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BIODIVERSITY, SUSTAINABILITY, GROWTH: THOUGHTS OF A MATHEMATICIAN

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Abstract

The topics of Biodiversity, Sustainability and Growth are strictly entangled. Some thoughts on the scientific and political aspects of the relations between them are presented, in the perspective of mathematical models.

Keywords

Mathematical models, Economics, Life sciences, Biodiversity, Sustainability, Growth

1. *Biodiversity, Sustainability and Growth*

The topic of biodiversity encompasses several scientific aspects and raises several questions, including the following: how the coexistence of different species in a given environment evolves, which are the causes of this evolution, what its consequences may be, and how the human behaviour acts in a direct or indirect way on this evolution.

The maintenance of biodiversity is a principle that must be embodied in the idea itself of sustainable growth, as the lost of biodiversity in an irreversible phenomenon which can jeopardise the stability of the nature equilibrium and possibly the mankind survival.

The natural evolution of the species preserves a delicate equilibrium that would be very risky to endanger. On the other hand, the extincion of biological species is growing at an impressively increasing rate. Biodiversity is by its nature in continuous evolution, the world has always changed, through species evolution, migrations, climate changes that have altered natural habitats.

However, it is clear to everyone how human presence, in the time we are living, not by chance called the Anthropocene, is affecting the acceleration of biodiversity evolution and causing abrupt changes that would hardly have occurred at the same pace without the influence of human activities.

Therefore, it is impossible to deal with biodiversity without strictly relating it to development (*growth*) and sustainability.

It is natural to think of the report on the *Limits to Growth* commissioned by the Club of Rome to the Massachusetts Institute of Technology in 1972. The Club of Rome was founded in 1968 at Accademia dei Lincei in Rome, and it is a nonprofit, informal organisation of intellectuals and business leaders whose goal is a critical discussion of pressing global issues.

The turning point marked by the MIT report was that for the first time the whole study of future economic landscapes was based on the finiteness of the available resources. The coming to light of a limit to the growth was an emerging point in the perspective of thinking about the future.

Some years later, in 1987, the so-called Brundtland Report, after the name of Gro Harlem Brundtland, Chair of the WCED (World Commission on Environment and Development) was published, whose title was *Our Common Future*.

Its targets were multilateralism and interdependence of nations in the search for a sustainable development path.

The report defined the *sustainable development* as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" and placed environmental issues firmly on the political agenda; it aimed at discussing the environment and development as one single issue.

It is interesting as well that the update of the *Report* after thirty years, in 2004, shifted the focus from resource exploitation to environmental degradation.

2. *Some thoughts on the scientific and political aspects and mathematical models*

From my point of view, as a mathematician, it is impossible to ignore development, understood as growth in economic terms, when speaking of the future, simply because the mathematical models of the economy do not admit *stationary* solutions, but only solutions such that all the quantities present in the model evolve in time.

There are mathematical models of other phenomena that admit essentially stationary or periodic solutions (just think of universal gravitation), but this is not the case for economic models.

I am not a specialist in mathematical models of the economy, nor in economics itself, but I can state that a stationary situation in economics is nothing more than the prelude to a collapse. Indeed, more is true: as stated by Ivar Ekeland (2000), "in economics, the past is not enough to determine the future". I shall comment again on this point later.

Let's reflect on the issue of planned obsolescence of devices, which is in the everyday experience: if devices last too long, the drop in demand causes a collapse in production and an industrial crisis. This obviously depends on market saturation, that is, the fact that everyone who is interested in equipping himself with a certain device and has the means to purchase it, already possesses.

Therefore, the only possibility of producing new ones—possibly by innovating them—lies in creating the need to replace existing items at a sufficiently rapid pace.

The content of this observation is intended to point out the difficulty of the challenges ahead, the difficulty of reconciling development with sustainability. In the example just cited, the need to reconcile the renewal of (programmatically) obsolete devices (which aims to support production, and therefore the economy) with the ability to recycle their components (which aims to safeguard the environment by reducing resource exploitation and waste mass).

We can draw from this simple example a general paradigm of one of the challenges that mankind has to face: to convert the physical limits of the finiteness of the resources into the promotion of activities aiming at reducing the ambient vulnerability.

This awareness, obviously not new, pushes towards the search for the formulation of a model able to define a possible perspective, not only from an economic point of view but also from an environmental one.

Though belonging to a scientific community, I cannot but recognise the foresight of an Italian poet who, in the same years as the aforementioned report on the limits to growth, strongly emphasised another aspect, more properly political and sociological. It was Pier Paolo Pasolini[1], see Pasolini (1973), that, in the same years, focused on a problem of enormous interest and relevance: the difference between *growth* and *progress*, the difficulty of bridging the gap between economic growth and the advancement of society as a whole and in all its different dimensions, including the reduction of inequalities.

The challenge that lies ahead is all the more difficult because one can no longer speak of sustainability and biodiversity in confined environments, just look at the phenomena of ethnic replacement: I think, for example, of the invasion of the gray North American squirrel in the Alpine arc, much more harmful, to the detriment of the red squirrel, or the invasion of the Mediterranean by the blue crab, which is capable of violently and irreversibly altering the current ecosystem and supplanting pre-existing species.

Similarly, one can think of large-scale infestation phenomena, such as Xylella, to speak of an issue of great local impact in my region, or the global spread of COVID-19.

Naturally, there are two perspectives from which to look at these problems: a scientific one and a political one.

On the scientific level, the first step is the experimental aspect of data collection (on climate changes, on the populations present in a given habitat, on the spread of new species); after that, there is the theoretical aspect of processing this information, and here obviously Mathematics has a central role.

To pursue the goal of a serious scientific analysis of phenomena, mathematical models must be developed that can provide reliable information on increasingly complex phenomena.

The available data are intrinsically affected by errors, due to the limits of acquisition possibilities,

[1] Pier Paolo Pasolini, Bologna, 5 March 1922 – Ostia, 2 November 1975.

the difficulty of obtaining data in an extended form, and to the complexity of the interactions between the various elements to be monitored.

The role of the mathematician is twofold. First, mathematicians can contribute to synthetise the information obtained from scholars of individual disciplines (botany, zoology, physics, meteorology, etc.) into the most complete and manageable possible models.

Then, mathematicians try to get useful practical information from the analysis of the model.

Here, two aspects of the models come into competition: on the one hand, one tries to take into account all available information, aiming for model completeness (which increases its complexity and induce the risk of exceeding the possibility of studying it with known tools to extract useful information); on the other hand, one tries to contain it within complexity limits that make it manageable with known mathematical tools, losing as little information as possible.

This is the everyday challenge of applied mathematical research: to simplify with a grain of salt and refine investigative tools to tackle increasingly complex problems.

The goal, in the context of the concrete problems we are discussing, is to indicate the available consequences of possible intervention strategies, once the constraints stated by the decision makers and the objectives to be pursued have been identified: constraints and objectives that represent the political perspective.

From these few reflections, two aspects emerge that are in a certain sense parallel, on the two scientific and political planes to which I referred earlier.

From a scientific point of view, it is clear how the study of the problems of sustainable development (and support for progress) and the protection of biodiversity is inherently interdisciplinary.

In this, if it is true, as Galileo said in his essay *Il Saggiatore* (1623), that "the book of Nature is written in mathematical characters", the role of the mathematician is crucial, in catalysing the dialogue between scholars of different disciplines, in data analysis, in synthesising the formulation of models, even before the qualitative-quantitative and predictive study of the models themselves. With some warnings well clear in the minds of mathematicians, perhaps not so much in those of less informed users.

First, as Einstein said, the study of a mathematical model cannot produce more physics (or biology, or economics, I add) than was present in the formulation of the model itself, and this is a crucial point in the interdisciplinary formulation of the model.

Furthermore, for a mathematician, it is clear that a qualifying point of the analysis to be performed is a measure of the precision and reliability of the conclusion that can be drawn from the model at hand. This is a purely theoretical point that concerns the mathematical tools that enter the discussion of the model.

However, experience teaches that sometimes Mathematics is expected to deliver much more than it can, and it is not easy to make interlocutors understand this aspect of mathematical analysis.

Indeed, this seems like a limitation but on the contrary it is a strength, consisting of a rigorous and intellectually honest assessment of the scope of one's work.

For example, if a mathematician bounds the validity of weather forecasts to a defined time interval, it is not because it is necessarily impossible to solve the equations in question for longer times, but because the conclusion that one can reach become unreliable.

The study of the equations starts from approximate data and the equations themselves, in turn, contain approximations, so that beyond a certain temporal horizon, control is inevitably lost over the difference between the values provided by the calculations and the real values of the quantities involved.

In this regard, I recall that during the recent pandemic, many scholars, led in Italy by the 2021 Nobel prize winner Giorgio Parisi[2], insisted that all known data be made available to scientists to study the pandemic trend with the utmost precision. No one listened to them, I believe more out of ignorance than for other reasons.

By the way, I mention that in the same year 2021 the Nobel Prize in Physics was assigned, independently of Parisi research, jointly to Syukuro Manabe[3] and Klaus Hasselmann[4] for their studies leading to "the physical modelling of Earth climate, quantifying variability and reliably predicting global warming", a further strong demonstration of how much the topic of ambient

[2] Rome, 4 August 1948; Nobel Prize in Physics, 2021.
[3] Shinu (Japan), 21 September 1931.
[4] Hamburg (Germany), 25 October 1931.

preservation is relevant in the scientific community.

Coming back to Ekeland's observation quoted above, I call the attention on another point which is presently central in almost all the mathematical models, in ecology, economics, geology, epidemiology etc.: the uncertainty aspects, which lead to models that are probabilistic in nature, and cannot produce any certain prediction. This is another example where the communication to nonmathematician users shows some weakness.

Of course, the rigorous introduction of stochastical tools reflects an enhancement of the available models, but paradoxically it is preceived as drawback.

Estimating the reliability of a prediction in probabilistic terms is much more difficult (but much more reliable) than producing a deterministic conclusion that ignores the volatility present in the real situation.

But, the uncertainty present in the former is often perceived as less reassuring than the latter, which on the contrary can be far from being plausible.

A typical situation is that of medical prescription: it is very rare that a medicine works on the 100% of patients, but it would be crazy to deny its use if it works on the 90% of cases and can cause dammages in the 1%. Nevertheless, that 1% is often sufficient to discourage unexpert people from assuming the medecine.

Summarising, it is an important task of the mathematical community to convince the social community (and the political decisors) that a correct probabilistic prevision has the same scientific value as a deterministic prevision, but simply, it depends upon the real context that one tries to model: sending a rocket in the space is not the same as estimating the price of an asset!

The preceding considerations lead to hope that research in innovative technologies will address towards targets that can combine realisation of more powerful devices with the duty of respecting the environment and saving the resources.

Basically, this means recycling the components of dismissed devices as much as possible, designing devices that save energy, taking into serious consideration the environmental impact of all human activities.

In this perspective, the contribution of Mathematics can be of great importance: the theoretical study of possible improvements of the available technologies, based on simulations rather than more expensive and less respectful experiments, could accelerate the innovation; the formulation and study of mathematical models of various aspects of the biosphere (climate evolution, effects of atmospheric phenomena on human activities, epidemies evolution, effects of the deforestation and the immission of CO_2 in the atmosphere, just to mention a few) could warn against negative effects of human behaviour and help in preventing the situation from worsening.

In this respect it is crucial to improve the exchange between mathematicians and scholars of other disciplines in order to develop a fruitful dialogue and a consequent advancement in the applications of Mathematics.

To this aim, a stronger education in Mathematics is needed in all scientific areas, in order to exploit as much as possible the capability of mathematical models: neither mathematicians nor experimental scientists can formulate a mathematical model on their own.

A further investment in technological innovation surely comes from the search of improvement of calculus capabilities of electronic devices.

This does not mean that pure Mathematics has to be disregared: first, it is a very rewarding theoretical human activity that cannot be stopped (as poetry, art, music or philosophy cannot), second pure Mathematics can provide abstract methods and results that are discovered for purely internal impulse and find applications much later.

My favourite example is the *Radon transform*: it has been introduced by J. Radon[5] in Radon (1917) for purely abstract reasons in connection with *integral geometry* and has proven to be useful in *radioastronomy* (starting in 1942, see e.g. Bracewell 1956) and subsequently in *radio diagnostics*, thanks to Allan Cormack[6], who applied it to the CT (X-rays Computed Tomography), see Cormack (1963).

But indeed more is true. A sensibility towards abstract Mathematics on the part of other scientists is fundamental to be aware of what Mathematics can predict and what it cannot, as well as the degree of reliability and the time

[5] Johann Karl August Radon, Tetschen (now Chech Republik), 16 December 1887 - Wien, 25 May 1956.

[6] Allan McLeod Cormack, Johannesburg (South Africa), 23 February 1924 - Winchester (USA) 7 May 1998, Nobel Prize in Medicine, 1979.

horizon of the prevision, as I tried to explain through the previous examples.

Coming to the political aspect, the counterpart of the interdisciplinarity of the dialogue between scholars with different training is represented, in the political sphere, by the dialogue between holders of different interests, both geopolitical and economic and social, and here the task of synthesis and decision is all politics.

In this regard, let me recall the great lesson of Amartya Kumar Sen[7], presented in a divulgative form in his famous 1987 work *On Ethics and Economics*.

A great philosophical and technical lesson, which I associate with Pasolini's reflections because it states there can be no sustainable development (as defined in the Brundtland Report), no progress, no protection of biodiversity without an ethical approach.

And then, it is clear that respect for Nature's rhythm is also respect for humanity, which is part of Nature and without Nature cannot exist.

Economics is the science that, the last among sciences, became autonomous and independent from philosophy and politics only in the 18th century (I think as a foundative text the Adam Smith's essay *An Inquiry into the Nature and Causes of the Wealth of Nations,* 1776).

Indeed, I recall that Amartya Sen in his essay reminds us, among other things, that the first place where Economics is discussed is Aristotle's *Nicomachean Ethics*.

Another great classic and we must all feel committed to realise what is contained in Aristotle's treatise: to restore to politics the sense of good governance and to restore a far-sighted vision, ultimately bringing economics back into the arms of ethics..

[7] Santiniketan, Bolpur, Birbhum district (West Bengala, India) 3 November 1933; Nobel prize in Economics, 1998.

REFERENCES

Bracewell, R.N. (1956), Strip integration in radio astronomy, *Aust. J. Phys.*, *9*, 198-217.

Cormack A.M. (1963). Representation of a function by its line integrals, with some radiological applications. *Journal of applied physics*, *34*, 2722-2727.

Ehrlich, P.R., & Ehrlich, A.H. (1981). *Extinction: the causes and the consequences of the disappearance of species*. New York: Random House Publishing Group.

Ekeland, I. (2000). Mathematical models in economy. In *Proceedings of the Conference on the Mathematical Sciences after the year 2000* (pp. 37-44). Singapore: World Scientific.

Galilei, G. (2023). *Il Saggiatore.* Camerota M., & Giudice F. (Eds.). Milano: Hoepli.

Meadows, D.H., Meadows, D.L., Randers, J., & Behrens, W. (1972). *The limits to growth.* Washington DC: A Potomac Associates Press.

Meadows, D.H. & Meadows, D.L. & Randers, J. (2005). *The limits to growth. The 30 years update.* London: Earthscan.

Pasolini, P.P. (1973). Sviluppo e progresso. In *Scritti corsari,* Milan: Garzanti.

Radon, J. (1917). Über die Bestimmung von Funktionen durch ihre Integralwerte längs gewisser Mannigfaltigkeiten. In *Berichte über die Verhandlungen der Königlich-Sächsischen Akademie der Wissenschaften zu Leipzig*, Mathematisch-Physische Klasse, Leipzig: Teubner (69): 262–277.

Sen, A.K. (1987). *On Ethics and Economics.* Oxford: Basil Blackwell Publ.

Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations.* London: Strahan and Cadeli Publ.

The World Commission on Environment and Development (1987). *Our common future,* London: Oxford University Press.