbabwe. The strategy to secure that people do not only graduate with a degree, learn how to read and write, but also acquire the capacity to provide themselves with food, water, health care and even shelter, also in the most adverse conditions, is probably one of the best remedies against poverty and one of the best contributions of education to local communities that can be imagined.

The education program has emerged as an amazing exercise in developing a new pedagogy which in the mean time has been adopted in China. There, all fables are distributed to all schools, and the books are recognized by the Alibaba Foundation is the best Nature Books of the country.

16. Waste

"Data for waste generation in the developing world are scarce, but citizens in many of these countries are estimated to produce roughly half a kilo of municipal waste each day. If this figure is applied to today's population, a total of 824 million tons of municipal waste is being churned out annually in developing countries. Population growth alone would boost this number to 1.4 billion tons by 2050. But a developing world generating as much waste per capita as industrial countries do today would be producing some 3.4 billion tons of municipal waste by 2050." (p. 93-95)

The conversion of old defunct cement plants as is undertaken is Stockholm, Sweden and is being planned in Colombia and Brazil offers the chance to

fundamentally rethink the waste problem. On one hand defunct factories which symbolize social and environmental disasters are capable of converting themselves into engines for local development, while they return to agriculture and forestry which was taken off fertile land in the first place. The cement-turned-compost factory will also secure that there is no leaching, that the excess carbon dioxide is fully recovered and that CO_2, and heat can be put to use for year round farming of salads and tomatoes at competitive prices.

Since most cement factories are fully equipped with silos and boat docks, the cumbersome transportation by truck can be drastically reduced, while the cost of production of compost can be slashed to the point that is can compete perfectly with synthetic fertilizer. With a production of 500 to 1,000 Tons per day, the link between urban and rural areas is not only secured, but also economically beneficial. The problem is not production, but rather the challenge to find buyers in the market.

The program initiated by Bedminster in Sweden and further developed by Taiheiyo Cement in Japan offers an insight in the potential provided by solid municipal waste, and identifies which waste issues need to be tackled in priority. It is clear that there no immediate and complete solution, but the accumulation for example of human organic waste in diapers, permit a search for a compostable plastic solution. It just does not make sense that human organic matter is "wasted" in non-compostable plastics with a half life of several years. Just a few months after the composting program of Bedminster was initiated in Stockholm, a group of entrepreneurs launched a compostable diaper which immediately received enthusiastic response from the market since everyone agrees that since the content is to be natural and its use is limited to a few hours, it does not make sense to package this in three different plastics which not only contaminate, it make composting of its content impossible.

The combination of sectors in order to ensure a conversion of waste in a resource has been implemented in various constellations: cement and composting of the organic component of solid municipal waste (SMW) was complemented by the blending of slurry from waste water treatment plants with SMW to generate gas in such a volume that the monies earned cover all the expenses of waste water treatment while cutting waste to landfill by half.

17. Conflict

> *"Throughout history population growth has worked in tandem with socioeconomic and political disruptions to drive unstable situations over the edge. Population growth makes things more precarious." (p. 97)*

ZERI is working actively in one of the most violent societies in the world: Colombia. While the country is in clear social, economic and environmental crisis, it is also the nation where most efforts are undertaken to translate the present inefficient economic model into a production and consumption system from which the world could learn. Las Gaviotas in Vichada is not only operating in an environmentally highly degraded area, it is hostile to its inhabitants especially due to the lack of quality drinking water, which is responsible for 70% of all diseases. It is also the area where guerrilla and paramilitary are most active.

Still it is exactly there that a new self-sustainable society is emerging. One that is based on transportation by bicycle. If one were to use a car, the guerrilla would take the car at gunpoint, and if the guerrilla does not take the car at gunpoint, then the paramilitary is convinced one collaborates with the guerrilla, and may simply murder you. The bicycle is thus a symbol for a non-violent society since neither the guerrilla nor the paramilitary are interested in riding bikes.

The Colombian highlands have remained an island of peace. But with a drop in coffee prices by an estimated 17 percent, and an increasing pressure on land use due to population explosion, there is a lingering danger that the regions which have remained stable could fall to insurgency. It is therefore that a special effort is undertaken in parallel: one in Vichada were violence is already rampant, and one in areas which hopefully will never fall to aggression. The determining factor is simple: respond to the urgent needs of the people in terms of food, water, health care, shelter and jobs.

The ZERI programs include an innovative way to ensure conflict resolution. This has been published on the Blue Economy website.

18. Meat production

> *"World meat production increased from 44 million tons in 1950 to 216 million tons in 1998, expanding almost twice as fast as population. Total meat consumption would be pushed from 216 million tons to 481 million tons in 2050, a gain of 265 million tons. If we assume an average of 3 kg of grain per kilogram of meat produced, this would require nearly 800 million tons of additional grain feed in 2050, an amount equal to half current world grain consumption." (p. 102-104)*

The focus on a simple conversion of vegetable into animal protein is the major bottleneck. There is a third source of protein which remains totally unused: mushroom protein. It is quite difficult to understand how it has been possible that the world has refrained from paying attention to this rich resource of nutrients, minerals and vitamins. After having farmed mushrooms on coffee waste, or rice straw, cellulose which is otherwise difficult to digest has been broken down, and the substrate is enriched with protein. Mycelium contains up to 38% protein, thus permitting direct consumption by cattle (when no wood is included), or indirect use (based on wood substrates) through the cultivation of earthworms, which are rich in protein.

Agriculture is discarding millions of tons of straw, husks, pellets, and there are massive resources in nature which are considered weeds such as water hyacinth, bamboo and rattan (which cannot be fed directly to cattle). All this can be converted to cattle feed through a fungal treatment. The potential is quite impressive, the technique is quite simple. The conversion could be complete in a few weeks time in a tropical climate. If one wishes to remain with a mushroom diet, the fruiting would be feasible in less than one month of inoculation. This is offering one of the most efficient generators of feed and food, with a unique capacity to adjust to consumer preferences in terms of vegetarian and non-vegetarian diets.

This process does require a conversion of the production model, but it offers a chance to secure a minimum supply of animal protein to perhaps even billions who have no access to protein from any source today. Whereas it does not make sense from a health point of view to merely convert vegetable and fungal protein to

animal protein, it at least offers us one more light at the end of the tunnel that it is possible to respond to the needs of this critical mass of people.

The programs for food expand the portfolio from plants or animals, to include fungi and algae. This is also inspired by the fact that the speed to pass from seed to food is much faster than a plant or animal could ever imagine. In terms of capacity to produce nutrition, algae and mushrooms offer a multiple. This offers a perspective on food systems that could one day eliminate hunger.

19. Income

"Global economic output, the total of all goods and services produced, grew from 6 trillion in 1950 to 39 trillion in 1998, expanding nearly three times faster than population. The growth in output from 1990 to 1998 exceeded growth during the 10,000 years from the beginning of agriculture until 1950. If the economy were to expand only enough to cover population growth until 2050, it would need to grow to 59 trillion. If the economy were to continue to expand at 3 percent per year, global economic output would reach 183 trillion in the year 2050." (p. 105-108)

The economy has been growing at a near record pace. The bad news is that the economy, as now structured, is outgrowing the Earth's ecosystem. This is because we have a production and consumption model which is linear, focused on core businesses, which totally neglect the need for material productivity, both at production and consumption level.

If the economic model is finally making full use of all raw materials, and is completely cascading the potential generation of energy, then the economy will be able to respond to this dramatic population explosion which we have to face anyway. Paradoxically, the only industry which is making nearly 100 percent use of its crude material as supplied by the Earth is the petroleum and petrochemical industry. The largest non-renewable industry dominates the world economy, deriving some 100,000 products from one singly crude source. It is making one of the most efficient uses of its available resource globally.

If all processing industries would crack raw materials with the same efficiency as the petroleum industry, then we would have a huge revolution in

productivity, supplying more goods and services ever possible to imagine, while at the same time creating the millions of jobs (thus revenues), making it possible to respond to the massive unmet demand as is evidenced in the nearly billion people surviving in absolute poverty. It is this productivity increase that will generate the revenues which will permit the poor to buy the products these *biorefineries* will produce.

The first biorefineries were imagined in the 1990s and by now these have been implemented. These projects with investments running in the 100s of millions demonstrate an appetite to invest in new production models that offer income for farmers beyond the world market price offered. This will finally offer a reversal of the trend that farmers, fishermen and miners are the most poorly paid while they have to be the custodians of our ecosystems.

20. Conclusion

The present economic model is incapable of responding to the world population's needs because it simply does not apply its own theory. A singular focus on productivity of labor and capital, while squandering massively and myopically natural resources is difficult to understand. Economists and management executives demonstrate an advanced state of "*Homo non sapiens*", people who just do not seem to know how to respond to the needs of people with available resources.

The change in the structure of production and consumption is the biggest challenge. This is nothing less than a redesign of the economy, a true challenge of re-engineering. The production of additional goods and services must go hand in hand with the creation of value added, which leads to the generation of income, and jobs. Since there is massive unemployment, and since there are unparalleled unsatisfied needs, the world has a unique opportunity to design and evolve towards a production system which is capable of responding to the needs of the people. The concept of the biorefinery as promoted by Prof. Dr. Carl-Göran Hedén is central in this conversion of the economic model.

It is clear that we cannot rely on a central body, an intelligent brain that is capable of envisioning this for each and everyone, all around the world. The production model that needs to be installed has to evolve along simple principles of nature: "**everything and anything which lives creates waste, but no waste is wasted**". Whatever is of no use to one, is an input to another, and as such the

system regenerates thanks to the permanent input of sun energy. This offers the core conditions which permit alleviating poverty at first, and generating quality of life afterwards.

The rapid and successful implementation of this new production and consumption model depends in the first place of a pervasive decentralization of production, distribution and decision making. If the model of nature is emulated, then innumerous inefficiencies which are embedded in the present centralized system will be eliminated. Local jobs and income will be generated, and the massive waste problems which dominate concentrations of people will gradually evaporate.

The focus on total productivity (labor, capital and raw materials) permits us to imagine an economy which generates more jobs, more income, more products while reducing waste to nil. This is the socioeconomic model of the 21st century. It implies no revolution in economic theory, it merely expects the application of what Adam Smith (Smith 1776) envisioned so clearly over two centuries ago.

It is now that we finally have the chance to rethink and design an economy to contributed to the Common Good.

References

Brown, Lester and Gary Gardner. *Beyond Malthus : Nineteen Dimensions of the Population Challenge*. Norton Press, New York, USA, 1999, 168 p.

Pauli, Gunter. *UpSizing: the road to zero emissions - more income, more jobs and zero pollution*. Greenleaf Publications, London, UK, 1998, 224 p.

Smith, Adam. *The Wealth of Nations*. 1776

Gunter Pauli (1956) is trained as economist. He worked for five years with Dr. Aurelio Peccei, founder of the Club of Rome and was the publisher of the State of the World Report, the flagship publication of the Worldwatch Institute for several years in multiple European languages. He organized presentations for Lester Brown to national parliaments in Europe, and the European Parliament and was instrumental in the set-up of the Worldwatch Institute Europe. He is author of +20books which have been published in +40 languages. His books demonstrate a permanent and creative search for a new production model which permits to respond to the needs of people, especially in developing countries.

for further information

www.zeri.org
www.TheBlueEconomy.org
www.gunterpauli.com
www.TheFableShop.com

@MyBlueEconomy