

Bioeconomy value indicators in Sicily

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Abstract The emergence of the bioeconomy and the concept of sustainability in production processes have been essential for the protection of the environment and biodiversity, as well as for the implementation of processes for energy recovery, the creation of new jobs and increased competitiveness. Bioeconomy includes all sectors of the economy that use biological renewable resources of land and sea (such as crops, forests, fish, animals and micro-organisms, as well as biological residues and waste) to produce goods and services in an economically, socially and environmentally sustainable strategy. The objective of this paper is to quantify the performance of bioeconomy and sustainability of the agri-food chain in Sicily through the analysis of the main business, innovation and bioeconomy start-ups connected to Circular Economy, the overall waste treatment plants that permit material recovery; and the number of biological surfaces.

Keywords: biomass energy; environmental impacts; bioeconomy indicators; development instruments.

1. Introduction

Bioeconomy could be defined as an economy which employs biological resources as input to produce goods and final services. Therefore, the building blocks of materials, chemical products and particularly energy comes from renewable and sustainable resources such as vegetable and animal sources and thus an economy founded on biomass rather than on fossil fuels represents a significant changing in the agricultural and energetic systems. Hence bioeconomy includes traditional field as agriculture, fishing, aquaculture, and forestry as well as modern economy sector such as biotechnology and bioenergy ones (McCormick and Kautto 2013).

The importance that bioeconomy has on the Italian economy and the high variety of productions related to this sector brings out the specificities and excellences of each territory in the different sectors covered by the definition of bioeconomy. Italy recently has developed crucial actions and innovative experiences, specifically in several areas in which has virtuously optimized recycling and bio-elements reuse in a circular perspective: according to the total index of circular economy stated in the “National Circular Economy Report” Italy gets, as in 2019, the first

place in the circular economy field.¹⁰ The ranking in the report considers the circularity index, which is the value attributed according to the degree of efficient use of resources in five categories: production, consumption, waste management, second commodity market, investment and employment.

The first two productive sectors are fundamentally the agri-food sector and, given that they have a renewable and biological origin of their inputs. The bio-based value (necessary to calculate bioeconomy value as in table 1) of their production corresponds to the total of their production. The following data can only give an approximate value of Bioeconomy, given the lack of output data concerning the bio-based quote that belongs to the chemical, textile and energy industry. As consequence, it will be enumerated only the agri-food contribute to bioeconomy, which is the largest, and just a description of the principle’s realities in other fields (Clasadonte et al., 2013).

Overall, in 2019 the agri-food sector in Sicily produced an output of 4,588,193 thousand euros, employing over 85,000 people. In 2018 the agricultural enterprises were 81,162 and the food factories were 8,799. To deepen more the value of Bioeconomy in Sicily, the following table shows the production values of the main agri-food chain in the Island, which major contribute to generate output.

Table 1 – Bioeconomy value of agri-food in Sicily (2019)

	Production value 2018-2019 (thousand euros)	Variation (%)	Weight on regional production (%)
Cereals	238,523 – 242,735	1.8	6.580
Vegetables	826,361 – 968,483	17.2	26.300
Wine	371,155 – 322,196	- 13.2	7.820
Olive	228,782 – 266,527	16.5	6.710
Fruit and Citrus	1,167,238 – 978,828	- 16.1	29.180
Other chains	1,756,134 – 1,809,424	3	
Total	4,588,193		

Concerning the bio-based quotes of the other industrial field (energy, biofuels, chemical...), already listed in table

1. to quantify the value of Bioeconomy in Sicily, there is a lack of data, probably because it is a new reality, and an estimation of the production value has not yet been made. Despite this, in the following sections it will be quantified (as much as possible) describing bioeconomy in Sicily via management and recovery of bio-waste and circular economy of main business innovations.

The bioeconomy has a close relationship with the availability of local bio-feedstocks, and, therefore, with the possibility of developing economies and new jobs where this availability is present (Matarazzo et al., 2018).

2. Sicilian Bioeconomy values

The Sicilian bioeconomy is for obvious reasons related to the territory, and it is mainly based on agri-food (Matarazzo et al., 2019; Arfo' et al., 2020). In Sicily were born bio-districts, which, following specific guidelines, put in the system resources for environmental protection, the enhancement of crops and the promotion of consumption based on the bioeconomy (Bugge et al., 2018). The bio- districts are poles that valorize and put to system the unused resources of the territory, integrating production of energies and renewable materials. Among the projects they include:

- 1 Mwe and 4MWth cogeneration plants powered by biomass obtained from agri-forestry waste.
- Plant for the production of pressed pallets made exclusively with post-use wood.
- Hemp-based bioplastics for the reduction of petrochemical materials.
- Agri-energy chains aimed at the recovery and enhancement of plant and agri-food waste that can be used for the production of electricity/heat.

The total Sicilian production of organic fraction from Solid Urban Waste is 389,576 tons in 2019 out of a total amount of municipal waste of 2,233,278 tons. The municipal waste management data has been collected and divided according to the type of plant used for energy recovery or biological treatment (European Commission, 2018). As already mentioned in the previous section, waste must be managed in an integrated system able of maximising the resources that can be extracted from the waste, and minimising the impact by decreasing the amount released into the surrounding environment. It can be treated by:

- Recovery plants (e.g., composting if waste is collected separately, steelworks, etc.).
- Mechanical biological treatment plants (e.g., shredding and biostabilisation of undifferentiated waste) before final disposal in landfill.
- Incinerator, an industrial waste incineration plant to eliminate waste and produce energy with the heat produced by their combustion.

In Sicily, in which the plant equipment is very poor or completely inadequate, municipal waste disposed of in landfills account for 69% of the total waste produced (Castellano 2018). The municipal waste disposed of in landfill in 2018 amounted to about 1,582,000 tons and is managed by 11 landfills (Intesa Sanpaolo 2020). It should be noted at national level that, where an integrated waste cycle exists thanks to a developed plant park, the use of the

landfill is significantly reduced. The implementation of the Circular Economy, in fact, will oblige to reduce the production of waste, to recycle, by 2030, at least 65% of municipal waste and to reduce, by 2035, disposal in landfill to no more than 10% of the waste produced. It will therefore necessary to implement a management system that is able to ensure the achievement of these objectives (Kardung, 2021).

Tab. 2 – Composting plants in Sicily (2019)

Province	Number	Tot. Urban Waste (t)
Trapani	1	8,667
Palermo	3	14,094
Agrigento	2	17,319
Caltanissetta	1	8,793
Enna	1	154
Catania	11	191,814
Ragusa	1	25,062
Siracusa	1	4,896
Sicily	21	270,808

In Sicily, the percentage of separate collection amounted to 39,34% in 2019, of regional production; improving very little compared to 2018 (38,5%) but still recorded a very positive trend in the last decade (13,2% in 2012). While in the rest of Italy there is a real circular economy based on second raw materials obtained from separate collection, whose turnover exceeds 23 billion euros, in Sicily separate collection travels on very low percentages. Sicily and all its provinces still take the last places in Italy in the separate collection.

This paper shows the number of waste recovery and disposal plants in Sicily in 2019: 21 composting plants, one integrated anaerobic/aerobic plant and 8 mechanical-biological treatment plants. Currently, Sicily is still lacking in waste-to-energy plants and has anaerobic digestion; despite this, the plants for the treatment of organic fraction, presently in Sicily have a capacity exceeding the production of organic fraction on a regional scale. NGO proposals to remove obstacles and increase the development of the Circular Economy are various: The End of waste to increase the recycling of municipal and special waste; rifiuti zero and impianti mille to complete the plant system for recycling and reuse of waste, urban and special, making self-sufficient each region. Overall, in Sicily the sum of the biomass produced and the energy recovered in 2019, amounted to 101,621 tons. Table 2 shows the number of composting plants in the island and the overall produced quantity in each province.

In Sicily there are a total of 21 composting plants, which deal with 270.808 tons of municipal waste. It is immediate to note that the largest number of these plants is in the province of Catania, for a total of 11 plants. There are several considerations that come out from this: the provincial territory of Catania is already equipped with sufficient plant capacity compared to needs. But this is justified because it compensates the plant deficiencies of other provinces, first Messina, which is totally devoid of it. Finally, about 40.65% is mixed compost; 5.83% is green compost and about 53.54% are other soil improvers. In the Sicilian mechanical-biological treatment plants there is no real recovery of material, with rare exceptions, since what

comes out of the plant is destined almost entirely for disposal. This is because from the treatment that provides the initial shredding of waste, it is not possible to recover downstream fractions of recyclable materials that still exist in upstream. This is why in Sicily, with the exception of a plant (Caltanissetta), what falls into the mechanical-biological treatment plants, except for the process losses, goes almost entirely to disposal, considering that the material recovery is about 1%. In total there are eight plants of this type, mainly concentrated in the province of Palermo. The output of the plants destined for material recovery is low, only 537 tons compared to the amount of waste treated: 791.446 tons.

The exposed data prove that if on one hand the willingness of the Regional Government to improve treatment processes seems promising and aims to lay the foundations for a healthy economy. This starts from the Circular Economy, on the other hand it is clear that an effort is missing. In order to avoid, for example, areas with capacity that is exorbitant with respect to needs, and other areas that are totally unmanned. Or through rewarding criteria for sustainable technological choices for the new plants to be built, for example, by targeting at least one anaerobic digestion plant with production of biomethane for each territorial area (McCormick and Kautto, 2013).

Tab. 3 – Mechanical-biological treatment plants in Sicily (2019)

Province	Number	Tot. Urban waste (t)
Trapani	2	92,348
Palermo	3	353,115
Caltanissetta	1	3,244
Catania	1	295,024
Ragusa	1	47,715
Sicily	8	791,446

Regional planning would therefore require a commitment to analyze, on a territory-by-territory basis, the needs and the associated plant capacity, so that only the necessary facilities will be available, avoiding long movements of waste, and with the most sustainable technological choices. It happens, in fact, that there are territorial areas today totally without plants for the treatment of the organic fraction and without any plant in anticipation: for these territorial areas the Sicilian Region in the new Waste Management Plan restrict itself to support some private initiative, avoiding that the organic fraction produced must be transported to plants in Catania and/or Palermo. To overcome these critical issues, actions should be taken on several fronts by the institutions, professionals and citizens: making every territorial area self-sufficient; adopting effective control systems throughout the waste chain; improving regional coordination on waste reduction (Notarnicola, 2017).

To conclude, the improvement that nowadays is recorded from the data of the differentiated collection in the last years to the first steps of a Sicilian circular economy, is supported by an increasing number of citizens aware of the need for a change of direction towards sustainable lifestyles (Pfau, 2014). The Sicilian reality that surrounds us is increasingly made up by citizens who look at biological, food waste, textiles from agricultural waste, bioplastics and so on; certainly, in the right direction towards a market

no longer niche, but a real productive growing sector. The road on which to move is long but possible. However, the attention of the citizens must then be supported by real and efficient institutional actions on the territories, which focus mainly on the quality of differentiated collection, technological choices and administrative choices (Scotti, 2012). The Region of Sicily boasts an agri-food sector of primary importance: the territory hosts some realities of excellence in the field of Circular Bioeconomy both at the productive level and at the level of private and public research. Sicily have 37 start-ups belonging to the Bioeconomy, a figure that represents 6,4% of the national total and 8,8% of the total number of innovative start-ups in the region, a figure higher than the national average that stops at 7%.

3. Results and discussion

Ultimately, it is immediate to notice that the Sicilian agri-food is more and more aiming at finding a concrete solution to the specific problem of the valorization of the waste and the by-products of the agricultural productions, paying particular attention to the transfer to the companies' partners of new opportunities to increase the added value of their products. It is clear that Bioeconomy in Sicily is a reality still completely new and in phase of development, compared to the Italian and European objectives. Nevertheless, according to the Sicilian agri-food industry, the production of high-quality elements, that are increasingly appreciated by the global market, is surely strategic. However, an efficient production system must ensure the correct placement of all the outputs in the supply chains, and therefore exploit waste, by-products and production surpluses. It is then necessary to find a cost-effective and rational way of using waste that allows high added value products to be obtained which can also be sold in commercial sectors other than traditional food. Moreover, the increase in biological farming in recent years in Sicily, given the large prevalence of arable land and favorable Mediterranean climate, is closely linked to bioeconomic performance, aimed at sustainable production. It benefits not only in terms of protecting the environment, but also ensures increasing demand for biological products. Nowadays, agri-food is at the centre of a major project of innovation and ecological transition, which involves the entire supply chain: businesses and industry representatives, consumers and citizens should be models of sustainable consumption and catering, a point of contact between production and consumption, a place where citizens are effectively called to make their concrete choices. In Sicily, the products of territorial quality DOP and IGP, protected for many years by the European Union as excellence of territory, have a priority role in educating a new paradigm of production, distribution and consumption: in order to do so, it is essential to promote comparisons between all the sectors of the supply chain (Ingrao et al., 2021).

To conclude, we underline that the pandemic emergency has totally upset the economy of the Country and radically changed the approach of the consumer with agri-food products. The buyer of the post Covid pays much more attention to the origin of the product and its sustainability, both from an environmental and economic point of view. In the light of a paradigm shift, it becomes even more

important for territories to value and promote themselves by aggregating and networking with their own excellences.

4. Conclusions

Circular Economy as well as biological farming has seen, in recent years, a steady increase in demand from consumers and an increasing interest of the Institutions, both at the level of Community European Agricultural Policy, and at national and regional level. The challenge facing agriculture in terms of sustainable development, bioeconomy and the green economy is to meet a growing demand for food from a growing world population, through practices and techniques that do not reduce or possibly increase productivity, while contributing to poverty alleviation, reducing negative environmental externalities and improving the supply of environmental services. The sustainability of agricultural systems incorporates the concepts of the ability of a system to react to shock and stress and the persistence, understood as the ability of a system to last in the long term.

The nature of the bioeconomy is such that it can address some of the inter-related challenges posed by food safety, which is confronted with the scarcity of natural resources and the dependence of some countries on oil and fossil energy resources, and that has to deal with climate change, while ensuring growth and development. The Sicilian bioeconomy needs more research, as well as infrastructure, which is still lacking. This is necessary to adapt to the fast and increasing changes in the Italian and especially European framework. First, it is crucial to focus on Small-Medium companies that use small plants. In Italy, only the Northern regions are taking more substantial measures to adapt to the European context of the Circular Economy and the Bioeconomy. On this front, the South, including Sicily, is still behind, but with great potential for its development; the main attention is turned to innovative start-up revolutions.

Concerning the Green Deal, at European level, the new Circular Economy Action Plan and the new Industrial Strategy are moving to the direction of accelerating the transition to circularity. Europe stresses that the transition to a Circular Economy is one of the necessary conditions for achieving climate neutrality by 2050. Waste management is a fundamental element of the Circular Economy, because the recovery of materials or energy is necessary to close cycles and provide a continuous flow of resources. To address this, all Countries will act also upstream, before a product becomes waste, through a commitment to reduce the consumption of natural resources by eco-design, the use of renewable resources and innovation. This last plays a key role in the transition to Bioeconomy, creating new technologies, processes, services and business models; all this is necessary to explore and what discoveries will change our lifestyle, already in continuous change.

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