AWeS0Me

Agricultural WastE as Sustainable 0 km building MatErial

DELIVERABLE D.T2.1.1

REPORT ON AVAILABLE AGRO-WASTE

Project number: ITALME-419

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Activity A.T2.1. This activity consists in performing an analysis of the state-of-the-art of the main agro- waste available in the involved countries considering the suitability of these residues to be used as new raw materials for the production of building components. The main goal of this activity is the production of a snapshot of the current regional situation regarding the availability and the technical eligibility of the agro- waste in the building sector. Availability on the market of products already based on the use of agro-waste will also be investigated, in order to avoid duplication and possibly use them in the subsequent steps. The activity is in view of the subsequent realization of building prototypes and demonstrators.

Deliverable D.T2.1.1. The report summarizes the agro-waste available in each region in order to identify which residues could be inserted in a circular economy system and could be suitably reused as raw materials for the production of building components.

Dissemination level: PU - Public

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Table of contents

1. Introduction

Several studies predict that by 2050 the world will be consuming as if there were three. Consumption of biomass, fossil fuels, metals and minerals is expected to double in the next forty years, while annual waste generation is projected to increase by 70% by 2050. A complementary and multidisciplinary strategy for a climate-neutral, resource-efficient and competitive economy was launched by European Green Deal (Circular economy action plan, 2020).

Half of total greenhouse gas emissions and more than 90% of biodiversity loss and water stress come from resource extraction and processing.

The European Community has given priority to circular economy policies providing research support on the waste-related aspects of the circular economy. To that end, it has been built with stakeholder experts the propose of end-waste criteria, safety and quality requirements for recycled materials. Reference information on best available techniques and best practices were performed, carrying out techno-economic and environmental assessments of recycling processes, waste disposal options and waste-to-energy options.

The promotion of circular economy is one of the main pillar indispensable to achieve climate neutrality by 2050 assuring the economy growth together with the sustainable ambition. Irreversible transition to a sustainable economic system represents a fundamental part of the European strategy with the aim to promote the circular economy and to provide new business opportunities. Recent studies demonstrate that circular economy has the potential to increase EU GDP by an additional 0.5% by 2030 creating approximately new jobs.

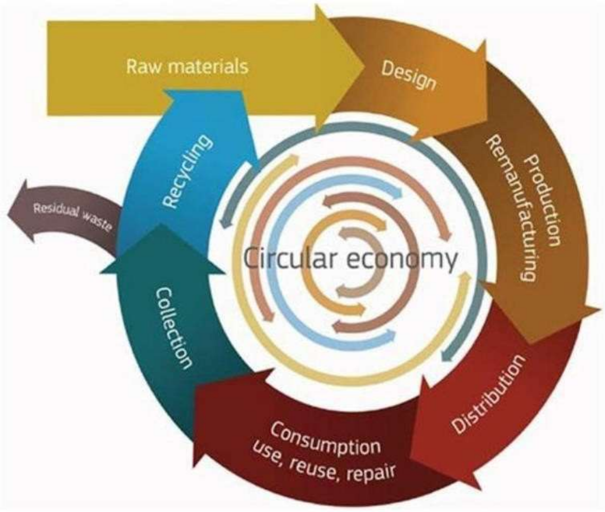


Fig. 1. Schematic representation of the Circular Economy concept
(Source: Circular economy – the way to a sustainable future (fcc-group.eu)).

From this perspective, agricultural wastes have become a big issue as they may cause significant environmental problems deriving from the burning in field or from the expensive disposal. Biomass burning has a significant impact on environmental quality, public health, and climate change worldwide. This practice causes the emission of particulate pollutants as CO_2 and CO, and fine particulate matter. This provokes an hazardous impact on human mortality as well as respiratory and cardiovascular diseases. However, the biomass may also be used for several beneficial purposes, as feed stock for energy production, for chemical recovery or as new raw matter in building components. Khan et al. (2009) affirmed that biomass accounts for only about 9% to 14% of energy sources in industrialized and developing countries. Pereira et al. (2015) demonstrated that biomass energy production can be regarded as a renewable energy process not emitting additional carbon dioxide into the ecosystem. The potential use of the agro-waste in building components plays an important role for the sustainability. Thus, the by-products derived from the agriculture can be considered as sustainable alternative aggregates in construction instead of cement. Ismail et al. (1996) demonstrate the replace of 10-30% of cement with agro-waste to achieve high-strength concrete. A great number of international studies have shown the significance and the potential of agro-wastes (Tangchirapat, 2007; Asdrubali, 2005; Barrecha and Ficheira, 2013). Several countries, with an agricultural vocation are paying a lot of attention to the proper utilization of agricultural waste. In Thailand, for example, the utilization of palm oil ash is a great concern, as the palm oil industry plays an important role in local agro-industries (Asdrubali et al., 2005).

2. Working methodology

The purpose of this report is to provide a snapshot of the agro-waste production in the countries involved in the project AWeS0Me (Puglia, Molise, Montenegro, Albania). At first it is shown the current situation about the actual agro-waste use and the main common way adopted to dispose the residues. Moreover, a general European framework is shown. In a second detailed phase, to gather information about the actual amount of waste production in each country involved in the present project, a focus on agricultural residues production is performed.

3. Agriculture and agro-waste

World Health Organization (WHO) defines agriculture as all kinds of activity concerning growing, harvesting, and primarily processing of all kinds of crops including breeding, raising and caring for animals and including tending gardens and nurseries (Jager, 2005). Agriculture is the largest contributor of any resource sector to the economy of lot of European countries.

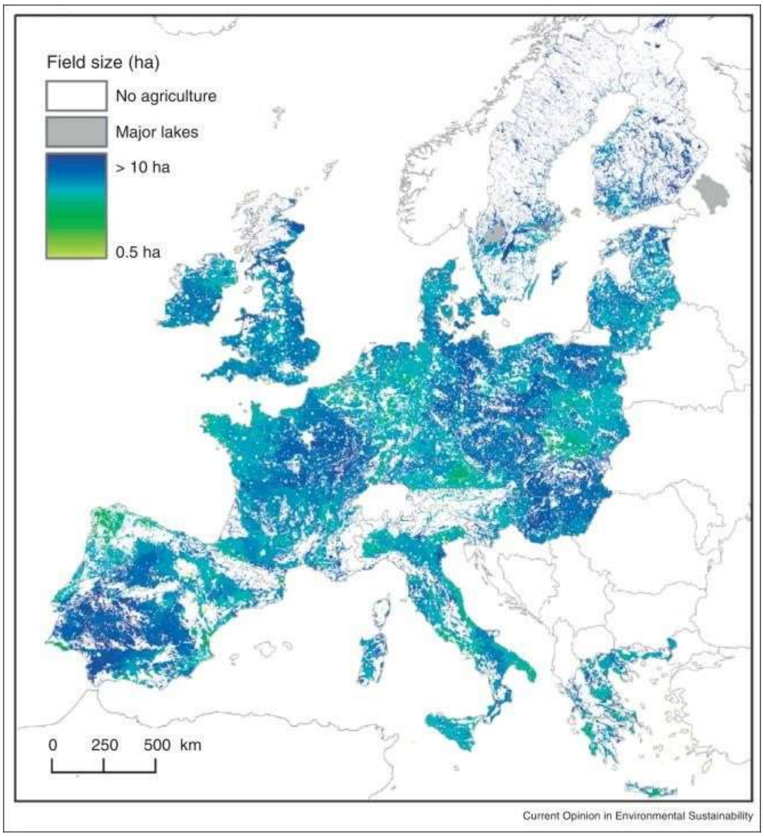


Fig.2. Map of cropland field sizes for Europe derived from interpolating ground-based survey data from
the Land Use/Cover Area Frame Survey (LUCAS) of the European Union using an ordinary Kriging approach. Source: LUCAS primary data 2009, (Source:http://epp.eurostat.ec.europa.eu/portal/page/portal/lucas/data/lucas_primary_data)

According to Lim et al. (2015) agro-waste is defined as waste which is produced from various agriculture activities. These by products can include manures, bedding, plant stalks, hulls, leaves, and vegetable matter. Agro-waste produced by farming activities is useless and it is discarded. The disposal of these kind of waste
represents a great concern because it may affect health, safety and sustainability of the environment. Currently, the common agricultural waste disposal methods include burning, dumping, land filling, random piling and so on. All these methods may cause pollution. Particulates (PM) refers to fine solid matter dispersed and spread by air movement; it is generated during the agricultural operations and processes. The human health is affected as the PM penetrates into the respiratory system. PM10,

produced by the burning in field, is generally defined as all particles equal to and less than 10 microns in aerodynamic diameter. The burning of the stubbles is one of the often preferred practice to remove the harvest leftovers from the field. Commonly, in areas where second crop production is a practice, stubble burning help to save time before planting. The smoke produced from burning in field, however, is very hazardous to the people living adjacent areas.

Fig.3 Agricultural waste burnt in field

According to Esparcia (2014) most of the waste comes from the building sector (33.5%) and the mining and quarrying sector (29.8%) while households take up to 8% of the total waste production. Agriculture, forestry and fishing are at the bottom of the list with 1.4% of the total waste production. Bedoic et al. (2019) affirmed that Agricultural Waste, Co-products and By-products (AWCB) could assume a significant role in the world's production of animal feed. The authors presented the estimated quantity of AWCB per capita classifying them in four categories from 2010 to 2016.

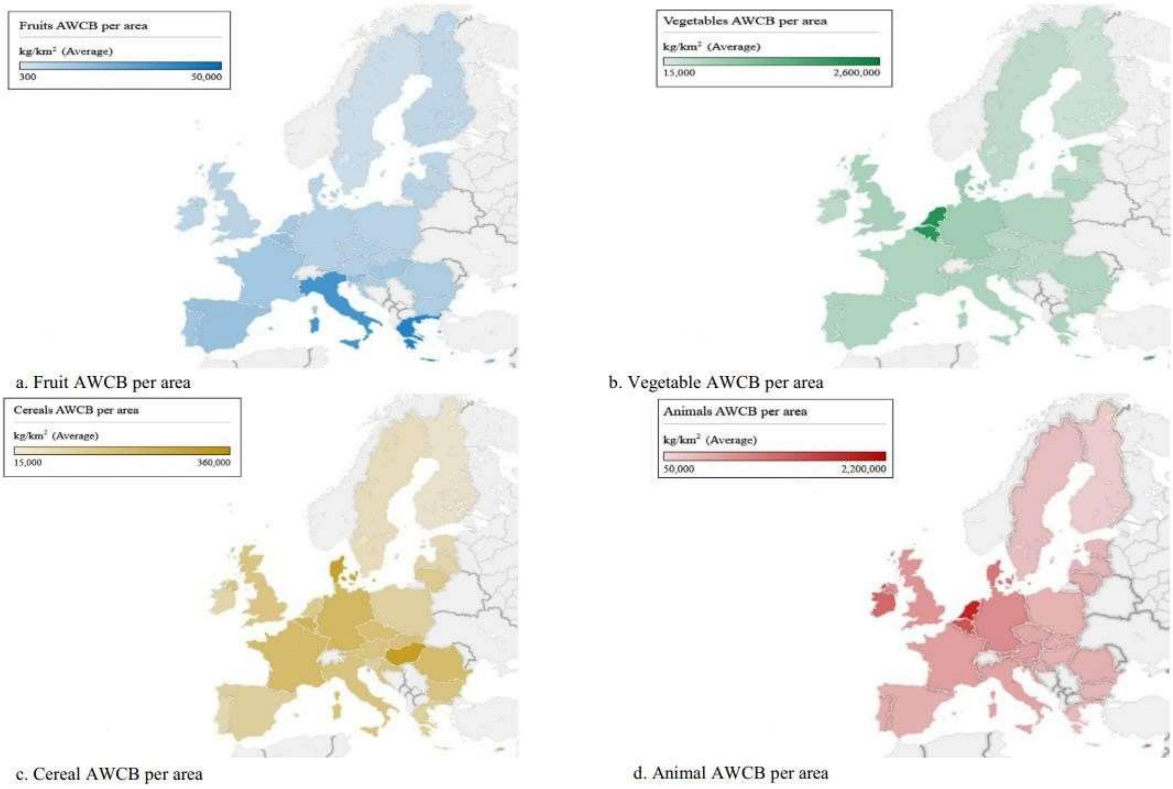


Fig 4. The average quantity of AWCB produced in Europe from all sectors per area in the period 2010–2016. Fruits AWCB (a), Vegetable AWCB (b), Cereal AWCB (c), Animal AWCB (d) (Source: Bedoic et al.,2019)

Sortino et al. (2014) reported that municipal bio-waste could substitute the synthetic chemicals for the depollution of contaminated soil and waters. Malico et al. (2016) evaluates the positive effect derived from the use of forest and agricultural residues for the production of bioenergy in the rural area of Portugal. Asdrubali et al. (2015) demonstrated that the biomass residues play an important role in the production of insulation materials for building applications.

4. Agriculture and agro-waste

The building sector is experiencing an increasing pressure to use "greener" and more sustainable materials, possibly based on natural and bio-based products which, independent of their increased costs, are capable of reducing the environmental impact while improving indoor environment quality and reducing energy consumptions (Liuzzi et al., 2015). Within this framework, bio-based materials obtained from by-products of agriculture represents an interesting alternative to those with from fossil carbon (Mati-Baouche et al., 2014). The use of biomass-based building materials received a significant boost (Ashour et al., 2011; Palumbo et al., 2016; Binici et al., 2016; Liuzzi et al., 2017). Liu et al. (2017) performed a statistical analysis about the studies affecting the potential use of the agro-waste as building components. It was demonstrated several applications are feasible using the agricultural waste as raw matter: panels, blocks, vegetable biomasses, multi-layer solutions, particles, slurries, and coils, etc.

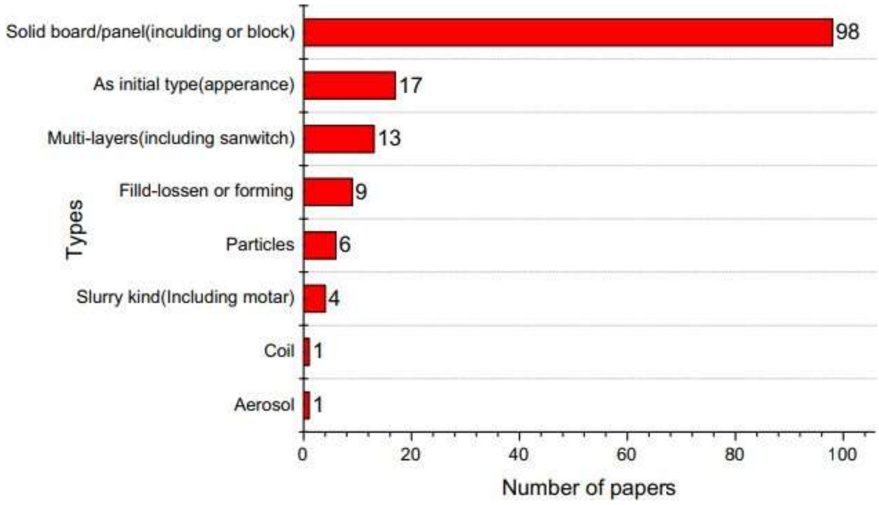


Fig. 5 Statistical analysis about the number of studies performed of different kind of insulating materials (Source: Liu et al., 2017)

Usually, the biomass after cutting from the pruning in field were drying and smashing or crushing, etc. Some kinds of residues, as straws, can be used as they are directly. However, most biomasses need extra treatments to obtain the final product. And then, the scraps will be mixed with other components or treated by chemical agents in order to achieve fire resistance, mechanical, acoustic and thermal properties. Different manufacturing methods currently exist.
Liu et al. (2017) classified the production methods into seven different categories as summarized in table 1: bonding moulding, pressing moulding, hot-pressing molding, injection molding, foaming molding, in natural (original/raw) form and others. The manufacturing method called bonding molding requests the use of one kind of binder. The curing process takes place at ambient temperature and pressure. The hot-pressing molding does not request any kind of binder; high temperature and pressure are used to bind the different components. The injection molding predicts the use of liquid form solution injected into a mold; the curing time is a long period of time.

Prusty et al. (2016) described the possibility to use agro-waste as sugarcane bagasse ash, giant reed, groundnut shell, oyster shell, rice husk ash and cork as concrete aggregate in order to improve the physical properties. The major differences occurring between these residues are the place from where they collected and the processes to convert into a fine aggregate. Figure 6 shows the different steps of the process of conversion of different vegetable biomasses into new raw matter mainly used as fine aggregates replaced in concrete. Sugarcane biomass is used as fine aggregate replacement in concrete. Giant reed is agricultural species which placed all over the world. Rice husk is one of the fundamental agrarian waste obtained from the external covering of rice grains. Cork is an eco-friendly and useful material deriving from cork oak trees growing in northwest Africa and southwest Europe. Cork is a heavy-duty, waterproof, fire retardant, flexible, and environmentally friendly material. It has very good insulating properties as well.

Asdrubali et al. (2015) illustrated the main hygrothermal and acoustic properties of innovative building materials with natural fibers (i.e. bagasse, cotton, straw), considering the possibility to convert the agricultural by-products into new raw matter for the creation of building insulation panels.

Table 1. Typical manufacturing method (adapted from Liu et. al., 2017)

Manufacturing methods	**Explanation**
Bonding	By help of at least one binder, such as glue, to make one or more kinds of loose/particle materials to form a whole body.
Pressing	By help of high pressing at environmental temperature, to make one or more kinds of loose materials to form a whole body.
Hot-pressing	By help of high pressing at a relative higher temperature, to make one or more kinds of loose materials to form a whole body.
Injection	A magma is first produced, and then the solution is injected into a mold at a specified pressure.
Foaming	Generate a porous structure in solid materials by physical or chemical foaming methods.
Natural form	Biomasses are packaged directly from raw type (e.g. straws bales with tight or loose structures).
Other	Such as needle-punching, hydro-entanglement, aerosol processing. etc.

Fig.6 (From top to bottom) Processes to produce sugarcane bagasse ash, giant reed fibres and its ash, rice husk ash, cork processing aggregates. (Source: Prusty et al., 2016)


Fig.7 Sound sorption absorber made with almond skin waste (Liuzzi et al, 2020)

A number of common issues have emerged through a review of international literature on agricultural waste. Fibrous agricultural materials are suitable for thermal and acoustical purposes. However, due to the non- homogeneous structural characteristics of some natural fibers, different configurations and binders should be undertaken to identify reliable combinations. The manufacturing process is one of the factor affecting the characteristics of insulation materials. Several and different possible combination of agro-waste can be considered for implementation within the construction industry. Balador et al. (2017) summarized the key issues emerging from different literature studies. Table 2 provide a synthesis.

Table 2-Advantages and disadvantages of agricultural by-products as insulation products. (Adapted from Balador et al., 2017)

Advantages	**Disadvantages**
Low thermal conductivity	Non-load bearing
Self-link	Thicker
Fast renovation	Treatment
Abundant	Non-homogenous
Natural	Variation
High specific heat	Unsuccessful theoretical models
High damping	Non-fire resistant
Bio-degradable	Hazardous additives
Cost-effective	Contaminants
Lower environmental impacts	
Energy efficient	
Less emissions	
Renewable resources	
No skin irritation	
Non- toxic	

This activity consisted in performing an analysis of the state-of-the-art of the main agro-waste available in the involved Regions, and considering the suitability of these residues to be used as new raw materials for the production of building components. The main goal of this activity was the production

of a snapshot of the current regional situation regarding the availability and the technical eligibility of the agro-waste in the building sector.
Availability on the market of products already based on the use of agro-waste were also investigated, in order to avoid duplication and possibly use them in the subsequent steps and in particular in the realization of building prototypes and demonstrators.

5. Italy: Puglia and Molise

In Italy the Registry of the Waste was instituted by the article 3 of the national decree 9 September 1988 n.397, converted, with changes, by the law November 9th 1988, n.475.
The Registry is organized in a national section by the Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) and in regional sections. Furthermore, a telematic registry exists.
According to the current law, the wastes are classified, according to the origin, in urban waste and special waste.

Fig.8 Special waste life cycle

Considering the riskiness, they are distinguished in hazardous and no-hazardous waste. The article 184, sub 3 of the legislative decree n. 152/2006 states that the agricultural residues belong to the category "special waste". In this category are included the residues derived from agricultural, agro-industrial, sylviculture and fishing activities. The Italian institute ISPRA (2021) estimated that the agro-waste production in Italy in 2018 was 324.370 tons and in 2019 was 311.001 tons with a slight inflection of the total amount. Actually, these number seem to be underestimated; probably they consider the waste disposed with fee. As a matter of fact, national production of the special waste (decree n.152/2006) asserted that the subjects involved are

obligated to declare the amount of the waste produced, transported and recovered in the previous year. In 2018 the national production of all the special waste amounted to 143,5 million tons. Between 2017 and 2018 an increase of the total production was registered. In particular it was recorded an increase of 4,2 million tons of no toxic waste (+ 3,3%) and of 376 mile tons of toxic waste (+3,9%). The national institute ISPRA estimated that just 2,2% of the waste originated from agriculture, hunting, fishing and food preparation can be considered hazardous.

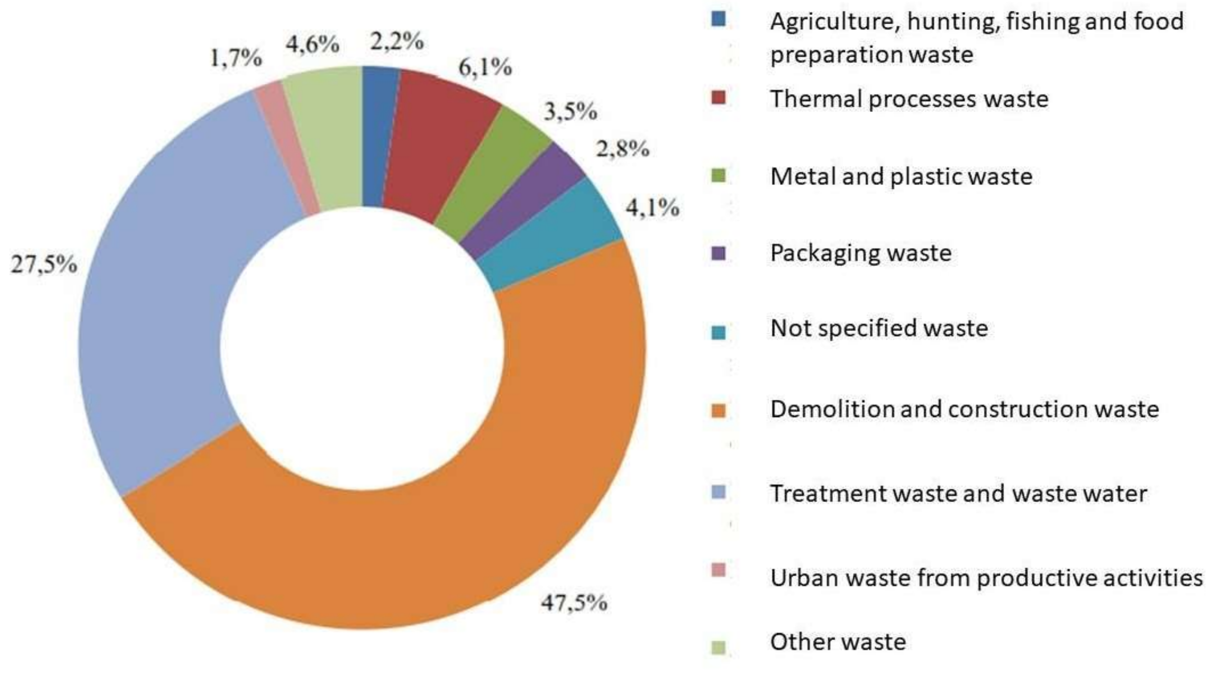


Fig.9 Italy, percentage repartition of not hazardous urban waste per waste type
(Adapted from: Rapporto rifiuti speciali, ISPRA Edizione 2021)

The same national research institute ISPRA has also defined the good practices adopted in the different regions collecting them in a national database GELSO (GEstione Locale SOstenibile). The sustainable projects accepted in the database are selected considering different criteria: environmental, social and economic sustainability. The map in the figure 10 underlines the area in which there were adopted good practises. It can be note that in Puglia the district of Bari and Lecce are involved in the renewable energy use good practices.

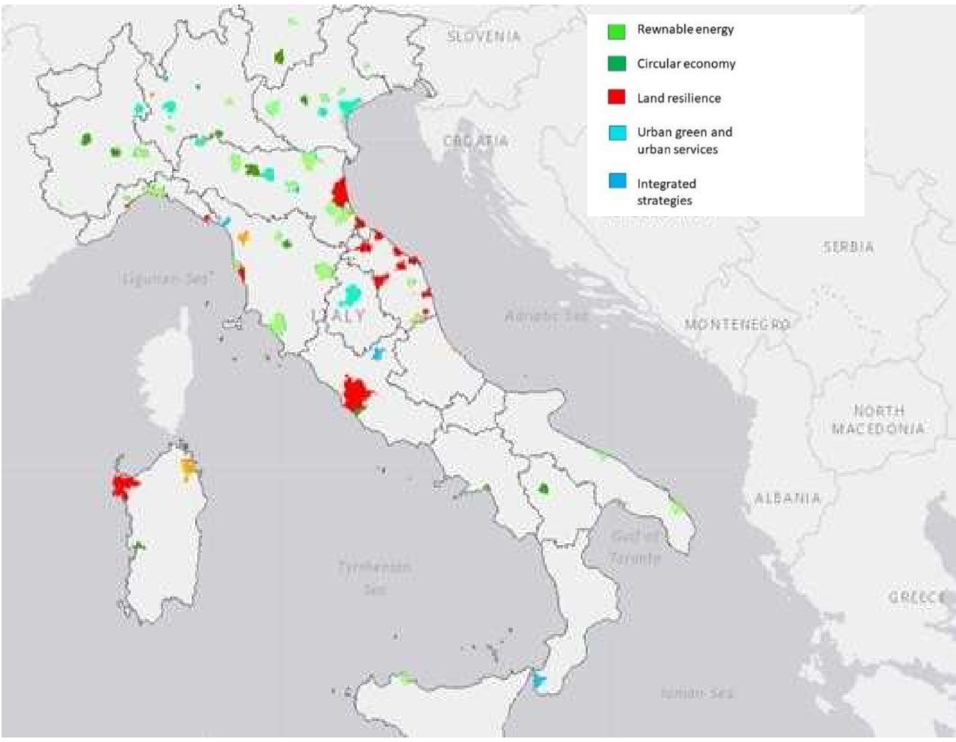


Fig.10 Circular economy, good practices (Source: Economia Circolare (isprambiente.it))

Bioenergy is the main contributor in the distribution of renewable gross final energy consumption in EU27 (Eurostat, 2019). Solid biomass, biofuels, biogas and renewable municipal waste are currently the most strategies common used in the heating and transport sector, whereas their contribution to electricity production is still less substantial. Currently, bioenergy plays a relevant role in Italy and it is the most important sector in which the agro-waste are mainly used.

In Italy marked differences between the regions actually exist (Moliner et al., 2021), showcasing disparities in economic and technological development. The northern regions have a more industrialized vocation, while the southern regions are mainly agrarian. Southern Italy is generally considered to include eight regions: Abruzzo, Apulia, Basilicata, Calabria, Campania, Molise, Sardinia and Sicily. Despite the division, southern regions do not seems to be poor in terms of renewable energy. Meleddu and Pulina (2018) affirmed that Southern Italy regions produced more renewable energy comparing to the national average.

According to the FAOSTAT (Food and Agriculture Organization of the United Nations) about 393 × 106 tons of agricultural residues were burned on field in the world in 2017, contributing to the increase if the environmental pollution. Of this quantity it was estimated that 1.50 × 106 ton were burned in Italy.

Any significant increase in the general production of special waste can be appreciated in Molise region from 2018 to 2019 (fig.11). However, in Puglia, in the same period, a significant increase can be note. Considering the annual regional incidence of special waste production on national base (fig.12) it can be asserted that Puglia reaches the maximum incidence of the southern area.

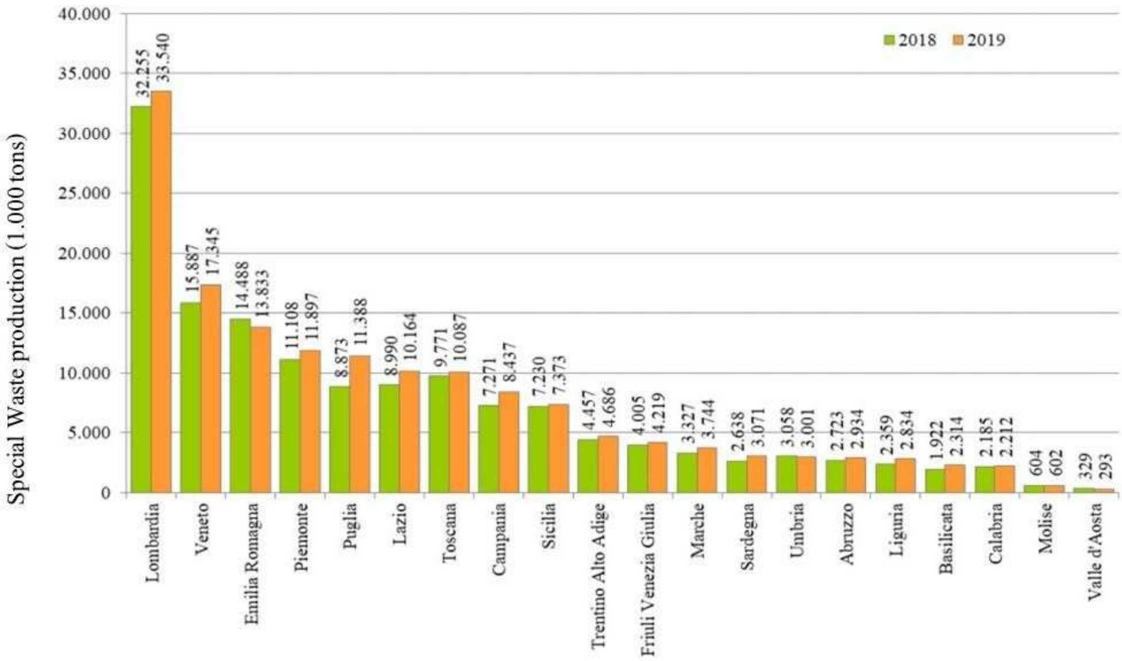


Fig.11 Total production of special waste at regional level from 2018 to 2019
(Source: Rapporto rifiuti speciali, ISPRA Edizione 2021)

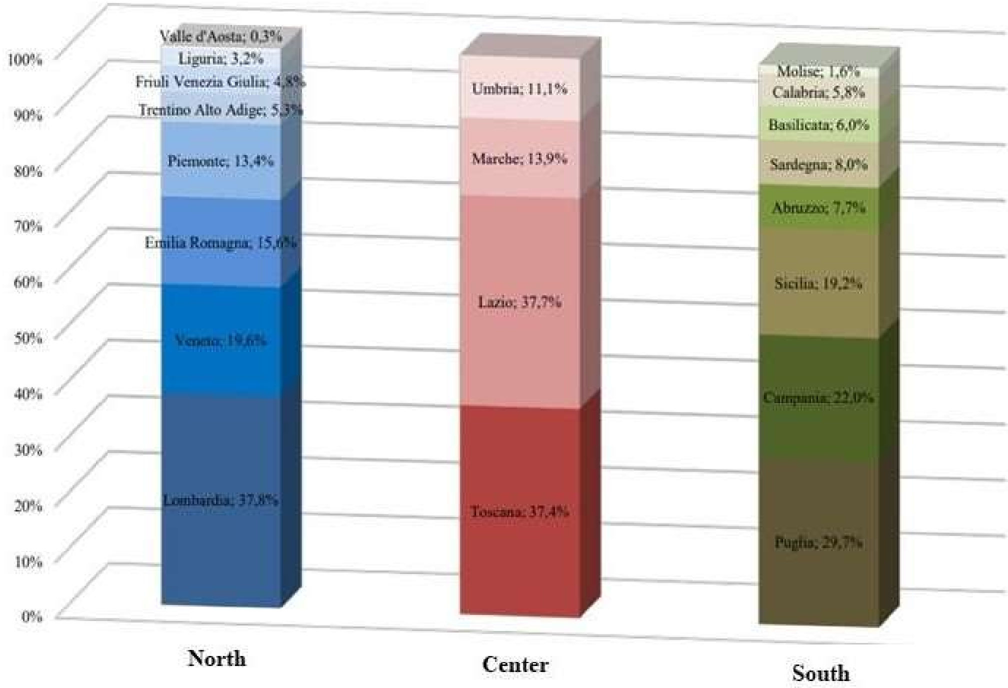


Fig. 12 Incidence percentage of the regional production of special waste according to the macro area (Source: Rapporto rifiuti speciali, ISPRA Edizione 2021)

The national Registry of Waste highlights that in Puglia there is a significant contribution of the agriculture sector to the increase of not-hazardous residues (fig.13-14). On the contrary, in Molise the agriculture sector does not play a significant role on the production of not-hazardous residues (fig. 15-16).

The data highlight that, in general, Southern Italy has a vast production of agricultural residues and generates most of the pruning and pomace residues of the whole country. These numbers further prove the potential of agricultural residues for energy production. Even though technological or logistic limits, the amounts of agro-waste in the Southern regions would bring enormous advantages to the Italian energy system and to the environment.

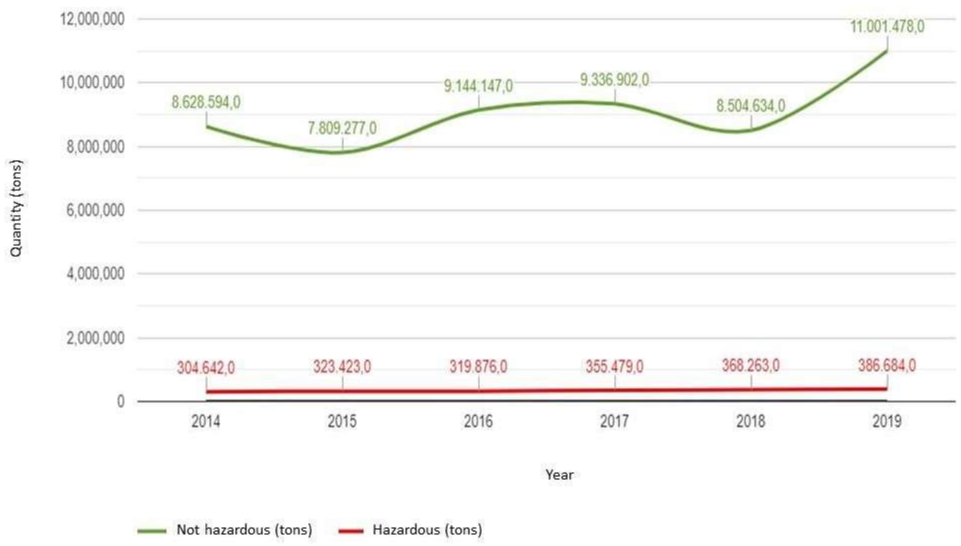


Fig.13 Solid waste production distinguished in hazardous and not hazardous in Puglia region (Source: ISPRA – Catasto dei rifiuti)

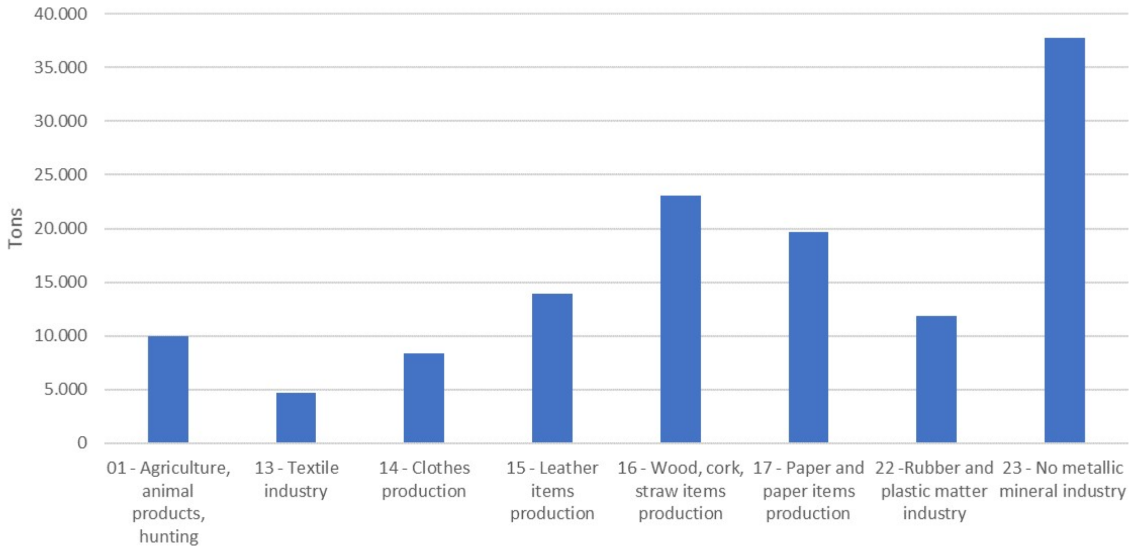


Fig.14 Not hazardous waste production (tons) in Puglia considering different activities - 2019 (Adapted from ISPRA – Catasto dei rifiuti)

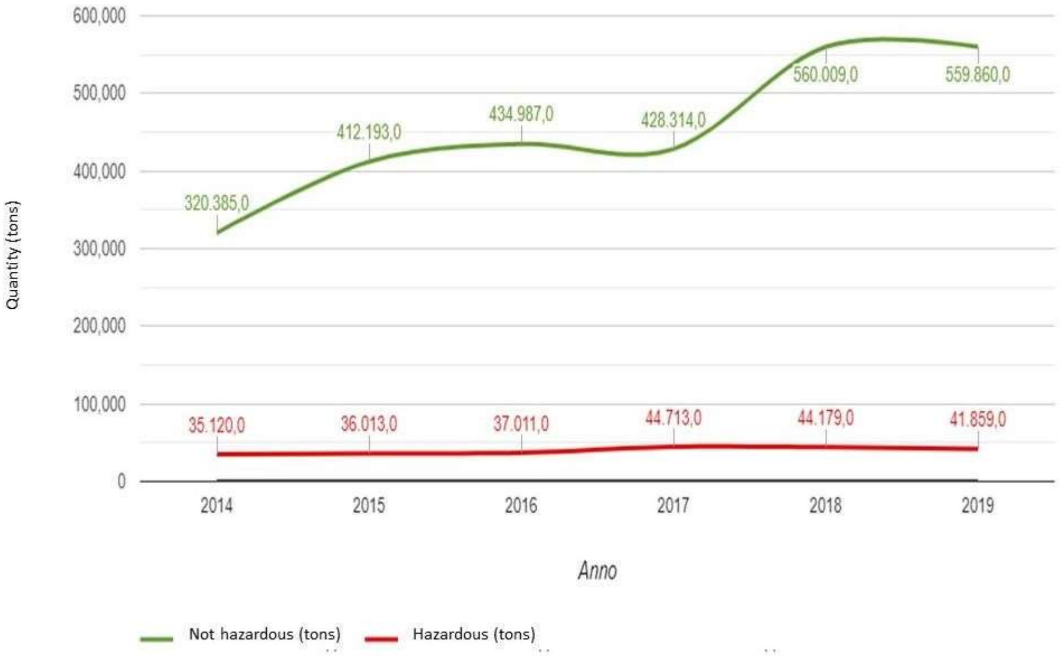


Fig.15 Solid waste production distinguished in hazardous and not hazardous in Molise. (Source: ISPRA – Catasto dei rifiuti)

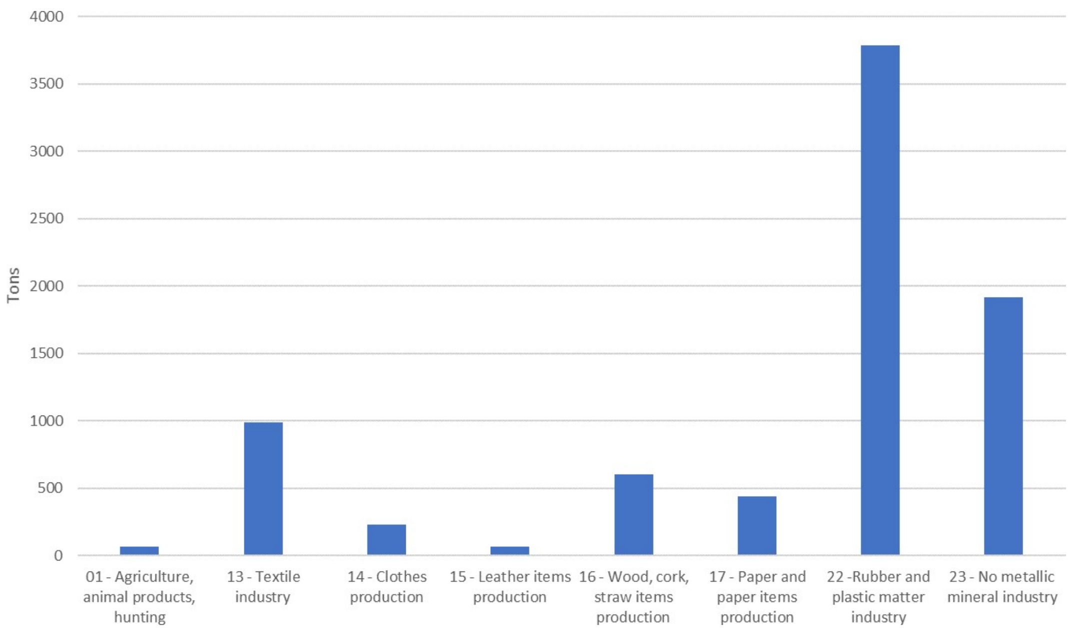


Fig.16 Not hazardous waste production (tons) in Molise Region considering different activities - 2019 (Adapted from ISPRA – Catasto dei rifiuti)

In general according to CORINE Land Cover 2000 (CLC2000) cartography it can be observed that Puglia has mainly an agricultural vocation, with a great concentration of vineyard, fruit trees and olive groves. On the other side, Molise shows a great concentration of broad-leaved forests and non-irrigated arable land.

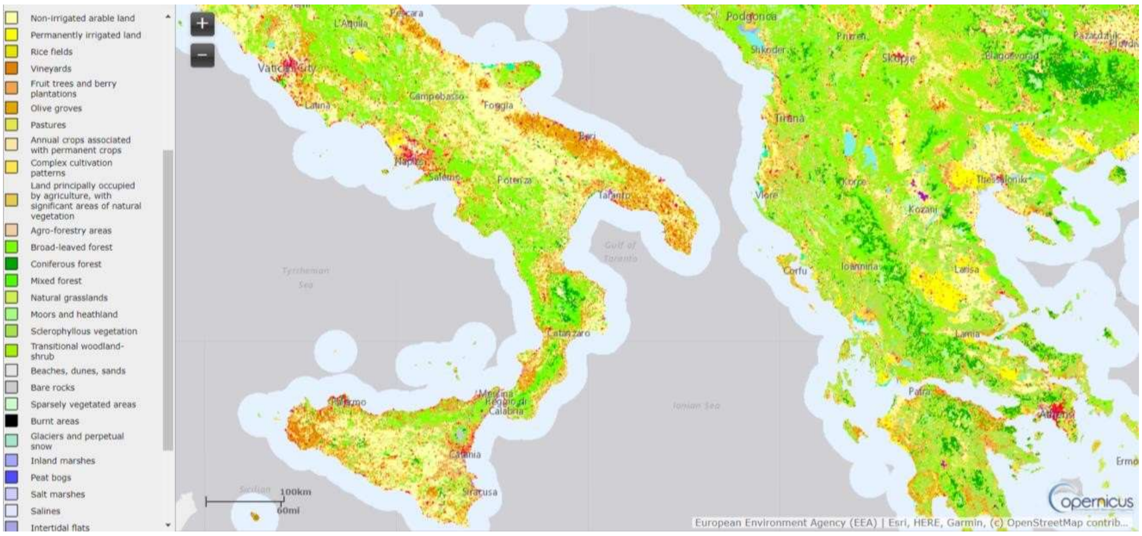


Fig. 17 CORINE Land Cover 2000 (CLC2000) (Source: CLC 2000 — Copernicus Land Monitoring Service)

The most detailed analysis on the agro-waste production is the study performed by ENEA (2009) which provides the values of the biomass potential for different kind of agricultural plantations considering the different regions.

Apulia is characterised by a great variety of plants, in relation to is morphological conformation, and it is also one of the Italian regions poorest in forest vegetation due to a long tradition of agricultural activities. Fig.18 highlights that in Puglia there is a significant contribution by straw and pruning to the biomass for energy use. Figure 19 underlines the different productions in the main districts. Spada and Dipaola (2008) affirmed that within the region the situation is not homogeneous: most of the woodland vegetation is located in the province of Foggia, which represents the most extensive surface area, at 56 thousand ha, corresponding to 48.6% of the regional total; next is the province of Taranto (25.5%), Bari (21.5%) and, with lesser values, Lecce (2.6%) and Brindisi (1.8%).

As consequence, it can be appreciated, by fig. 20 that Foggia has the highest availability of dry biomass within the region.

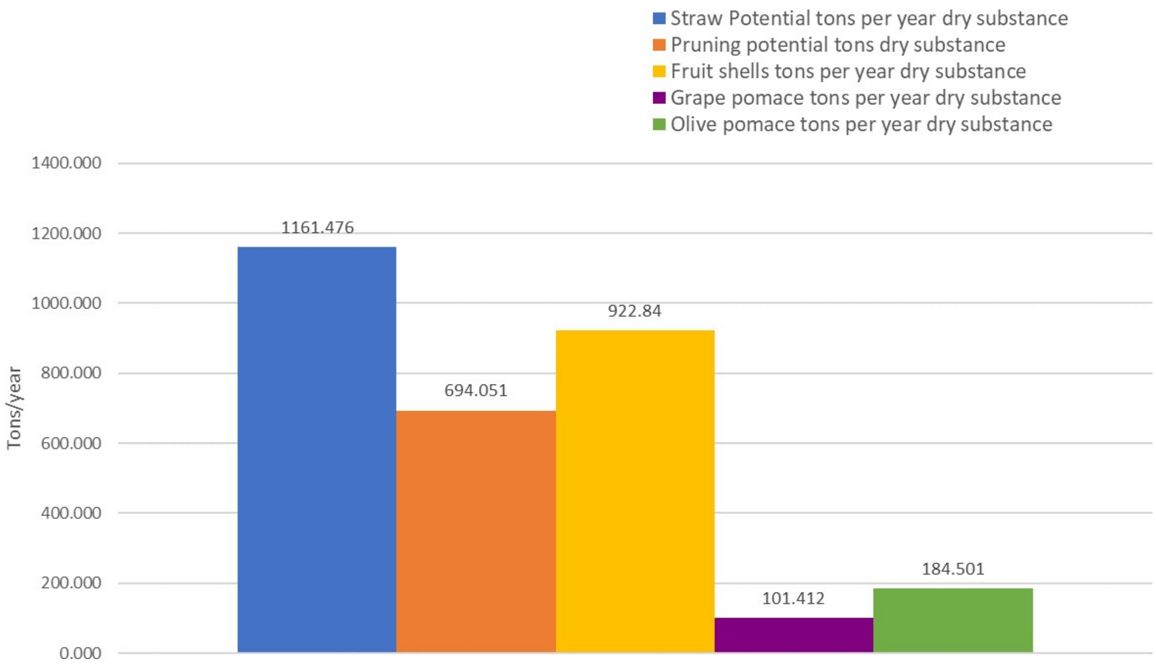


Fig.18 PUGLIA: Biomass potential produced by different agro-waste in the Region, dry fraction. (Adapted from ENEA, Report RSE/2009/16 ENEA)

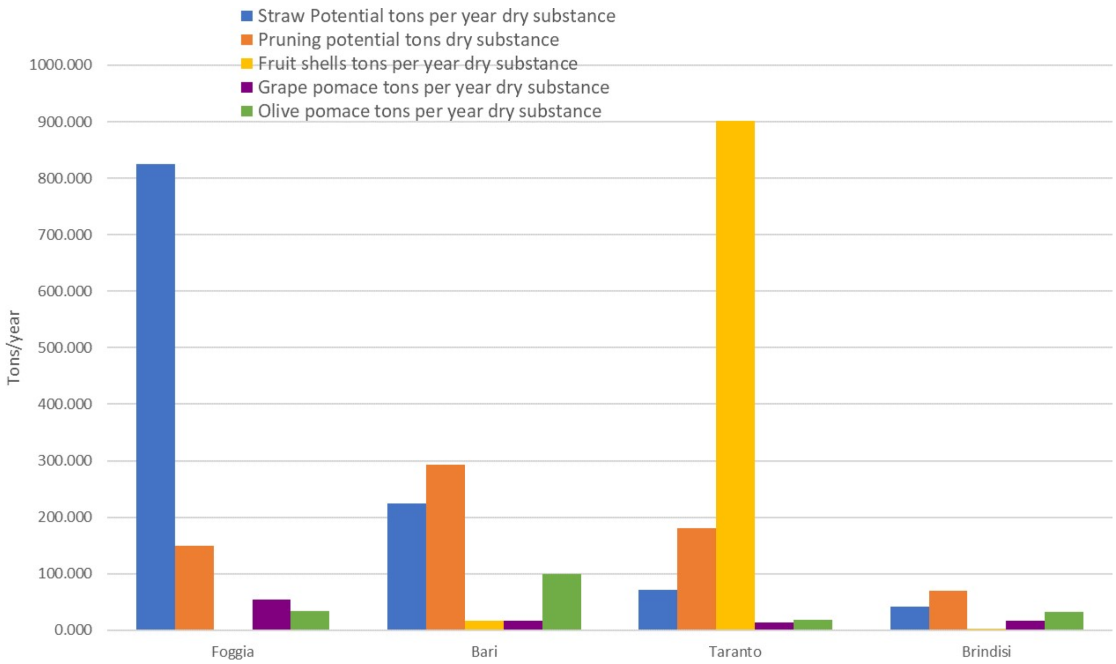


Fig.19 PUGLIA: Biomass potential produced by different agro-waste in the main provinces, dry fraction. (Adapted from ENEA, Report RSE/2009/16 ENEA)

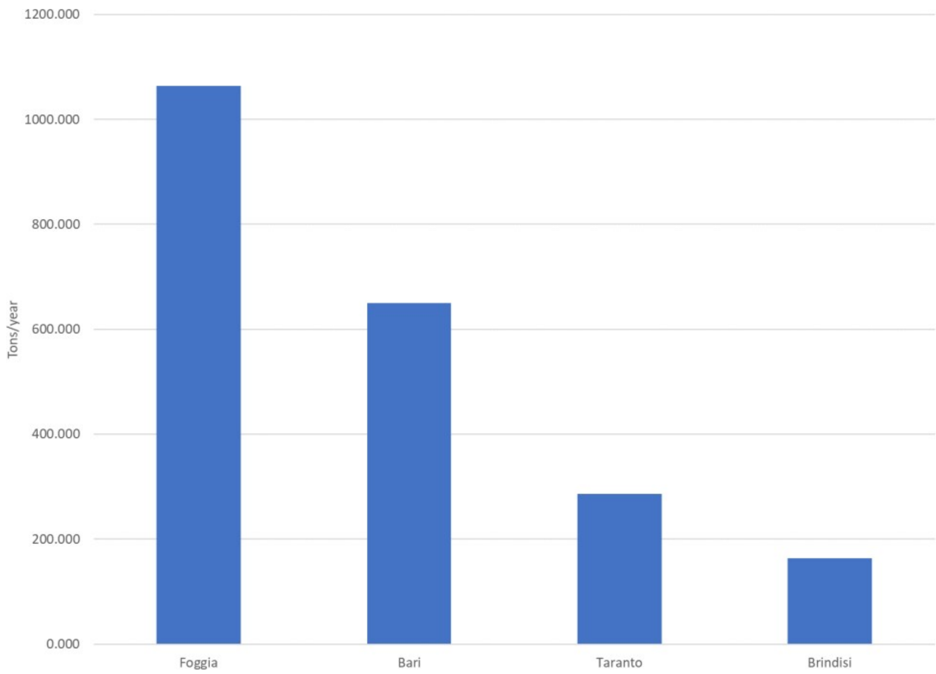


Fig.20 PUGLIA. Total agro-waste production in the main provinces, dry fraction.
(Adapted from ENEA, Report RSE/2009/16 ENEA)

Molise has a total surface of 4,483 km^2. It is the second smallest region in Italy. The territory is mainly mountainous (55.3 % of the total regional surface), while the remaining 44.7% is hilly. The agricultural sectors of main interest are related to herbaceous crops (mainly cereal) and to zootechnics, in particular: arable crops (mainly hard wheat) cover 72% of the total arable land. The remaining areas are covered mainly by green fodder cultivations, and permanent crops are represented mainly by olives followed by vines. The graphs in the figures 21, 22, 23 demonstrated that the biomass involved in the energy sector mainly derived from fruit shells. Furthermore, there is a great production of straw. A slight potential to use the biomass derived also from the grape and olive pomace production.

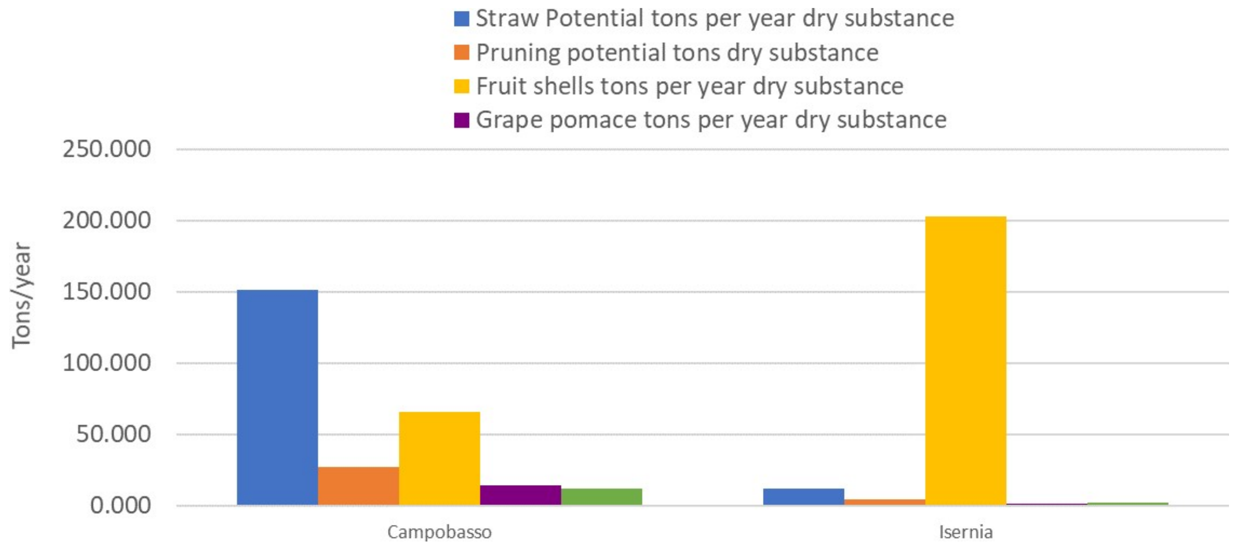


Fig.21 MOLISE: Biomass potential produced by different agro-waste in the main provinces, dry fraction (Adapted from ENEA, Report RSE/2009/16 ENEA)

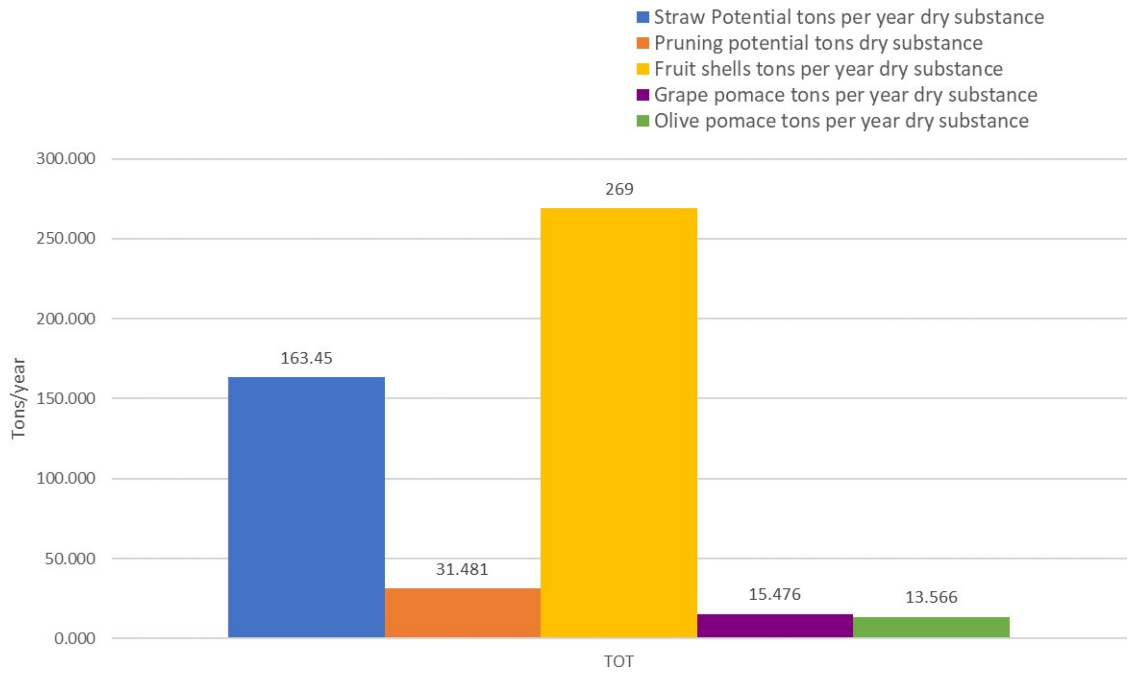
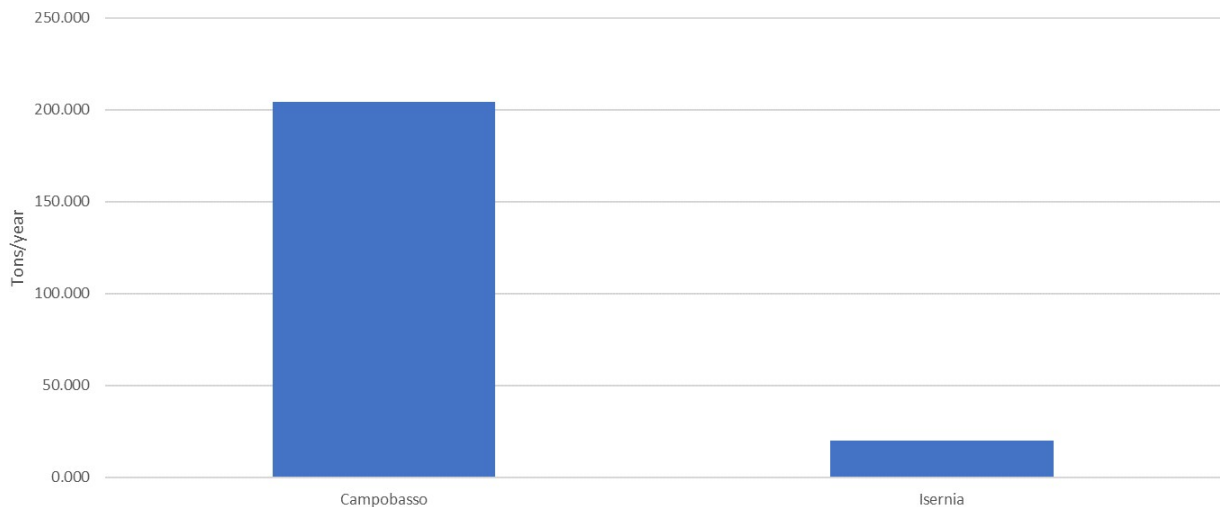


Fig.22 MOLISE. Total agro-waste production, dry fraction.
(Adapted from ENEA, Report RSE/2009/16 ENEA)



. Total agro-waste production in the main provinces, dry fraction. (Adapted from ENEA, Report RSE/2009/16 ENEA)

6. Montenegro

According to Monstat, during 2019, in Montenegro, 1.276.244,6 tons of waste were generated. A comparison between 2018 and 2019 demonstrated that there was an increase of 1.2% in relation to the total amount generated. In particular, agriculture, forestry and fishery sector recorded a decrease of 7.3%, sectors of manufacturing, mining and quarrying and other industries decreased of 0.7%; construction sector recorded increase of 2.1%. In 2019, recycled amounts of waste recorded an increase compared to the previous year of 74.5%, due to increased recycling of construction waste.

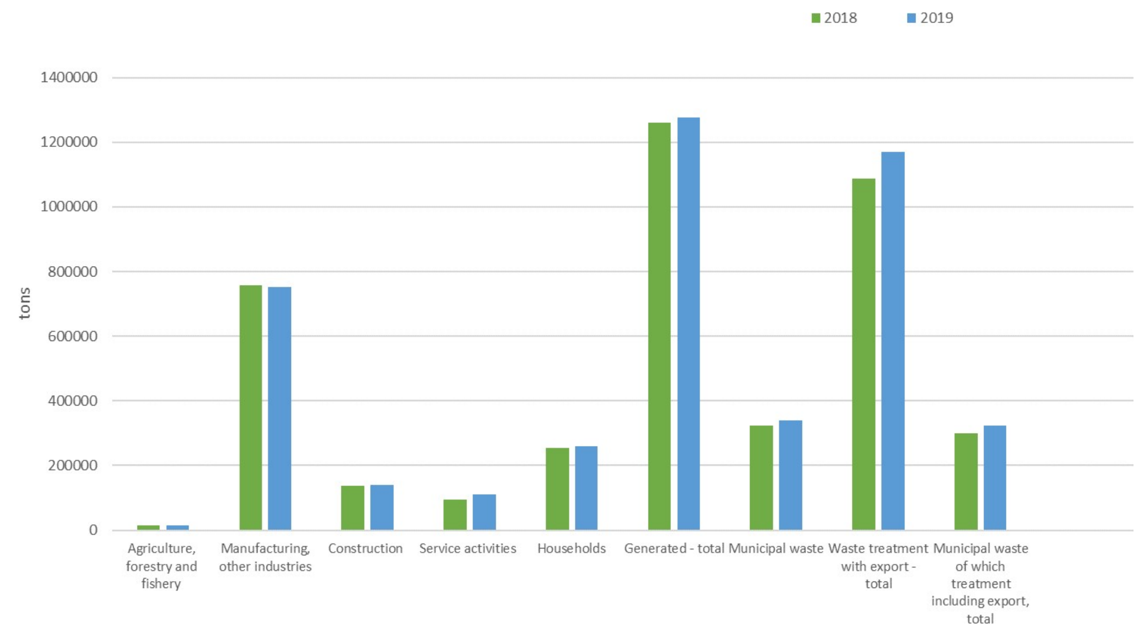


Fig.24 Montenegro: Generated and treated amounts of waste, 2018 and 2019
(Adapted from MONSTAT, Montegro statistical office release No. 218 Podgorica, 29 December 2020)

Considering the not hazardous waste (fig.25) there was a decrease of the production of waste originated from agriculture, forestry and fishing sector. A slight increase was instead verified about the production of hazardous waste from 2018 to 2019 (fig. 26).

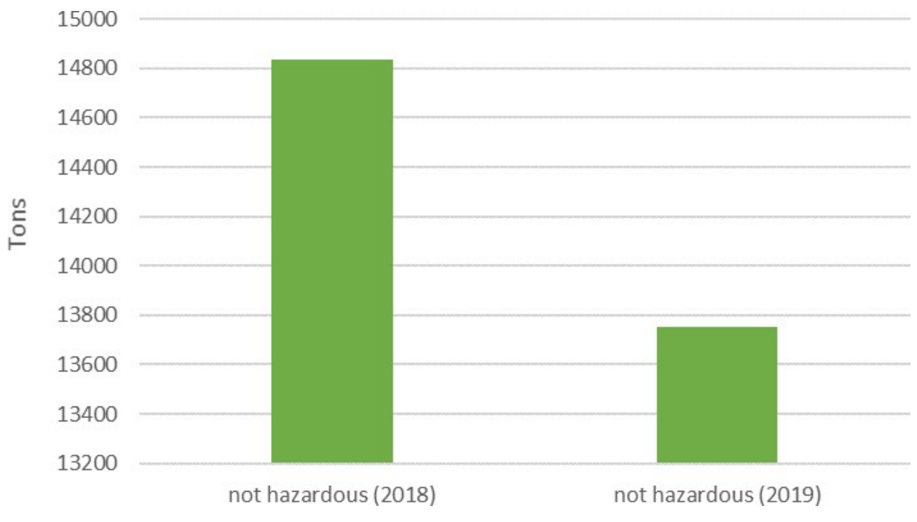


Fig.25 Generated amounts of not hazardous waste by agriculture, forestry and fishery sectors.
(Adapted from MONSTAT, Montenegro statistical office release No. 218 Podgorica, 29 December 2020)

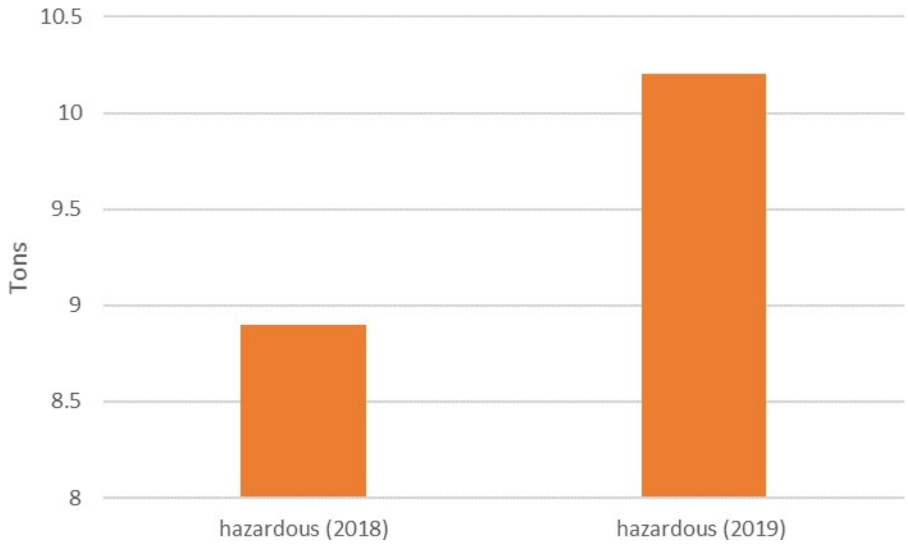


Fig.26 Generated amounts of hazardous waste by agriculture, forestry and fishery sectors. (Adapted from MONSTAT, Montegro statistical office release No. 218 Podgorica, 29 December 2020)

According to the data by MONSTAT (2020) the utilized agricultural land in 2019 is 257.469,6 ha that demonstrates an increase of 0.3% compared to 2018. In total, utilized agricultural land areas, perennial meadows and pastures areas prevail with the share of 94.3%, while arable land expands for 2.8%, permanent crops for 2.1% and kitchen gardens for 0.8%. In comparison with 2018, perennial meadows and pastures area registered an increase by 0.2%, arable land by 0.1%, permanent crops of 1.0%, while kitchen garden decreased by 0.2%. Total production of potato in 2019 undergoes a rise of 1.6% compared to 2018. An

increase in production was also recorded in the following crops: oats (7.4%), maize of grain (1.1%), dry beans (7.8%) and melon (2.4%). Compared to 2018, the total production of olives was increased, while production of plums, apples, pears, peaches, mandarins and grapes was reduced.

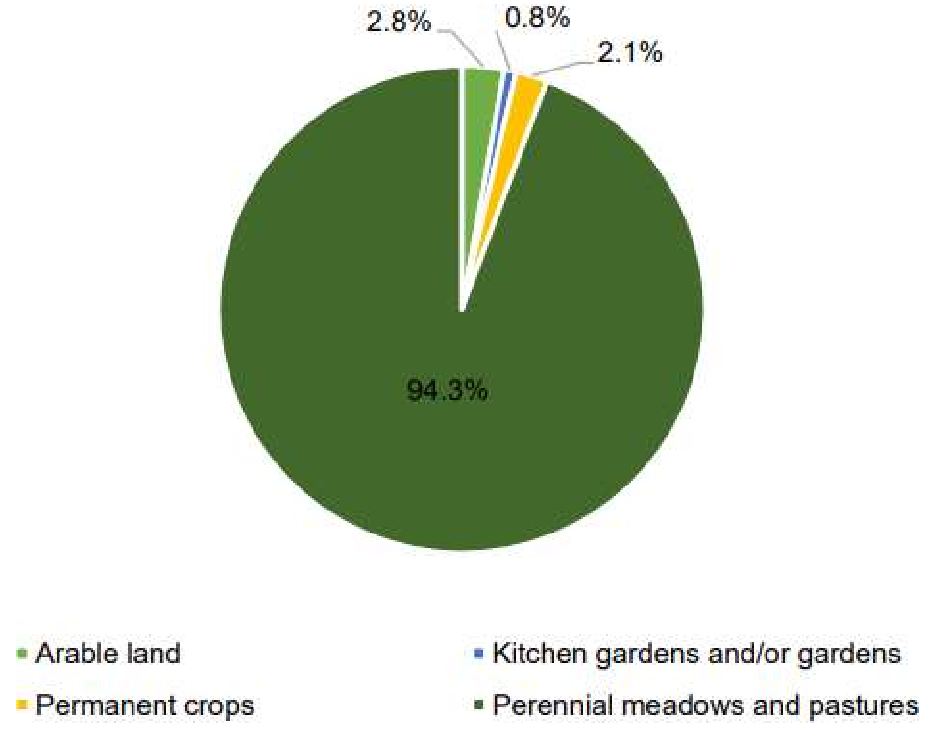


Fig. 27 Montenegro. Utilised agricultural area, 2019
(Source: MONSTAT, Montenegro statistical office release no. 117 Podgorica, 1 July 2020)

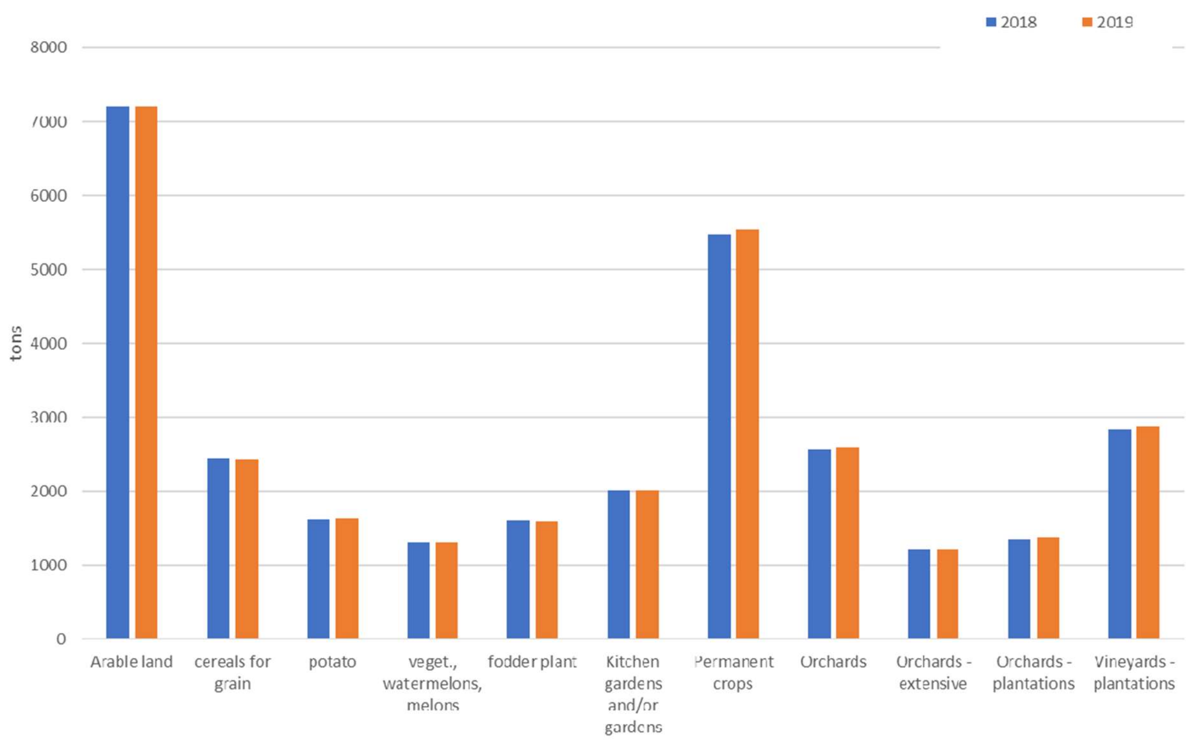


Fig.28 Montenegro: Utilized agriculture area
(Adapted from MONSTAT, Montegro statistical office release no. 117, Podgorica, 1 July 2020)

The Montenegrin agriculture considers traditional production, extensive methods of production and fragmented holdings with average size of 5 hectares (Curovic, 2016). The exact estimation of the quantities of agricultural waste currently used for energy production depends on the degree of availability of each crop. Year to year the total amount of residues strictly depends on many factors as follows:

- the harvesting method;
- the moisture content;
- the demand of agricultural residues for other purposes as animal feeding or animal bedding;
- the need for some residues to remain on the soil to maintain the level of nutrients.

The main crops producing considerable amounts residues on fields are potato, maize, wheat, rye, and barley. The main arboriculture residue resources available in Montenegro are vineyards, olives, apples, plums, pears and citrus fruits pruning. Vineyards pruning are the most significant source of biomass to the total crop residues potential.

The exploitation of livestock residues represents another opportunity for energy production through anaerobic digestion process. The biomasses derived from the livestock residues are mainly used for energy purposes: biogas, methyl ester production from bio-oils. Due to the outdated technology and lack of systematic collecting, thermal energy use of biomass residues as pruning does not constitutes a consolidated

technique. Thermal energy use of biomass residues as pruning is not enough apply in Montenegro because of outdated technology, extensive production and lack of organized collecting.

Of the total arboriculture amount the olive production is 19% while the vineyards is 58%. These wastes can represent one of the most important factors for obtaining biomass suitable for energy purpose or as new raw matter for sustainable products. Unfortunately, the use of olive residues is only 50%.

Approximately the 80% of the olives production contain elements suitable for new uses: vegetable water, pulp and stones from the olives, and the hard part has a high heating value.

Furthermore, Curovic (2016) affirmed that waste derived from the vineyards pruning contributes almost by half (40,6%) to the agricultural plant production residues potential. Glavonjic (2012) underlined that the overall potential of timber biomass residue from vineyards and orchards is 2.482 tons per year. The overall potential of agricultural biomass residue is 8.154 tons per year.

In conclusion there is a high potential of agricultural residues as biomass in Montenegro. Curovic et al. (2016) have estimated that approximately 9490 tons of dry matter of agricultural residue is available. However, currently there is no use for energy purpose or as raw matter for sustainable building materials.

7. Albania

Lushaj (2012) affirmed that the UN Economic Commission for Europe consider the state of waste management in Albania at a low level, with waste collection systems being implemented only in cities. The disparity is caused by the inability of national, regional and local administration to reach a sustainable waste collection even if the legal framework in accordance with European Union Acquis Communautaire exists (Oncioiu et al., 2020). Any data exists about the waste generated by agriculture, forestry and fishery sector. According to INSTAT (2019) there were managed 1,08 million tons of urban waste marking a decrease by 18 %, compared to 2018. The annual amount of urban waste managed per capita, nationwide, in 2019 was 381 kg/ capita, from 462 kg/ capita in 2018.

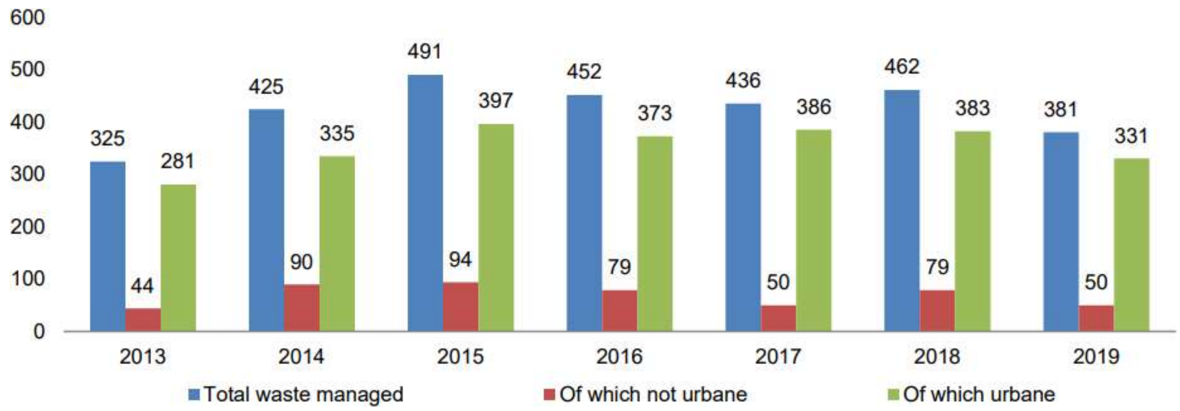


Fig. 29 Total urbane waste managed by generating resources (kg/capita) (Source: INSTAT, 2020)

Brahushi (2020) affirmed that the increases of agricultural production in Albania lead to the formation of large residues which in turn can be used for energy production. On the contrary the current use of agricultural residue is limited but it has a great potential for the future.

The statistic data highlight that there is an increasing trend of fruit trees, grape and citrus production in Albania from year to year with an approximate amount of 15.000 tons/year for fruit tree, 4000 tons/year for grape and 3000 tons/year for citrus.

The calculation of predictive production trend in short and long term in Albania, are based on actual production trends, available surface areas, the intensification technology of plant production and the potential of agricultural farms to increase production and plant yield. The stone fruits (as plum, cherry and peach) are prevalent in comparison with other type of fruit in Albania. The use of the residues derived from stone fruits is strictly connected to the potential use for energy production. The processing of grapes in Albania varies from 50 to 70% of the production.

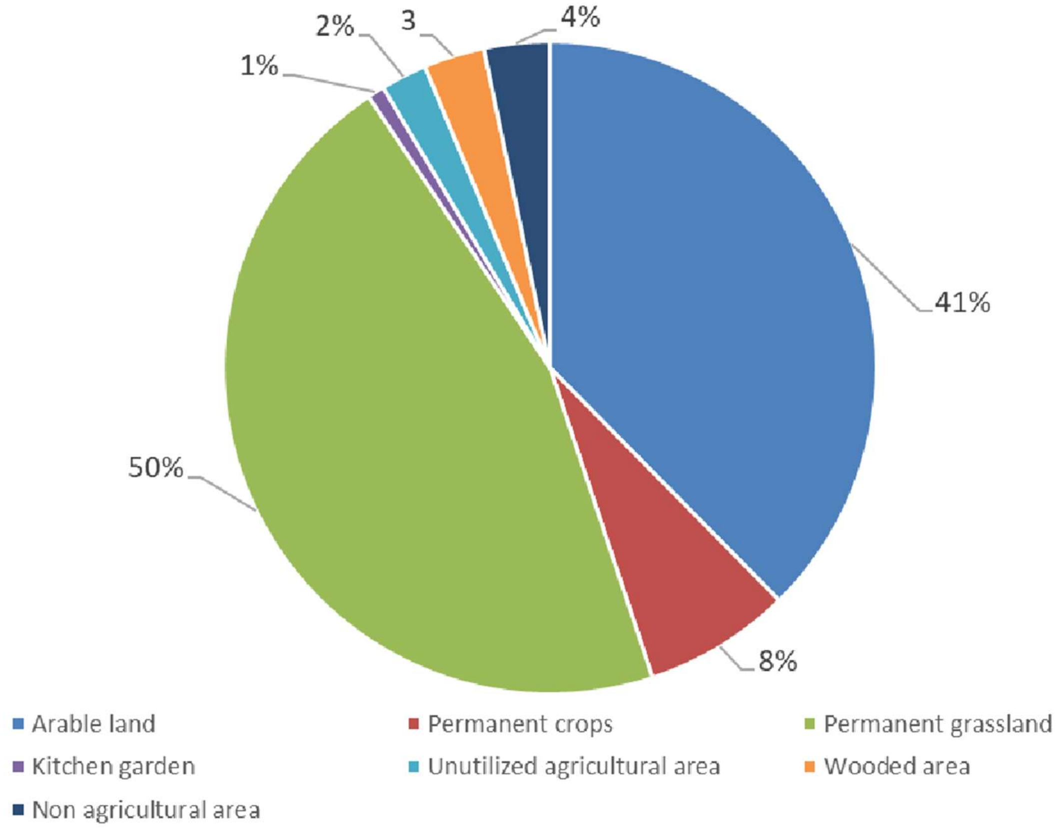


Fig. 30 Albania, Utilised agricultural area, 2020
(Adapted from INSTAT, Institute of Statistic, 2020)

Brahushi et al. (2020) predicted that the amounts of the processed fruit in the year 2020 will reach up to
75.000 for 25% of production and in the year 2025 will be about 130.000 t or 35% of production. The authors asserted that the residues produced by fruit trees, citrus and grape biomass, including the fruit pomace are suitable for bio-energy production. Furthermore, pellets production from fruit and grape processing waste represents a great opportunity for sustainable energy production. Thus, in Albania there is a potential on using the waste of processed fruits, vegetables, citrus, grapes, etc., due to the increasing productions from year to year.

According to INSTAT (2020) the vegetables production in 2020 is 1.295,726 tons, increasing by 2.99 %, compared with the year 2019. The highest level of vegetables production was achieved in the prefectures of Fier with 503.531 tons, Berat with 131.735 tons and Tirana with 130.001 tons.

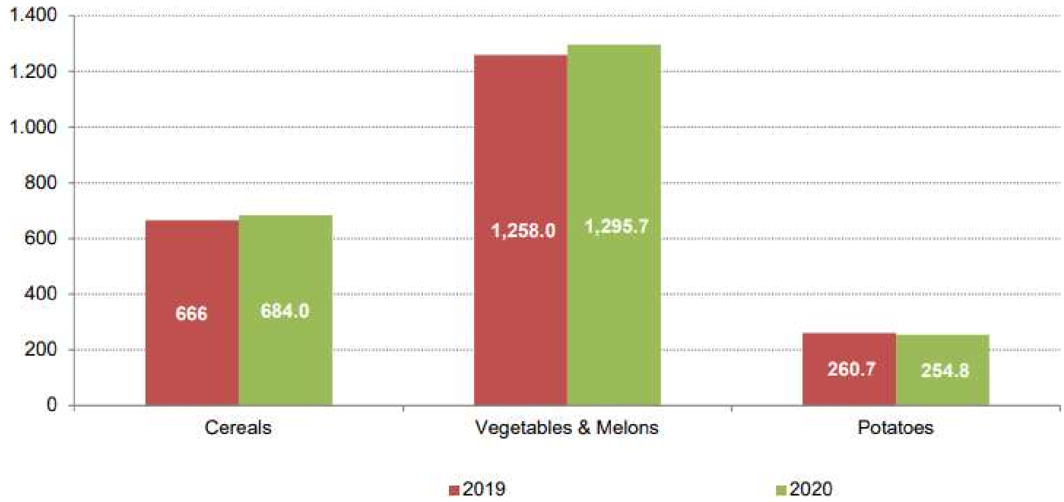


Fig.31 Production of cereals, vegetables and potatoes (thousand tons) 2019-2020
(Source: INSTAT, 2019)

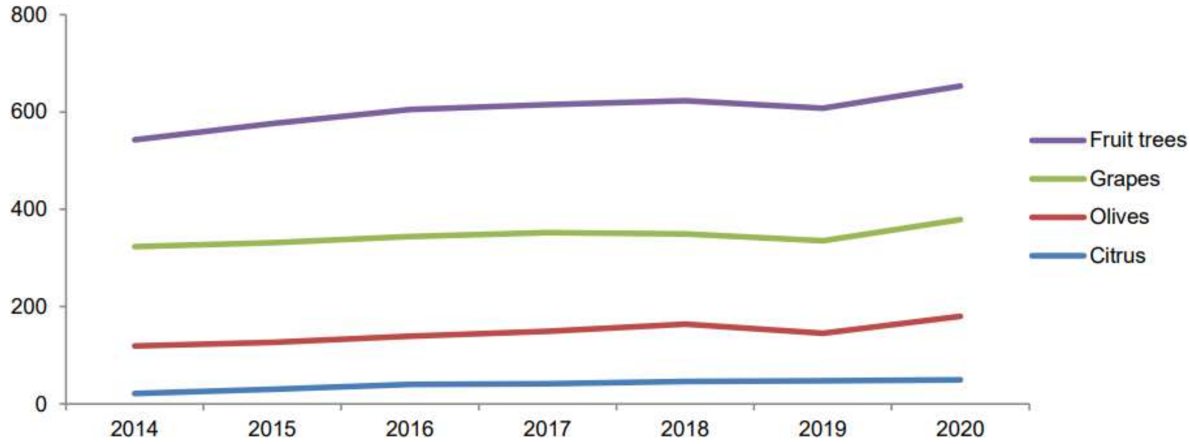


Fig. 32 Production of permanent crops (thousand tons) 2014-2020
(Source: INSTAT, 2019)

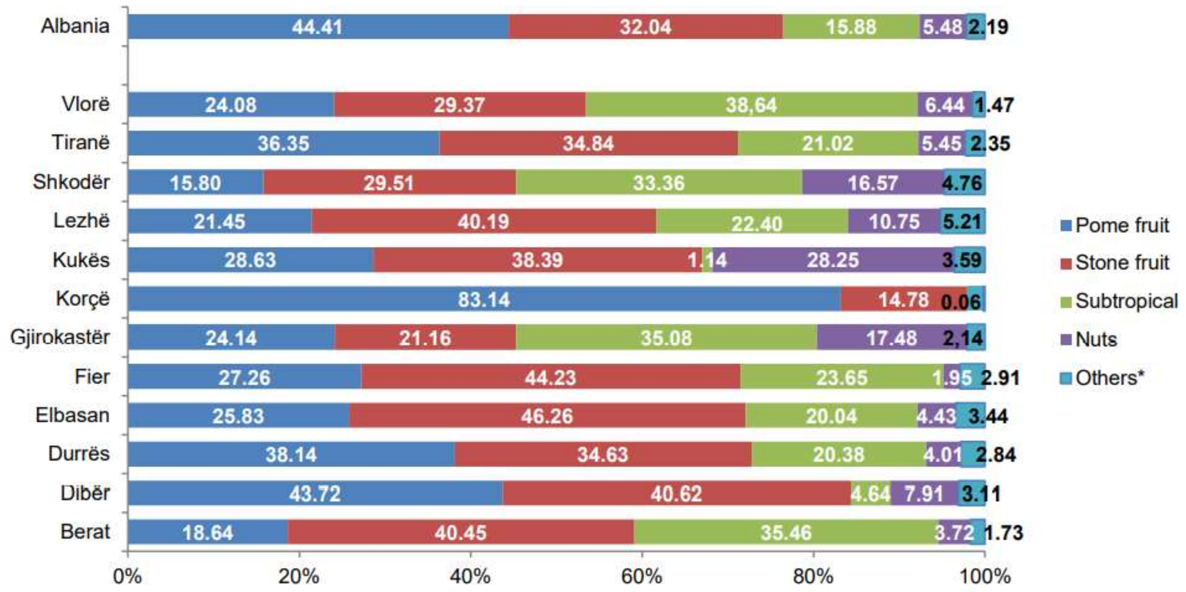


Fig.33 Structure of fruit trees production by kinds and prefectures, 2020
(Source: INSTAT, 2019)

Fruit trees production in 2020 is 274.749 tons. The highest level of production was reached in the prefecture of Korça with 82.007 tons, followed by the prefectures of Elbasan with 38.470 tons and Fier with 33.829 tons. Pome fruits group occupy 44.41% of the total production represented by apples with 84.03 %. Korça prefecture occupies 83.14 % of total apples production in country The production of permanent crops is represented by the production of fruit trees, olives, citrus and grapes.

In the stone fruits group the largest category, is represented by plums with 47.55 %, followed by peaches
23.25 % and cherries with 23.34 %. In 2020, were produced 131,971 tons of olives, increasing with 34.24 % compared to the previous year. The highest level of olive production was reached in the prefecture of Fier with 35,854 tons, followed by the prefectures of Berat with 33,082 tons and Elbasan with 22,764 tons. Olives variety for oil represent 82.22% of total olive production and olives variety for table 17.78 %. The citrus production in year 2020 was 49,201 tons, increasing with 4.95 % compared with the previous year. In 2020, grape production is 199,070 tons, increasing with 4.83 %, compared with the previous year, where 59.68 % is represented by grape from vineyards and 40.32 % from pergolas.

Brahushi et al. (2020) presents the data of fruit trees, citrus and grape productions from year 2000 to 2015 (fig.34).

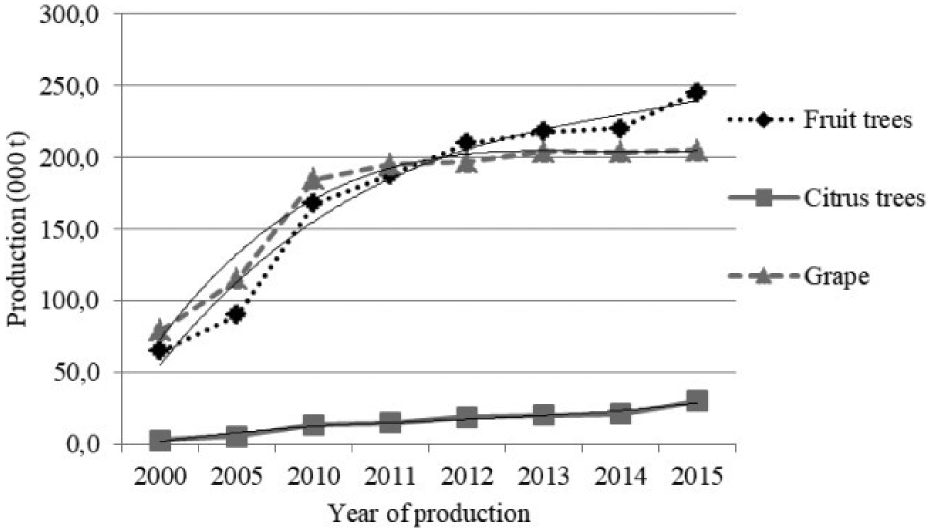


Fig. 34 The trend of fruit tree, grape and citrus production in Albania (Source: Brahushi et al., 2020)

The authors used a polynomial model of third order for the calculations of predictive production trend for the short term of the year 2020 and for long term of the year 2025 (fig. 35-36). Thus, the predictive estimation of fruit trees, grape and citrus production in long term (6-10 year) indicate that the production in 2025 will be about 370 000 t/year for fruit trees, 240 000 t/year for grape and 56 000 t/year for citrus. This demonstrate that the residues produced by these kind of trees will constitute a significant amount of new potential raw matter for the next year.

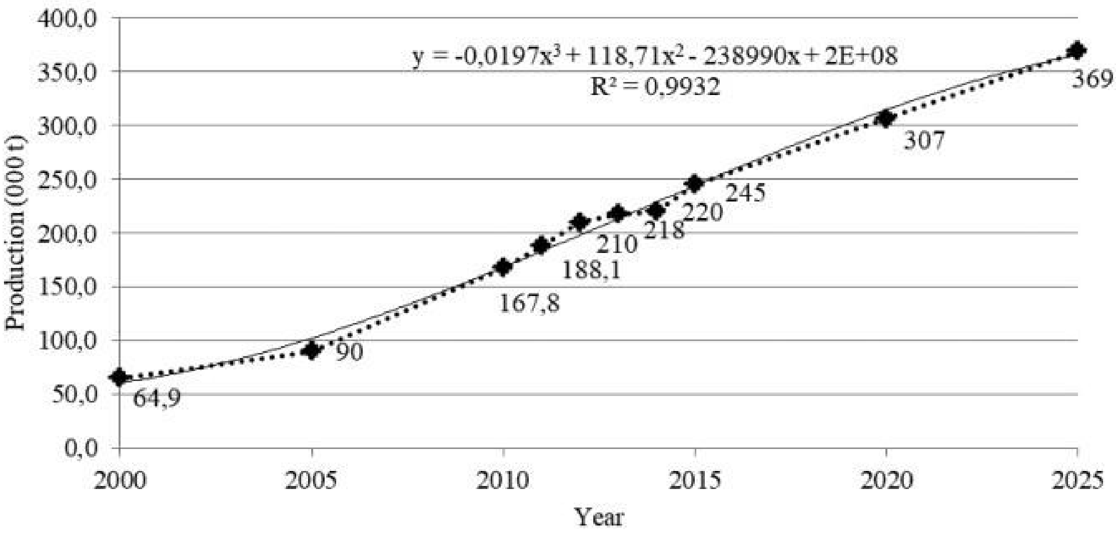


Fig. 35 The predicted trend of grape production in Albania (Source: Brahushi et al., 2020)

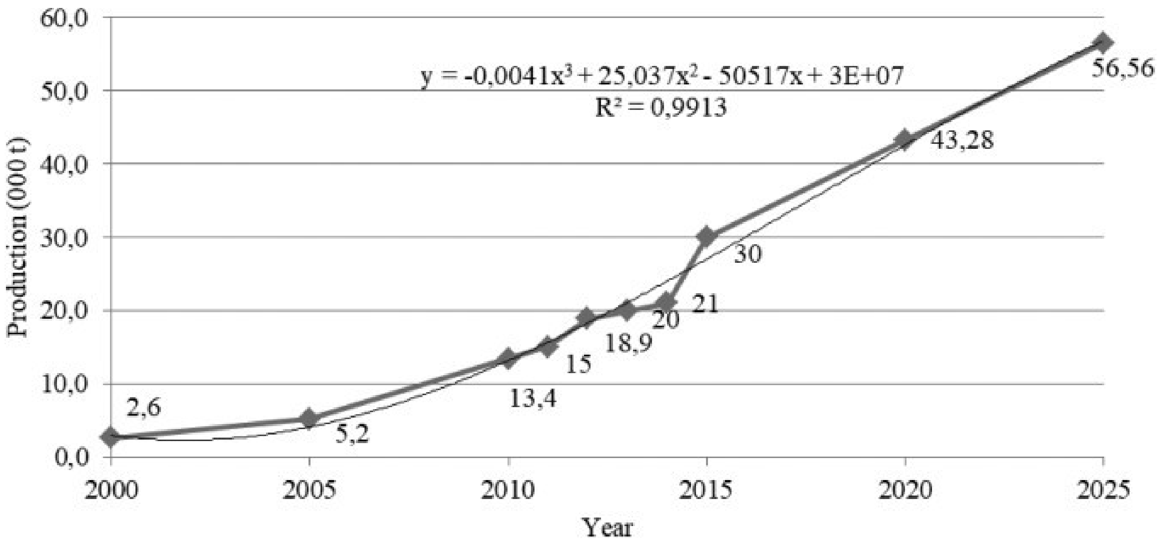


Fig.36 The predicted trend of citrus production in Albania (Source: Brahushi et al., 2020)

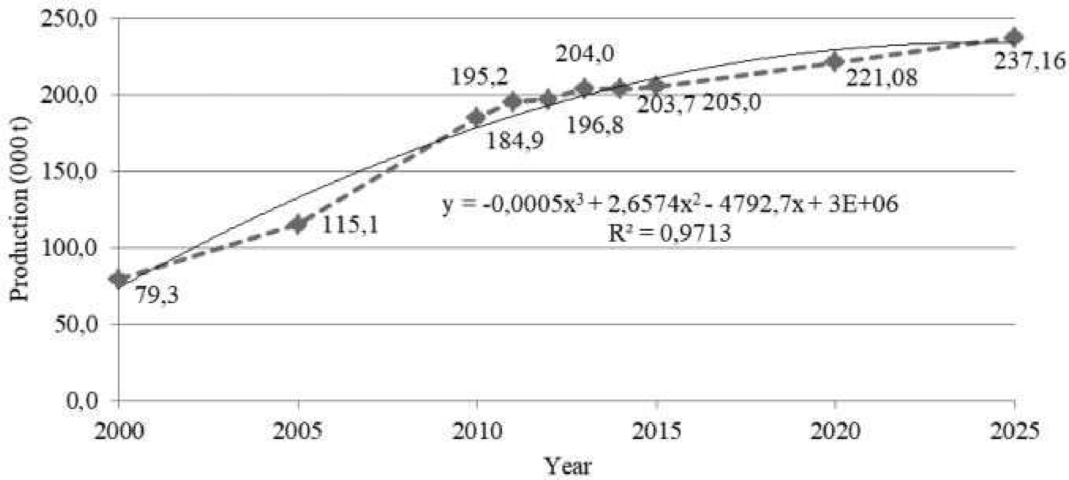


Fig.37 The predicted trend of grape production in Albania (Source: Brahushi et al., 2020)

8. Conclusions

The use of agro-waste, better known as biomass, is growing across the world. In Europe, the biomass is mostly used as pellet, chip form or burned converting it in thermal energy. Starting from the assertion that agricultural residues are carbon neutral fuel, the present report has shown a snapshot of the biomasses available in the countries involved in the project AWeS0Me (Puglia, Molise, Montenegro, Albania).

The analysis performed has highlight that in Italy the agricultural by-products are considered "special waste", thus the re-use of it as new matter can contribute to cut down the disposal costs, currently supported by the agricultural companies. Some legislative decrees regulate the disposal of the agro-waste. Bioenergy, biofuels, biogas are currently the alternative strategies most used to recycle the biomasses. In Italy marked differences between the regions actually exist showcasing disparities in economic and technological development. The northern regions have a more industrialized vocation, while the southern regions are mainly agrarian. Molise and Puglia belong to southern Italy. Despite the division, southern regions seems to be efficient in terms of renewable energy. In fact, Meleddu and Pulina (2018) affirmed that Southern Italy regions produced more renewable energy comparing to the national average.

In Montenegro and Albania some studies and statistics analysis have contributed to demonstrate that there is a great production of residues derived from arboriculture amount of olive and vineyards production. However any kind of politic strategy exists in terms of re-use and recycle the agricultural waste.

In conclusion, the framework built by the present report is strictly connected to the next deliverable D.T2.2.1 in which a detailed snapshot of the structural and hygrothermal properties will be produced. These studies will allow to have useful guidelines for the realization of the building prototypes at the end of the project.

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