May 27th, 2019
Lectio Magistralis by Catia Bastioli

Bioeconomy for territorial regeneration

Doctoral Dissertation on the occasion of the Honorary Doctoral Degree in Civil, Chemical, Environmental and Materials Engineering awarded by the Alma Mater Studiorum–Università di Bologna

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Acknowledgments

Good afternoon everyone.
I am sincerely honoured and grateful to be here today, in the oldest University in the Western world which still holds high the banner of Italian education and research and is a source of pride for our country.
I would like to thank most sincerely the Rector, Professor Francesco Ubertini, and the entire Department of Civil, Chemical, Environmental and Materials Engineering for this great honour which the University of Bologna has seen fit to bestow upon me.
I would also like to express my heartfelt gratitude to Professor Fabio Fava – a tireless and tenacious supporter of the bioeconomy – for his crucial work, which is greatly appreciated in Italy and in Europe.
A heartfelt thanks also goes to everyone – researchers, engineers, agronomists, environmentalists, entrepreneurs, the world of cooperatives and associations, the agricultural world and the representatives of institutions, the worlds of finance and distribution – who over the years have contributed in varying degrees and in various ways to help me build case studies from the bioplastics and biochemicals sector, and with whom I would like to share this recognition. I would also like to thank in particular all the men and women who have worked and grown with me and who have made it possible to create, from a model of territorial regeneration, a real integrated bioeconomy value chain made up of new plants in de-industrialised sites, a wide range of bio-based products and solutions for major environmental problems, agricultural value chains in marginal lands, a formidable network of collaborations and interconnections and a bioeconomy platform because these make up the great heritage we have built over the years.
In my dissertation I am not going to talk specifically about the results of my activity in the field of bioplastics and biochemicals over the past years, which I have described in a recently published book. Instead, I would like to try to analyse the fundamental role of the circular bioeconomy in the decarbonisation of systems and the regeneration of territories, starting from the centrality of soil health and the ensuing need to redesign integrated value chain, our consumption habits and our approaches to recycling. I would also like to elaborate on the potential offered by the circular bioeconomy for Italy and for Europe in terms of sustainability and systemic competitiveness, and on the fundamental importance of the educational, training and research system in making it truly possible to change from a model of dissipation to a model of conservation and inclusion and to be able to speed up the regeneration process with respect to the degradation of resources, which is currently significantly faster.

Where "business as usual" has got us

Already back in 1972, the first global think tank on sustainable development, the Club of Rome, which made its name worldwide with the book *The limits to Growth*,[1] warned us of the risks of unlimited development with predictions that have proved to be absolutely right.

The current economic system is not resilient and is definitely not circular

When the Club of Rome was founded, human beings numbered 3.5 billion, today there are 7.6 billion and this number is forecast to reach 9 billion in 2050. The concentrations of greenhouse gases in the atmosphere have increased from 322 to 403 parts per million. We have gone from being an empty planet to a full planet where destructive effects can only be synergistic.[2]

The IPCC report,[3] published in October 2018, is anything but positive and the planet continues to see increasing emissions and the destruction of resources and the social fabric.

The current economic system is not resilient and is definitely not circular. The global environmental crisis has been joined over the past two decades by financial, industrial and social crises.

We have reached this point because of a model of linear, dissipative development of the economy that has become globalised, creating increasingly large organisations with short-term objectives, minimising the rights of the majority and producing waste. In the past, capitalism thrived in limited areas that were governed by clear rules: territories were virtually closed systems and the interests of the company and the share holders were for the most part the same as the interests of those territories. Today, however, the scenario has become fluid. We operate in open systems with more and more frequent disruptions of increasing intensity, which end up affecting the entire planet without it being possible to reach a steady state. This explains the financial, environmental and social catastrophes that are generated swiftly without anyone being able to manage their evolution and their consequences.

Open systems without rules or buffers are destined to create perfect storms, in which man and his habitat are in danger of perishing

In short: open systems without rules or buffers are destined to create perfect storms, in which man and his habitat are in danger of perishing.[4] This was understood by Ilya Prigogine[5], who was awarded the 1977 Nobel Prize in Chemistry for developing the non-linear thermodynamics of irreversible processes and who was one of the first to build a bridge between physics, chemistry, ecology and social sciences to study the complexity of sectors as interacting systems.

This concept perfectly explains the impact of the increasing concentrations of carbon dioxide in the atmosphere, which is leading to an alteration of ecosystem flows and stocks of natural resources, which are our dams, our buffers. This then leads to extreme atmospheric phenomena, with the risk of knock-on effects, not all of which can be easily predicted. The rise in the

Our inability to change the development model and to stay within natural limits risks leading us to the point of no return

earth's temperature, the acceleration of soil desertification, the retreat of glaciers, the rise in water levels, the destruction of ecosystems such as coral reefs are just a few of the known effects.

Our inability to change the development model and to stay within natural limits risks leading us to the point of no return, making us leave the Holocene, the geological epoch that has allowed the development of humans and human activities. We have entered the Anthropocene epoch.

The message of renowned expert on sustainability Johan Rockström is that if we continue with "business as usual", the planet will not have sufficient resources to combat both climate change and poverty, the two major issues that are being targeted with the 17 SDGs.[6]

The bioeconomy

This is yet another reason why we have a duty to speed up this process and the Bioeconomy, which uses renewable biological resources from the land and the sea[7] in a circular approach, is a powerful tool that aims at regenerating territories starting from their specific natures, multiplying the cases of integrated value chains and developing the ability to monitor the results in the field. We have an unmissable opportunity to transcend the linear model of development and decarbonise the economy, addressing the problems of the degradation of the ecosystem where it is still possible to do so, and including communities.

The fundamental words for this acceleration are: transform, regenerate, contribute

The fundamental words for this acceleration are: transform, regenerate, contribute. We need technologies that can transform the business as usual approach; integrated projects that can regenerate resources while relying on a contributory society in which it is clear that we must give as well as receive. All this requires a change of mindset which has to happen as soon as possible if we are still to have an impact.

As was highlighted in the report by the EU 2050 High-Level Panel of the European Decarbonisation Pathways Initiative,[8] a long-term strategy is essential in this context, but work must be on what can be achieved in the short- and medium-term to trigger an induced incremental innovation process, with major impact and an exponential growth of aspirations and opportunities.

The "great challenge" of soil pollution and ecosystems

In this revolution, although technology is a necessary condition, it is not sufficient for the development of the circular Bioeconomy. In reality we have numerous technologies available, some of which have been developed right here in Italy in recent years, but we need land management projects in which to incorporate them and connect them intelligently. All innovations and technologies, even the best ones, can produce negative effects if they are not used wisely in terms of sustainability, and if they are not part of an eco-design and circular economy approach, especially when it comes to raw materials of vegetable origin and the soil, a precious, non-renewable resource that plays a central role in our lives.

All innovations and technologies, even the best ones, can produce negative effects if they are not part of an eco-design and circular economy approach

Soil is a non-renewable resource – it takes over 2,000 years to make 10 cm of soil. It is the starting point for food production, it is essential for maintaining life on Earth and, thanks to carbon sinks, it is crucial to cutting CO_2 emissions from the atmosphere.[9]

Soil is a non-renewable resource, essential for maintaining life on Earth and crucial to cutting CO_2 emissions from the atmosphere

However, according to the FAO,[10] 33% of soils are now degraded and affected by salinisation, compaction, chemical pollution, acidification, accumulation of non-biodegradable substances and depletion of nutrients. The European Union Joint Research Centre claims that 20% of the EU's surface is subject to erosion at a speed of 10 ton/ha*y, while soil sealing (the covering of the ground by an impermeable material) leads to a loss of 1,000 km^2 of productive land every year.[11]

Soil degradation is an environmental problem throughout Europe and particularly in the Mediterranean region where many areas are affected by desertification, with Spain in the forefront, followed by Greece, Bulgaria, Italy, Romania and Portugal.[12] This progressive degradation requires the adoption of soil carbon accumulation practices in order to at least stop, if not reverse, the phenomenon.[13]

The lack of a European directive on the matter has repercussions not only for greenhouse gas emissions but also on soil preservation and regeneration, on water resources, intensive farming and the use of antibiotics, on the use of chemical fertilisers and herbicides[14], and on soil contamination by plastics and microplastics[15] and other substances that can accumulate and impact fertility. These may be residues of products placed directly in contact with the soil, as in the case of agricultural mulches and herbicides, or accidentally spilled as in the case of lubricants or brought about by low quality organic soil improvers.

Over the next thirty years it is estimated that at least 4 billion people will be living in arid areas[16] and the combination of soil degradation and climate change could lead to a reduction in agricultural production of up

to 50% by 2050 in some regions, with such effects further amplified by population growth.[17]

Mitigation in Agriculture, Forestry and Other Land Use (AFOLU) can be achieved by two factors: reducing the intensity of greenhouse gas emissions per unit of output (by improving agricultural land and farm management) and conserving or increasing carbon stocks in vegetation or soils (through afforestation/reforestation, bioenergy with carbon capture and by raising the carbon content in soil).

Soil regeneration must start with a responsible use of agricultural land, promoting the creation of new integrated value chains based on the diffusion of best practices, the sustainable use of biomass and the addition of organic matter

These mitigation actions must take place in synergy with the preservation of the quality and functionality of the soil, linked to fertility.[18]

Soil regeneration must start with a responsible use of agricultural land, promoting the creation of new integrated value chains based on the diffusion of best practices, the sustainable use of biomass and the addition of organic matter. Regeneration can take place in marginal, abandoned and non-cultivated land especially land with negative economic margins, also through the use of non-irrigated crops, and could encourage the creation of new income opportunities for farmers by stipulating agreements. This would also create an opportunity to develop physical, chemical and biotech technologies that can use the various raw materials made available by these value chains.

With regard to regenerating soil through the addition of organic matter, mention should be made of the international initiative known as the "4 per 1,000 initiative: soils for food security and climate", launched in 2015 in conjunction with the Paris Agreements, which notes that a 0.4% annual increase in organic matter in the soil would be sufficient to compensate for the increase in CO_2 concentration in the atmosphere linked to human activities, while at the same time improving soil fertility. [19]

The use of compost is an important solution to two types of problems: firstly, by preventing organic waste from ending up in a landfill, and secondly, by adding an invaluable soil improver

The use of compost and other quality organic materials in agriculture in the face of the problems of degradation and desertification we are witnessing appears to have considerable potential[20] and is an important solution to two types of problems: firstly, by preventing organic waste from ending up in a landfill, a practice prohibited by the new Biowaste directive as from 2023,[21] and secondly, by adding an invaluable soil improver. This practice leads to a gradual improvement in crop health and keeps the input of pesticides and fertilisers to a minimum. Despite this opportunity, considerable amounts of organic matter, both solid and liquid, are still sent to landfills or incinerated, instead of being returned to agricultural land, and huge amounts of microplastics, lubricants, herbicides and other pollutants compromise the quality of both soil and water, putting ecosystems at risk. An example of the dissipative economy we have developed over the past decades.

Urban organic waste and sludge can produce organic matter – compost – which can be used in agriculture to increase the organic matter in the soil and which tends to neutralise greenhouse gas emissions,[22] and could do so for at least 25% of the amounts required by the 4 per thousand initiative, but there is not sufficiently widespread awareness of the importance of these streams and their quality and cleanliness.

In actual fact, around 96 million tonnes of urban organic waste are produced in the European Union and 66% of this is still sent to landfills.[23] Sewage sludge from urban wastewater treatment, which is often either landfilled or incinerated,[24] is another significant waste of resources and a source of illegal practice.

Considerable amounts of organic matter are still sent to landfills or incinerated, instead of being returned to agricultural land, and huge amounts of pollutants compromise the quality of soil and water

The same goes for phosphates from wastewater or animal manure, which could instead be recycled to produce fertilisers or for industrial applications, in a circular economy approach. Instead we continue to extract finite and limited quantities from rocks, practising a linear economy that transforms precious finite resources into water and soil pollution.

All these sectors can help restore soil fertility and promote sustainable agriculture, even in marginal areas, by transitioning towards regenerative and socially inclusive practices. We need only to consider that proper management of the around 62 million tonnes of organic waste in Europe that currently ends up in landfills could create an additional 68,000 jobs as opposed to the current 23,000. The potential CO_{2eq} that could be saved is in the order of 50 million tonnes. The construction of adequate, extensive plants would also give a boost to investments. For Italy, the increase in employment can be estimated at 10,000 jobs[25] and savings in terms of CO_2 in the order of 5 million tonnes.[26]

In Italy, the "Italy Towards zero organic waste in landfill"[27] initiative was launched by the Kyoto Club and SUSDEF (Sustainable Development Foundation) a few years ago, with the aim of exploiting the organic fraction of waste, considering it as a precious resource and not as waste.

This programme was supported by many environmental associations and universities and by the country's largest multi-utilities.

In this context it is clear that centres of consumption and cities and metropolitan areas in particular have an extremely important role to play, since they influence the type of food consumption, the production of waste, the types of packaging, the quality and quantity of disposable products, the systems for the collection and treatment of organic waste and municipal and industrial wastewater, and the practices of recycling organic and non-organic materials.

A virtuous example of this is the "Food Policy" initiative undertaken by the City of Milan.[28] This is a very advanced experimental project that addresses this great challenge, involving a series of issues such as the collection and quality of organic waste, food saving, educational programmes starting with school canteens and student diets, street markets and retailers, the recycling sector, water treatment operators and innovative companies in the bioeconomy sector.

The importance of a new relationship of cities and agriculture with the food and organic waste value chains, focusing on soil health, the effect of decarbonisation and territorial regeneration is evident.

In relation to maintaining the health and fertility of soils, the property of being biodegradable in soil is crucial for all those products for agricultural use that create problems of accumulation (herbicides, lubricants, seed additives, slow release systems, agricultural mulches).

Likewise, biodegradability in water and soil is crucial for those products with accumulation problems in sewage sludge and water, as in the case of non-biodegradable additives for cosmetics and detergents.

Biodegradability in composting becomes essential for all applications in which the materials used are highly likely to be polluted by food residues and in which the lack of biodegradability would pollute organic waste that would then end up in landfills, rather than being turned into valuable compost. I refer here to thin packaging, multilayer packaging, food-serviceware products and coffee capsules.

In a circular economy approach having soil and water quality at its core, it must be absolutely clear that all the liquid and solid streams of organic carbon must go through composting and anaerobic/composting and purification systems. The combination of an efficient network of treatment plants and the biodegradability of the products back into the soil, remunerating the virtuous farmer and compost of adequate quality. Thanks to the case studies in Italy, it is now possible to count on farmers, composters, environmentalists and academia firmly believing in the need for adequate standards for compost to be returned to the soil and to be remunerated.

The combination of an efficient network of treatment plants and the biodegradability of the products will ensure that no persistent substances accumulate in purified water, sludge and quality compost

The need for biodegradable products in various settings in the applications mentioned earlier creates incredible opportunities for the development and multiplication of projects and collaborations, starting with the bioplastics and biochemicals sector, already established in Italy, and the paper and cellulose sectors and their interactions, as well as the organic and chemical recycling of these products for the ultimate virtuous and circular value chain. According to Plastics Consult, the bioplastics sector now numbers 4,000 people, involves 250 processing companies and has a turnover of € 685 million.[29]

Furthermore, the potential of induced incremental innovation applied to organic waste and agricultural and agro-industrial residues as raw materials for the production of new products should also be considered.

Research conducted by Milan's Bocconi University[30] has shown how the introduction of new bio-based and compostable packaging can contribute to improving the quality of the separate collection of both paper and organic materials, limiting the use of landfills for waste, leading to great savings deriving from a decrease in the estimated cost of contamination of the paper and organic waste recycling chain.

Other opportunities obtained from the synergy between these two biomaterials concern the world of recycling, with technologies that now allow us to develop biochemicals from cellulose waste.[31]

As regards traditional plastics, we must not make the mistake of looking at the consequences without thinking about the causes. The problem is not the plastic itself: plastic is neither good nor bad. The benefits depend on the use we make of it. But its volume growth cannot be ignored: around 50 million tonnes of plastic was produced in 1972, and over 325 million tonnes a year today, with the prospect of reaching one billion tonnes a year in 2050.[32] According to the Ellen MacArthur Foundation, today only 2% of plastic packaging is actually recycled and processed in the same application or in applications of comparable quality, and around 12% is recycled in lower value applications (so-called downcycling), because of how the products were designed upstream, without any systemic vision. The majority, 72%, is not recycled but goes to waste-to-energy or landfills, or else it pollutes the environment.[33]

Plastic is neither good nor bad. The benefits depend on the use we make of it

We are hearing more and more frequently about plastics and microplastics in our seas and about islands of plastic in the oceans: according to a recent WWF report, the Mediterranean Sea holds only 1% of the world's waters but 7% of global microplastics.[34] It is not so well-known that 80% of marine pollution is caused by inadequate management of waste on land.

80% of marine pollution is caused by inadequate management of waste on land

If the percentage of mechanical recycling of plastics with the same properties is still very limited after so many years of talking about it, it is because there are significant critical issues that must be kept in mind to prevent recycling from remaining a mere token gesture. However, there are many positive examples of recycling. I will mention just one here – the PET packaging chain. Then there are also prominent cases that are worthy of mention here, such as Aquafil which, through chemical recycling, regenerates fishing nets and polyamide-6 mats and which has created a real chain with major developments on this basis.

All this tells us that we need to redesign the entire system, to rethink the products, their use and their disposal from a circular and eco-design perspective, consuming as few resources as possible, using plastic wisely, only when really necessary and possibly for long-lasting applications. Bio-based and biodegradable products should be used in applications where there is a risk of an accumulation of non-biodegradable residues in liquid and solid carbon streams and in soils with effects on water quality.

We need to redesign the entire system, to rethink the products, their use and their disposal from a circular and eco-design perspective

Lastly, we must stop thinking about unlimited growth. On this front we need a complete change of mentality which is currently rather complicated, given that we still think of growth in terms of volumes rather than value, still ignoring the costs of externalities which are becoming increasingly unsustainable as the planet goes from empty to full.

Over the years I have seen an increase in the number of people ready to go down the route of working together to overcome the challenge of territorial regeneration. But what has been done is by no means enough to turn the tide in terms of consumption of natural resources and revitalisation of the social fabric.

The revolution is being played out at the level of territories and on topics such as agriculture and the maintenance and strengthening of soil fertility, the relationship between cities and food, the eco-design of products. It also concerns the networks that are able to follow this new use of territories, and the development of plants of the right dimensions and technological quality, essentially for composting and anaerobic digestion with biomethane production and stabilisation of digestate, and the implementation of chemical, physical and biotechnological processes to transform waste into products. It is being played out on the interdisciplinary nature and the interconnection of territorial projects, on their multiplication and their capacity for inclusion and on the possibility of producing the required energy directly.

The revolution is being played out on the interdisciplinary nature and the interconnection of territorial projects, on their multiplication and their capacity for inclusion

In this respect, the energy system also plays a key role in changing the model to that of a circular bioeconomy, evolving rapidly from centralised to widespread, with exponential growth of renewable energies, with the need to overcome the problems of non-programmable and non-stable sources, to

face up to the criticality linked to the absence of inertia of the system, taking into account the growth in energy demand, energy independence, the resilience of systems to increasingly extreme climatic conditions, the effects on agriculture, on industry and on communities.

Conclusions

In conclusion, the circular bioeconomy can be an effective accelerator for sustainable innovation, regenerating resources and marginal/desertified/abandoned lands and transforming peripheral areas into strategic centres, a driving force of competitiveness for Italy and for the EU.

It will only be possible to accelerate the conversion process with a long-term strategy and by working to trigger an induced incremental innovation process.

The circular bioeconomy can be an effective accelerator for sustainable innovation, regenerating resources and lands and transforming peripheral areas into strategic centres

We need a new Age of Enlightenment in the definition of policies. This new Age must be characterised by a better balance between man and nature, between markets and law, between private consumption and public goods, between short- and long-term thinking, between social justice and incentives for excellence.

Being able to live well and within the natural limits is the great challenge of our century and it requires a change in mentality that must take place as quickly as possible if we want to try to turn the tide of the degradation of resources.

Today's new frontier is therefore more cultural than technological. Our mindset and our entrenched habits are actually the greatest obstacles to experimenting with new models and are what makes us short-sighted, fuelling selfishness, delaying the process of change and ending up by prolonging the structural crisis we are experiencing.[35]

We need a new Age of Enlightenment in the definition of policies, characterised by a better balance between man and nature, markets and law, private consumption and public goods, shortand long-term thinking, social justice and incentives for excellence

We must also keep in mind that the social fabric is not something separate from the economic world, and that we do not only have a debt to ecosystems, but that there is also a deep fracture that needs to be healed: one that has formed, over time, between economy and society, between development and territories. This makes it even more difficult to make integrated projects work, especially in areas that have suffered the most from the crisis. For this reason, the contribution of schools and of a University like that of Bologna is essential for quality education and training with a holistic approach, ensuring that teaching is multidisciplinary and systemic and able to bring together scientific, technological and economic/humanistic training, as well as allowing experiences in the field in integrated territorial projects that work towards the construction of shared value. The bioeconomy is the cornerstone between agriculture and industry, and agriculture, the environment, industry and academia must work together. What is needed is a commingling between science and technology on the one side and knowledge on the other. We must also be able to count on managers and entrepreneurs, as well as on investors, academics and institutions, who fully understand the value of natural capital and social stability and factor it into their development plans.

There is a deep fracture that needs to be healed: one that has formed, over time, between economy and society, between development and territories

This type of culture is formed in the field, by sharing territorial projects that act as a catalyst for a multitude of initiatives, where building and learning together generates trust and respect between the stakeholders, as well as wealth for many and without waste.

We need an interdisciplinary and systemic type of education that overcomes the paradigm of competence and individual leadership, embracing topics such as ethics, so that we are women and men first and foremost and then scientists or entrepreneurs. Otherwise, as Bertolt Brecht reminds us in the *Life of Galileo,*[36] "if the scientists [...] limit themselves to piling up knowledge for knowledge's sake, then science can be crippled and your new machines will lead to nothing but new impositions. You may in due course discover all that there is to discover, and your progress will nonetheless be nothing but a progress away from mankind."

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Publisher
Edizioni Ambiente

Printed in october 2019
by GECA S.r.l., San Giuliano Milanese (Mi) – Italy