SCIENCE AND TECHNOLOGY – THE GRAND DISRUPTORS AND SOLUTION PROVIDERS

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ABSTRACT

The role of science and technology as one of the most important pillars of sustainable development has been analysed within the new FLOGEN sustainability framework. Many distant and recent historical examples have been considered to make the point that science and technology are grand disruptors of boundaries, borders, and ways of life, and they have opened society's eyes to new serious problems and realities. The paper points out that science and technology are well credited for this great diagnostic role, but have been frequently ignored for their role as solution producers. Numerous examples illustrate the fact that usually solutions are sought far from science and technology, or without their close cooperation, and this has been in fact the cause of failures. It is shown that science and technology are grand solution providers, and this is clear from the distant, recent, and current realities, where they have proven wrong all non-scientific solutions or doomsday predictions. It is concluded that no sound long term solution can be found when science and technology are not considered as a solution provider and as the pillar at the forefront of sustainable development, and this is even more so valid for the acute problems faced by the world today.

INTRODUCTION

In previous articles [1-3], the role of science and technology on sustainable development has been analysed in various aspects in the framework of FLOGEN's newly defined sustainability framework [1]. Within this framework, the focus of this paper is the role of science and technology as both a grand disruptor, as well as a grand solution provider at the same time.

The position of science and technology in the sustainability framework, as detailed in the previous publication [1], is only briefly described here for the sake of clarity. Figure 1 gives the sustainability framework as defined by the author [1]. This framework definition summarizes the sustainable development criteria and sustainability development actors, and makes clear distinctions between the two.

Sustainable development consists of a set of 3 **criteria** that have to be achieved simultaneously:

- Environmental protection
- Economic development
- Social development

The sustainable development **actors** are those who, with their actions, facilitate or undermine the process of simultaneously achieving the 3 aforementioned sustainable development criteria. Alternatively, these can be named as the "pillars" of sustainability. They are:

- Science, Technology, and Industrial Practice
- Governance (executive, legislative, judicial) and Management
- Education and Civil Society

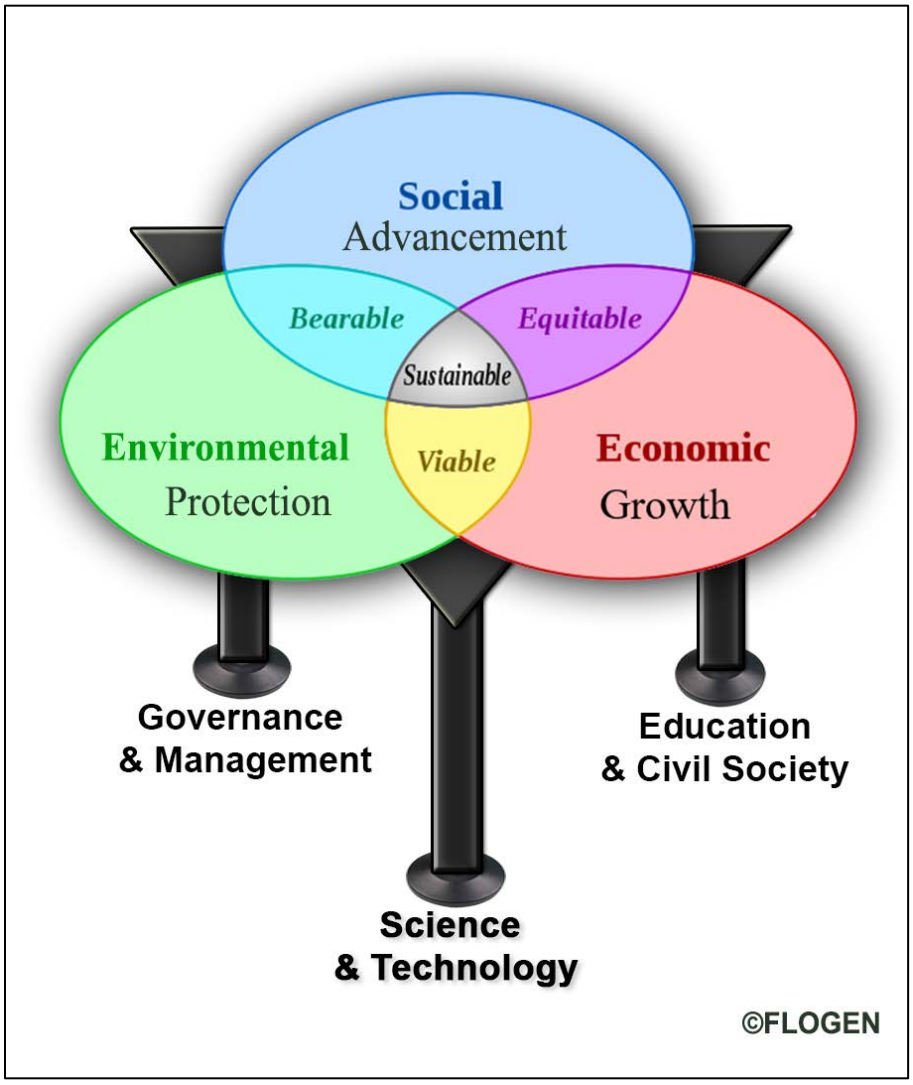


Figure 1 - Sustainability Framework as defined by FLOGEN [1]

The advantages of this new simple sustainability framework are multiple:

1) It clarifies the existing confusion about sustainability where the criteria, actors, and goals have been unsystematically mixed without clear distinctions.
2) It is compact, but also general enough, since any other aspects fall within one criteria or one actor/pillar.
3) It determines the 3 equally important pillars of sustainability, putting science and technology at the forefront of priorities to achieving short and long-term sustainability.

Within this sustainability framework, the role of science and technology will be described here from the viewpoint of being both a major disruptor and a solution provider. This is because the science and technology, although a very important forefront pillar of sustainability, has not been given the right importance by the society, politics and governance.

SCIENCE AND TECHNOLOGY - THE GRAND DISRUPTORS ….

Among many issues the world is facing today, there are two that have attracted most attention: (1) CO_2 emissions increasing the average surface temperature of the planet, resulting in global warming and/or climate change, and (2) the world population is increasing with such a rate that it will make it impossible to have enough food and water for it.

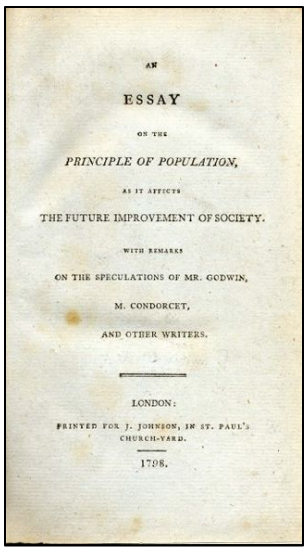
These conclusions are based on scientific research carried out around the world. As such, science served as a disruptor of our normal way of living, opening our eyes to the dangers the world faces. Science gets a lot of credit on this. However, solutions are usually sought on political, cultural, and management domains, and science is among the last in importance.

Let's have a look at recent history to enlighten us and to demonstrate that the approach above is wrong.

Malthus

About 250 years ago, in 1798, Thomas Robert Malthus wrote a book entitled "An Essay on the Principle of Population as it Affects the Future Improvement of the Society" [4]. This became a very influential book, and it was published in 6 improved editions from the date of its first publication until 1826. Two supplementary publications followed; an article in 1823 on Population to the supplement of the Encyclopedia Britannica, and a long extract from the 1823 article, were reprinted in 1830 as "A summary view of the Principle of Population".

In the book, using his own mathematical exponential growth models, Malthus predicted that the population would increase exponentially, essentially doubling every 25 years while the food production would only grow arithmetically, which would result in famine and starvation unless births were controlled. The predictions of his scientific model were not entirely wrong. Although the world population has remained below his predicted value, since 1955 the population has increased at a rate of over two billion per 25 years, more than twice of Malthus' predicted maximum rate. In other words, his science was a grand disruptor for the time and it was not wrong.


AN

ESSAY

ON THE

PRINCIPLE OF POPULATION,

AS IT AFFECTS

THE FUTURE IMPROVEMENT OF SOCIETY.

WITH REMARKS

ON THE SPECULATIONS OF MR. GODWIN,

M. CONDORCET,

AND OTHER WRITERS.

LONDON:

PRINTED FOR J. JOHNSON, IN ST. PAUL'S CHURCH-YARD.

1798.

Figure 2 - Book Cover of Malthus (1798 edition)

However, strangely enough, as a scientist he proposed solutions that were anything but scientific solutions. He found the solution in the political, management, and war domains. He proposed two types of solutions to hold populations within resource limits: *positive checks*, which would raise the death rate using hunger, disease, and war; and *preventative ones*, which would lower the birth rate by using abortion, birth control, prostitution, postponement of marriage, and celibacy.

The question is: Why hasn't the general famine predicted by Malthus occurred in the last 250 years since his prediction?

Paddock

About 50 years ago, in 1967, William and Paul Paddock published the book "Famine 1975! America's Decision: Who will Survive" [5], which became quickly a bestseller. In the book, the Paddock brothers used scientific models to conclude that the population will increase much faster than the limited earth resources available, and forecasted that it would be impossible to feed the entire global population within the short-term future, and a widespread famine would be the inevitable by 1975. His scientific prediction on population growth based on mathematical models was not wrong. The world population increased by more than 2 billion in the 25 years since the last half of the 20th century. As a result, his science was a grand disruptor for the time, and it was not wrong.

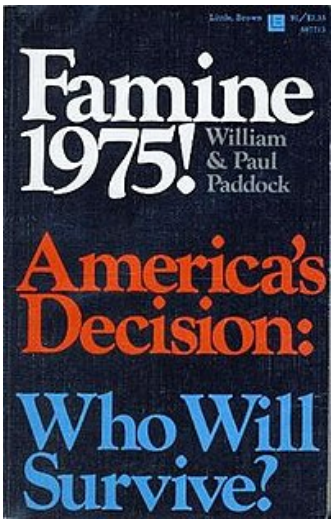


Figure 3 - Book Cover of William and Paul Paddock (1967 edition)

However, the solutions they proposed were in the political arena, and far from scientific domains. He proposes a "triage" system that would leave hopeless countries like India and Egypt to perish so that the others can survive.

The question is: Why didn't the widespread famine forecasted by the Paddock brothers happen in 1975, or even now, about 50 years after his book?

Ehrlich

In 1968, Paul R. Ehrlich, a Professor at Stanford University, published the book: "Population Bomb: Population Control or Race to Oblivion" [6] which also very quickly became a bestseller. The book sold over two million copies and raised the general awareness of population and environmental issues, and influenced 1960s and 1970s public policy.

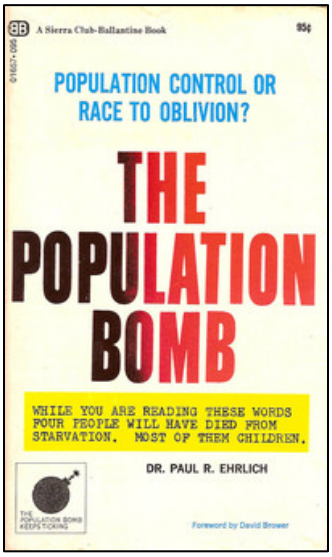


Figure 4 - Book Cover of Paul R. Ehrlich (1968 edition)

In his book, Ehrlich observes that the population of the world since 1930 had doubled from about 2 billion to nearly 4 billion within a single generation. Using mathematical models, he predicted the same dynamic magnitude in the future, while available resources, particularly food, were nearly at their limits. As a consequence, in the beginning of the book he states:

"The battle to feed all of humanity is over. In the 1970s hundreds of millions of people will starve to death in spite of any crash programs embarked upon now. At this late date, nothing can prevent a substantial increase in the world death rate".

His scientific prediction based on mathematical models on population was not wrong. The world population increased by more than 2 billion in 25 years since the last half of the 20th century. As a result, his science was a grand disruptor for the time and it was not wrong.

However, the solutions he proposed were also in the political arena and far from scientific domains. In order to keep the population under control, he proposes a tax scheme for families, which is higher for higher number of children and high luxury taxes on childcare goods. He proposes tax incentives for men who agree to permanent sterilization before they have two children. He proposes a powerful Department of Population and Environment, which "should put an end to the steady deterioration of environment by supporting research into contraceptives, mass sterilizing agents, and prenatal sex discernment, and put forward legislation that guarantees the right to abortion and sex education."

He also supported the "triage" system developed by the Paddock brothers, that will leave "hopeless" countries like India and Egypt to perish so the others can survive.

The question is: Why have millions of people not starved as Ehrlich forecasted in 1970s or 1980s, or even now, about 50 years after his book?

The Club of Rome

About 50 years ago, in 1972, the Club of Rome commissioned and published a report funded by Volkswagen Foundation entitled: "The Limits to Growth" [7]. This became an influential book that sold about 30 million copies in 30 languages.

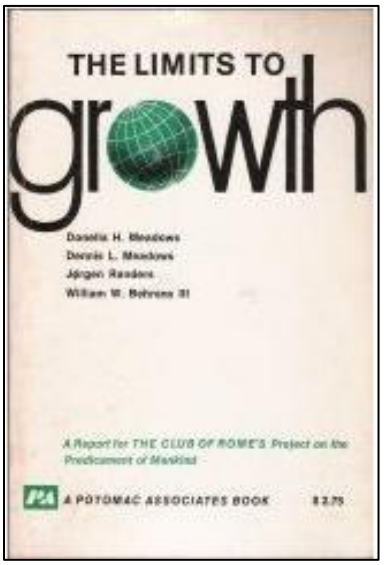


Figure 5 - Book Cover of Club of Rome (1972 edition)

The authors of the report used a computer model to analyze global resource consumption and production. The model had five variables: population, food necessity, industrialization, pollution, and consumption of non-renewable natural resources. The study concluded that all these variables were increasing, and will continue to grow exponentially, while the ability of technology to increase resources grew only linearly. They predicted resource depletion and associated economic collapse by the end of the 20th century or by the middle of the 21st century.

The scientific conclusion that all variables—population, food necessity, industrialization, pollution, and consumption of renewable resources—would increase exponentially was not wrong. As a result, the science behind the model was a grand disruptor for the time. Again, the solution proposed by the author was grounded in the political arena, and far from scientific domains. They mainly suggested government and political actions to limit the growth of the economy as per the available resources.

The question is: Why didn't the resource depletion and associated economic collapse materialize by the end of the 20th century as predicted, and will be unlikely to materialize in the middle of 21st century?

Gerald O. Barney / Jimmy Carter

In 1977, US President Jimmy Carter commissioned the report entitled: "The Global 2000 Report to the President" [8] that was published in 1980. The report was authored by Gerald O. Barney who directed the study and had a Foreword by Jimmy Carter. It was sold 1.5 million copies in 9 languages.

The report was based on the best data available on population, energy, agriculture, forestry, economy, minerals, non-fuel minerals, water, etc. from 14 participating government agencies as well as the World Bank. It used computer models to make projections and reach conclusions.

The main conclusion of the report was: "If present trends continue, the world in 2000 will be more crowded, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today".

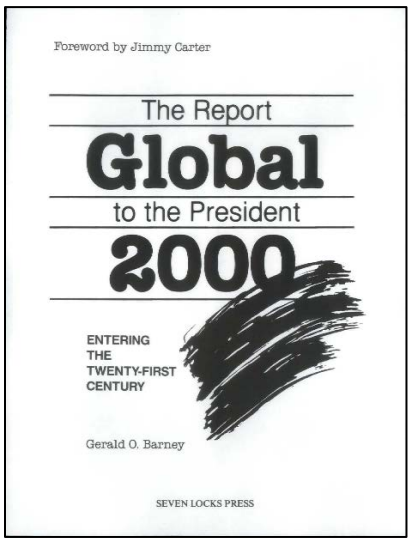


Figure 6 - Book Cover of Gerald O. Barney / Jimmy Carter (1980 edition)

In this report, the solutions proposed also emphasize a political perspective, rather than a scientific one. It is interesting to note that Global 2000 report does not refute or contradict the conclusions of Limits to Growth report by Club of Rome, mentioned above.

The question is: Why didn't the prediction that the people of the world will be poorer in 2000 compared to 1980 come true? Why was the world no more vulnerable and disrupted in 2000 than in the 1980 as predicted?

…. AND THE GRAND SOLUTION PROVIDERS

All the studies above use mathematical models to diagnose the problem – the considerable increase of the population with time. The models' conclusions on population growth are more or less correct. The population has grown considerably, especially starting from the second half of the 20th century, as shown in Figure 2.

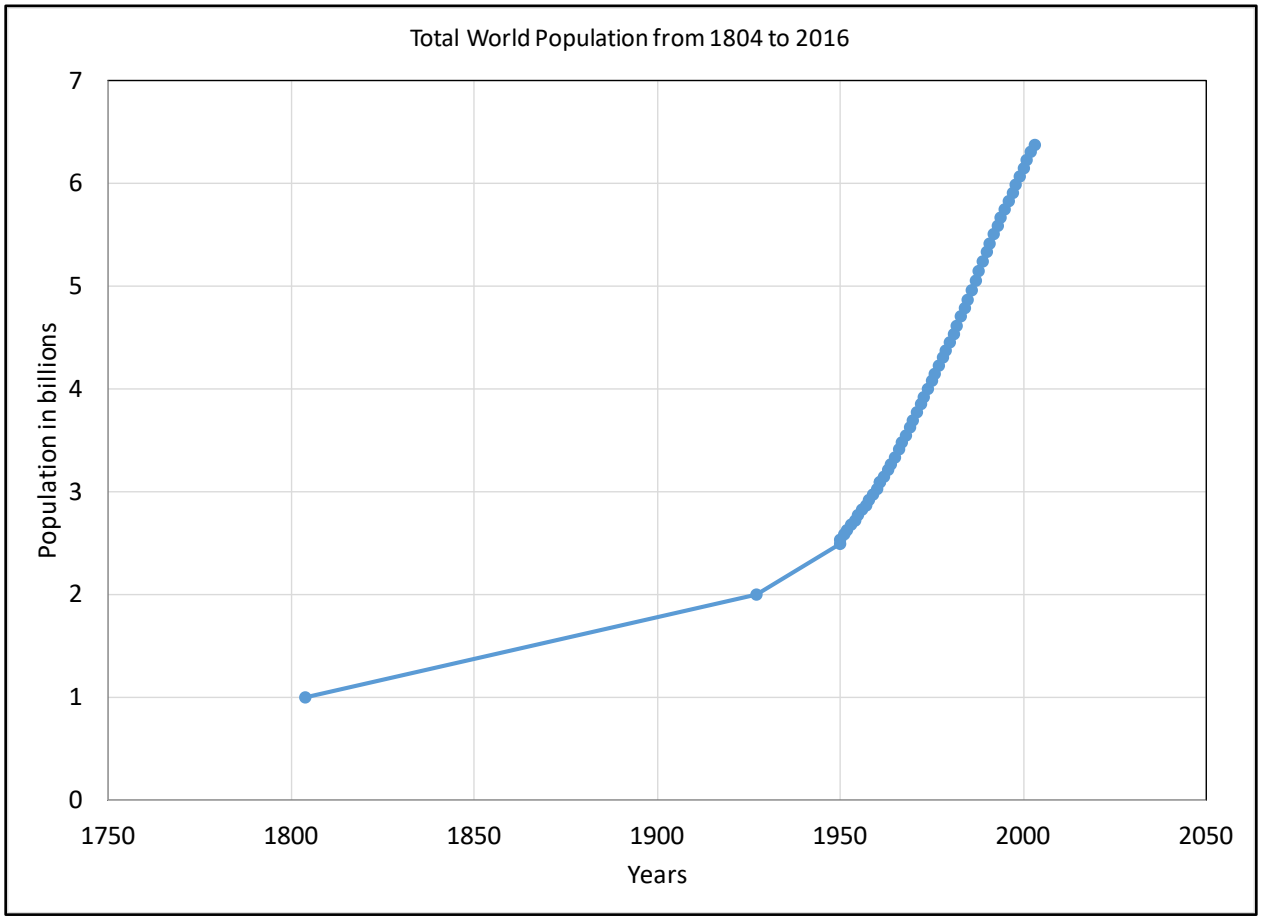


Figure 7 - World population growth during the period 1804 to 2016
based on data from The UN World Population Prospect 2017 [13]

What did not materialize were the critical problems forecasted in these studies related to extreme population growth—and this is because science and technology provided the solutions to those problems. The issue in the aforementioned studies was the fact that paradoxically, science and technology were correctly used to diagnose, but were not used to find solutions. Despite the fact that the scientific data analysis and models were generally true, the solutions were sought in the political arena, and not at the level of science or technology or in cooperation with them.

In the midst of the panic and predictions on doomsday scenarios due to food and water shortages, the "Green Revolution" quietly solved the issue of food shortage with scientific and technological means. The Green Revolution was a series of research & development, and technology transfer initiatives that increased agricultural production worldwide, particularly in the developing world [9]. The new technologies made it possible to develop high-yielding varieties of cereal grains, expand irrigation infrastructure, modernize management techniques, and distribute hybridized seeds, synthetic fertilizers, and pesticides to farmers [10]. This started in the late 1960s under the leadership of Norman Borlaug, with the strong support of the Ford Foundation and the

Rockefeller Foundation [11], and following and expanding on the previous work of agrarian geneticist Nazareno Strampelli during the 1920s and 1930s. In 1968, Prof. Swaminathan adapted the work of Norman Borlaug in India, and caused the country's wheat harvest to soar from 12 to 17 million tons. Norman Borlaug, who became known as the "Father of the Green Revolution", won the Nobel Peace Prize in 1970, and was credited with saving over a billion people from starvation. With the help of scientific innovations, India exceeded expectations of its demise, and defeated popular perceptions of the time—such as those of the Paddock brothers—that it was a "hopeless" state.

As it stands today, scientific breakthroughs on better scientific farming practices and the development of genetically modified crops (GMO) have made it possible to significantly increase the production of crops compared to the increase of the population in the world, while simultaneously increasing life expectancy.

The UN Food and Agricultural Organization has meaningful statistics for the above. Table 1 shows the increase of worldwide production of food items from 1961 to 2016, as well as the world population and life expectancy for the same period. Figure 3 shows the increase in % of the same values. It is evident that due to role of science and technology, the food items production for this period has increased by 237% to 414%, while the world population has increased by about 139% and life expectancy by 43%.

It can be easily said that science and technology were ignored as a solution provider for about 250 years, particularly in the mid- 20th century. However, it was science and technology that triumphed over all political doomsday forecasts, and theoreticians that used science successfully as a diagnostic tool but ignored it as a solution provider. Science and technology saved the world from famine and the major social disturbances that would have been created from it.

	World Production (tons)		Increase %
Food Type/Year	1961	2016	
Cereals	1,352,700	6,947,712	414
Fruit, fresh	6,569,445	33,252,906	406
Maize	205,027,583	1,060,107,470	417
Rice	215,646,633	740,961,445	244
Roots & Tubers	2,397,785	10,455,162	336
Sugar Cane	447,977,522	1,890,661,751	322
Vegetable,fresh	62,307,653	290,130,864	366
Wheat	222,357,231	749,460,077	237
	World Population (persons)		
Total	3,090,305,279	7,383,008,820	139
More developed regions	927,484,926	1,253,206,546	35
Less developed regions	2,162,820,353	6,129,802,274	183
	Life Expectancy (years)		
Total	49.34	70.79	43
More developed regions	67.72	78.43	16
Less developed regions	44.06	69.10	57

Table 1 - Increase of food production from 1961 to 2016 based on data from The UN Food and Agricultural Organization [12], and World Population & Life Expectancy for the same period based on data from The UN World Population Prospect 2017 [13]

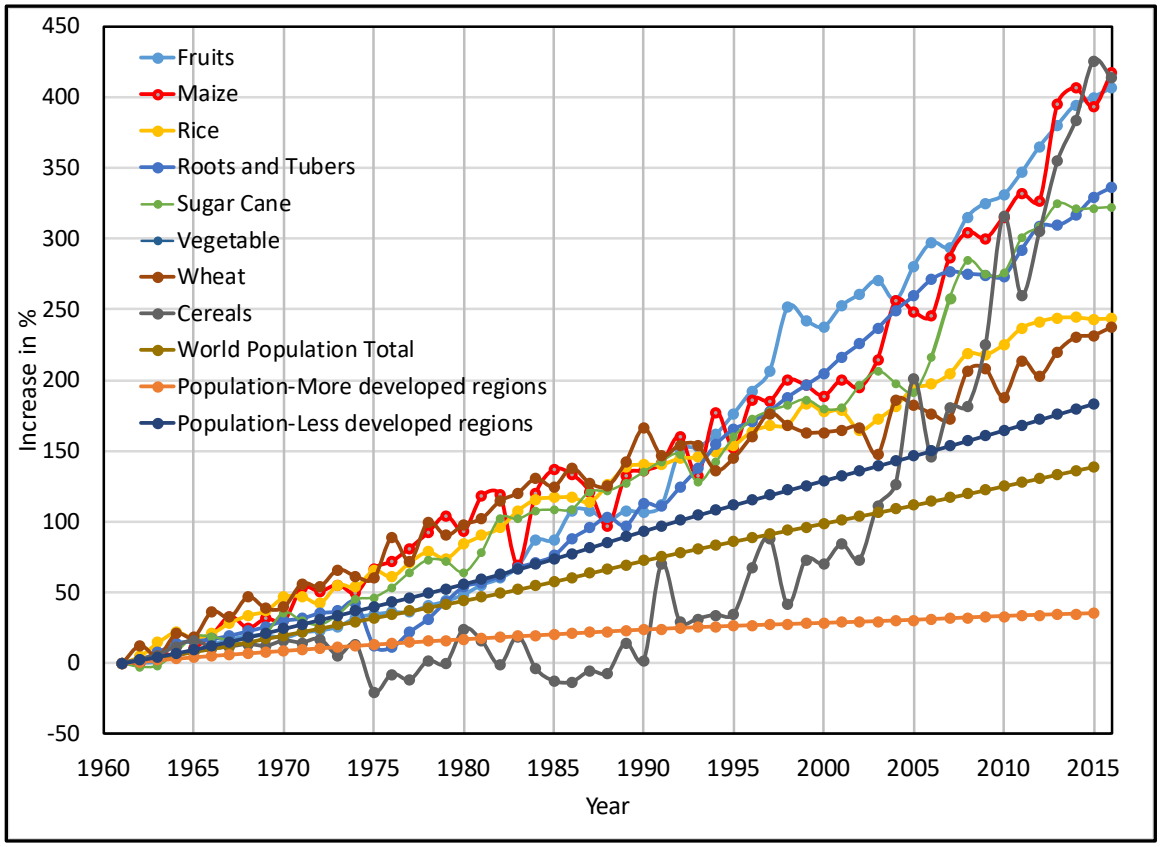


Figure 8 - Increase in % of food production from 1961 to 2016 based on data from The UN Food and Agricultural Organization [12] and World Population for the same period based on data from The UN World Population Prospect 2017 [13]

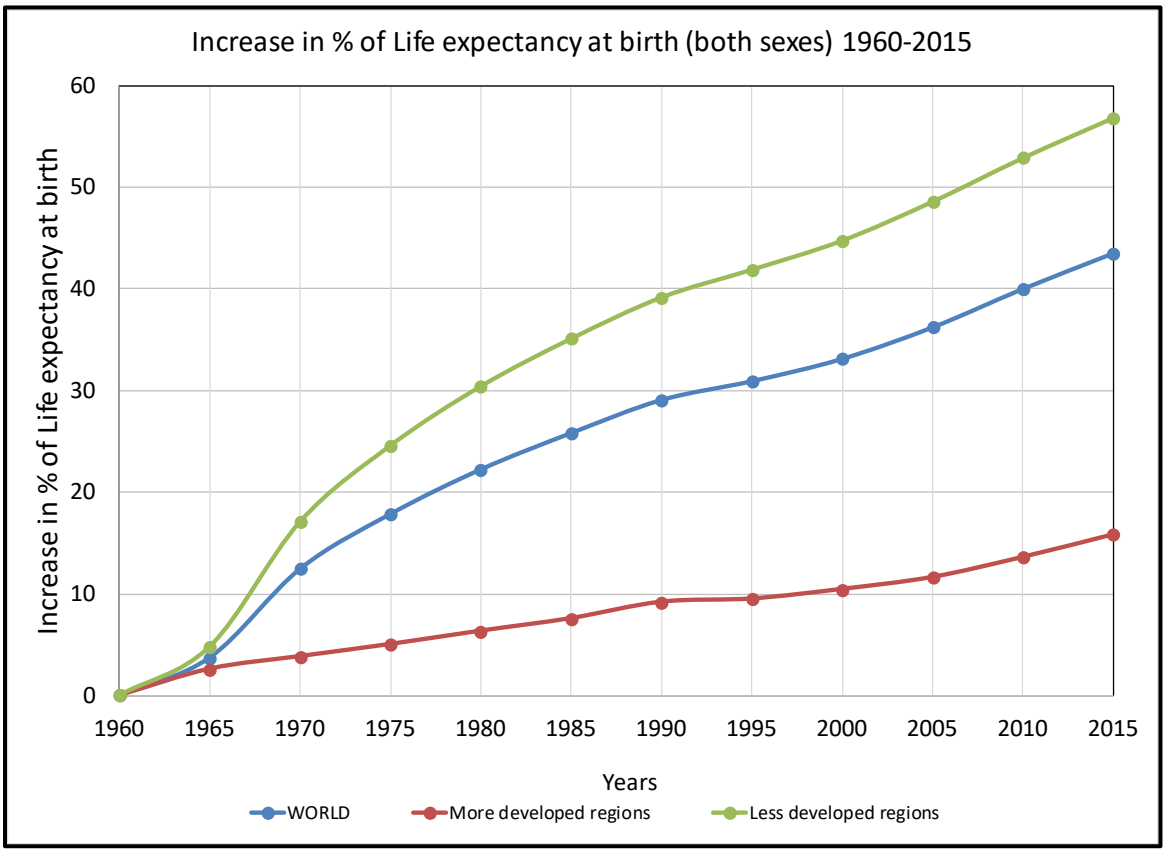


Figure 9 - Increase in % of Life Expectancy from 1961 to 2016 based on data The UN World Population Prospect 2017 [13]

RECENT REALITY

Currently, the world faces very similar problems related to resource scarcity and global warming or climate change. The similarities and/or the problems, and the way the solutions are searched for, are striking. Global warming is based on scientific research from multiple scientists around the world, a research that concluded that the surface of the world is warming and humans have a role in it. However, the solutions, even today, are mainly searched in the political area rather than in science and technology. It seems that the lessons are not learned from the past. If CO_2 emitted from industrial activity is the cause of global warming, the solution lies in science and technology development. Either eliminate the emissions of CO^2 by developing new sustainable technologies that do not use carbon, or develop new sustainable technologies to capture CO_2 and use it for beneficial purposes. This can be done only through science and technology. Consequently, much more resources need to be allocated to the development of new sustainable technologies.

At any stage of development, the best golden formula is using science as a diagnostic tool that breaks boundaries at a given time, and as a main grand solution provider, that can, in cooperation with other domains, find the solutions for the problems that are created by society or previously by science and technology itself.

Science and technology are unique. They never fall within predetermined templates and social models, and as such, the power they bring to society cannot be forecasted. When the aforementioned theories were so popular in predictions, none of them were able to forecast the invention of computers, laptops, smart phones, internet and the programming languages that make these devices totally change the life of human beings. All these inventions are directly related to human ingenuity, which has no limit in the power to find problems as well as solutions through science and technology.

Science and technology are first grand disruptors that break boundaries and borders. Computers, laptops, smartphones, internet and the digital world in general disrupted the existing equilibrium of laws, regulations and societal norms. Forced by this new reality, a series of new laws needed to be enacted to deal with numerous issues such as copyright, communications etc. The CEO of Daimler Benz once said that the real competitors of Mercedes-Benz are Tesla, Google, Apple and Amazon. This is because software in the future will drive cars better than humans. This will disrupt the society as we know it today: owning a car or parking a car might not be necessary anymore. A driver's license might not be necessary anymore. No car accidents will happen anymore. As such, no insurance companies may be needed anymore. A plethora of new laws and regulations forced by this new reality will follow.

We have seen the disrupting and boundary breaking power of new technology in various fields. Uber is a software tool. This company does not own any cars. However, it is the biggest taxi company in the world. Airbnb is a software tool and it is the biggest hotel chain without owning any hotel property. New laws were enacted to meet the demands of this new reality.

Software has already started to recognize retina and human faces, and it the future they will be better than humans doing so. In the very near future, it is expected that software will become more intelligent that humans. Software will give blood analysis when you breathe in a device and will identify any disease. If there might be a problem today with fresh water, the new software-based technologies will produce as much clean water as we want from sea water for a low cost. Numerous new laws will be surely enacted to account for this new upcoming reality.

Once the reality is disrupted and boundaries and borders are broken because of new sciences and technologies, the time comes to find solutions. New laws and regulations are part of this. However, none of these laws can be enforced without science and technology that created this new reality in the first place. For instance, the music copyright in the internet era can not be protected using classical laws or even new enacted laws if science and technology does not develop new software that makes possible this protection in the internet. In other words the solution of issues creates by the new disrupted reality can be done only through science and technology otherwise the new laws remain a good written desire in paper.

Certainly, on the way of disrupting and boundary breaking processes, new social problems may and will appear. It will be science that will diagnose them and it will be also science and technology, in close cooperation with and help of other pillars of sustainability (Governance/Politics and Education/Civil Society, that will find the proper long-term solutions.

CONCLUSIONS

The role of science and technology as one of the most important pillars of sustainable development was analysed within the new FLOGEN sustainability framework. Based on case studies from distant and recent history, it is evident that science and technology are grand disruptors of boundaries, borders, and ways of life, and they have opened society's eyes to new serious problems and realities. Science and technology have been credited for their diagnostic role in problems, but they have been frequently ignored for their role as solution producers. Numerous examples demonstrate that usually solutions are sought far from science and technology, or without their close cooperation, and this has been the cause of failures. It is shown that science and technology are grand solution providers, and this is clear from the distant, recent, and current realities, where they have proven wrong all non-scientific solutions or doomsday predictions. It is concluded that no sound long term solution can be found when science and technology are not considered as a solution provider and as a pillar at the forefront of sustainable development, and this is even more so valid for the acute problems the world faces today. The only winning formula is a strong equal partnership of the three pillars of sustainability: Science and Technology, Governance/Politics and Management, and Education and Civil Society.

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