Decision analysis for the determination of biomass in the territory Tuscia Romana by geographic information system and forest management plans

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Abstract

The growing interest in the development of chains for the use of agroforestry biomass for energy demand, is due to the awareness they are a crucial element to mitigate the global climatic change effects. The true effort is to have a reliable estimation of biomass availability by some instruments like forest management plans, which allow to locate the forest supply and to know the forest biomass availability in a medium period. In this paper we carried out a decision analysis by geographic information system, in Tuscia Romana area comprising 11 municipalities for a total amount of 813 km^2. An estimation was carried out taking into account the bibliographic data on the analyzed species, reporting the biomass in weight taken out by the forest cut utilization. A comparison was also performed in field on chestnut trees cut in a sampling area near Bracciano and in a close sawmill. The results show long, medium and short-term dynamics, but some critical points were found related to the process of estimation and to the real procurement of biomass in some years. The results suggest to be care in a possible project of a biomass plant.

Introduction

In the energy scenarios developed at international level, the role of renewable energy sources, is become more and more relevant. In this overview the role of biomass is considered crucial for achieving the objectives of climate change mitigation both at International and national level. The role of renewable energy sources (FER) is not limited to the decreasing of pollutants but it goes far beyond, going to affect the great fundamental choices concerning sustainable development, resource conservation, agricultural and rural development, safety of supply, and a hopefulindependence from foreign markets up to the fight against poverty. An increase of FER can also help to overcome the inequalities in access to energy sources that are recorded both at global and national levels, as well as to support the growth of the economy of the developing countries.

In Italy we have moved at an early stage in the exploitation of the great potential that renewable energy sources represents. The barriers to be removed are not only economic, but also social and cultural. The problem of social acceptability is in fact still the second obstacle for the development of FER especially in central-southern Italy. In this area there are many difficulties to apply a regular forest management, because the stumpage value is very often negative and also becausethe woods are often degraded making the priority to recover forest predominant. In such situation biomass supplyfor energetic purposes sometimes fights with the production of wood assortments suitable for other uses (boards, beams etc.) especially in the very few cases where wood quality has some potentiality for the developing economy of the territory.

The exploit the use of biomass for energetic purposes in this area should take into account the existing forest chains and do not depress the possible use of forest in a multipurpose overview, allowing also the productive role where it is a resource for the territory, limiting only to the use of the residuals which cannot find any other possibility of employment.

To address the efforts towards the use of biomass for energetic purposes, being careful of the social and economic equilibrium of some territories, means to operate in a descending approach which can be so organized:

To make a general overview of the biomass availability and the feasibility for energetic purposes.

To verify the estimation by case studies in order to understand the residuals of biomass which could be used after forest harvesting for biomass in energetic purposes. The study is addressed to the knowledge of the biomass which is usually leaved in the forest stand after cutting the trees that means branches and the top of the tress with a diameter below 5 cm.

To enlarge the whole perspective to the forest-wood-chain taking into account the final product that means in central-southern Italy to consider the transformation in the sawmill.

Starting by this assumptions we have carried out this study in the territory of Tuscia Romana in Lazio Region. The aim is to approach a feasibility study based on the information of the potential biomass and verifying the estimated data on one case study during forest harvesting and transformation in the sawmill.

At the moment the case study is related only to chestnut species harvested during winter season at 2012-2013 and worked in the sawmill in order to obtain as final product beams for the buildings.

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Materials and methods.

The estimation of biomass for energetic purposes has been carried out in the territory of Tuscia Romana, which cover 12 municipalities at North of Rome, using the information collected in a prepared form which has been delivered by the professionals foresters of the territory. In our study we were able to collect the information only of 11 municipalities.

The most important required information are: the name of the stand which is going to be harvested in each municipality, the general site characteristics (i.e slope, altitude, viability, civic uses, wildfire accident, accessibility). The collected information was get by means of forest management plans where it is reported the surface and the total biomass in cubic meters which will be cut in each single stand in each year. Such biomass considers the trunk, it does not take into account the branches and the top of the tree which in this area, as custom, is leaved inside the forest .

The transformation of volumetric data to weight has been carried out using the wood density values reported in Hellrigl (2004) for each species, at 33% of hydric content (measured on the fresh weight) i.e. 50% of moisture content (i.e. measured on the dry weight). The water content was chosen because it allows the operation of biomass boilers with enough efficiency, it is well known as too much water makes difficult to burn woody biomass. In order to estimate the total energetic power, it was decided to apply the percentage of 18% at the total weight biomass cut by the forest sands. This value has been considered reasonably usable for energetic purposes considering the species which are widespread in the area (oaks, beech, chestnut) collecting the references on this subject.

The potential basins of biomass (stands to be cut), according to the species and to the year of harvesting, were located on the map by Geographical information System divided in each town of the Tuscia Romana and indifferent colours were used for each year of cut, in order to provide a useful tool for the administrators. For each town it has been calculated the total biomass to be cut on the whole time period considered in the forest management plans and the total energetic power developed. At the end a general graph up to the year 2027 was prepared in order to show the general trend of biomass supply enhancing possible a lack of availability and the prospective in order to build one or more biomass boilers.

Residual Biomass from Harvesting and sawmill operations

In order to verify if the estimation of the biomass carried out by forest management plans, one case study in Vicarello (Bracciano, Central Italy) stand was applied during harvesting operations in winter 2012/2013. In a coppice stands of chestnut a sample area located at about 450 m of altitude, and a slope of 30%-35%, 36 stumps were cut with about seven shoots for each stump. The mean diameter at the bottom of the shoots spans from 15 cm to a maximum of 20 cm.

The harvested trees were weighted considering on one hand separately the tree top, which was cut when the diameter of the stem was below 5 cm, and the branches; on the other hand the whole log was weighted. Moisture contents of fresh wood was measured by means of a gravimetric method. The biomass of the tree top and branches was compared to the weighted whole trunk.

In order to have an idea of a total residual in the entire chestnut chain, 10 logs of chestnut in the sawmill with a diameter at the bottom spanning from 15 to 22 cm and spanning by 8 to 10 cm at the top of the tree, with a total length of about 12 meters, were followed in the sawmill. We could not follow the material coming from Vicarello but some logs coming from the same area that means the municipality of Bracciano. It was measured the starting weight of the logs and their volume in cubic meters. The logs were processed in the sawmill it was possible to obtain poles or boards and small joists using a trimmer and a multi-blade circular saw. The final assortments were weighted again and their sizes were measured. The percentage of the residuals as volume and weight was measured.

Results

The species which are going to be cut in the next years in the area Tuscia Romana are mainly chestnut coppices, and deciduous oaks both in coppice and in conversion from coppice to high forest, sometimes mixed with chestnut; the remaining part is the Mediterranean forest of sclerophyllous and beech forests.

The town in which there is the highest content of biomass to be cut is Tolfa where more of 200.000 $m^3$of wood were estimated as harvested by the foresters freelancers, up to the year 2034 (the forest management plan is actually under revision).

The lowest availability of biomass is in Anguillara where about 5000 m^3 of wood in turkey oak coppice stands were predicted in forest harvesting up to the year 2033.

As regards chestnut the most part of the biomass is in Bracciano site and it is about 80.000 m^3 predicted by a forest management plan which spans up to the year 2019 (Table 1). We report the table and the map of the localization of forest stands which are going to be cut in Bracciano (Figure 1).

Taking into account all the surface which will be interested by forest harvesting in the territory Tuscia Romana, comparing this value with the estimated surafce covered by forests as reported in ISTAT in the year 2000, we could suppose that a further area in all the municipalities could be used as biomass supply for energy. In fact, according to the surface which is classified as forest in ISTAT 2000,we have a gap between what is reported by the prepared forms by forest freelances and that wooden area as reported in each municipaliy by ISTAT. The potential adding biomass supply spans from a remaining potential surface which could be cut by 25% (Manziana) to over 60% in Allumiere. It is not known if such difference is real that means that forest is pres-

Table 1. Biomass supply of Bracciano town.

Municipality	Management	Species	Biomass at fresh state (m3)	Hydric content (%)	Moisture content (%)	Specific density according to the Hydric content kg/m^3	Biomass for energetic purposes (t) 18% of the total amount	Pcs MJ/kg	Pci MJ/kg	Thermal energy production (kWh_{th})
Bracciano	Ceduo	*Quercus cerris*	87.937,49	33	50	900	14.246	18,12	11,74	41.811.638
	Ceduo misto	*Quercus cerris*	16.688,50	33	50	900	2.704	18,12	11,74	7.934.881
	Ceduo	*Castane sativa*	79.341,06	33	50	780	11.139	19,80	12,51	30.193.574

ent and possibly available to be cut, or if the forest is not available because it takes into account the shurbs which are not object of forest management and which are not going to be cut.

The 18% in weight of the total biomass was assumed to be available for energy purposes and the total availability of the areaTuscia Romanais reported year by year in Figure 2. If we assume the total biomass which would be necessary to have a total develop of 2 MW in all the examined period we can see that there are two important minimum in the biomass supply in the year 2021 and 2023

In the analysis of chestnut in Vicarello, during winter forest harvesting we could verify two loads in which 350 and 440 kg of branch and tree top were weighted; the weight of their corresponding tree is respectively 1220 and 2200 kg. Comparing the biomass which could be used for energy we have a percentage of 16.9 and 16.6%. If we transpose this result to the biomass which was reported in the forest management plans it means that we could estimate a percentage of 20% in chestnut in weight which we could use for biomass for energy. Because the wood moisture content we measured in the field is about 50% we can be satisfied because this value approaches the percentage 18% we assumed during the feasibility study.

In the sawmills the percentage of residuals is higher. The percentage of biomass which can be used for energetic purposes increases up to 40% taking into account the log were some block full of defects were eliminated trunks (without tree top and branches) and as final product poles, small joists and boards. In fact the 10 logs were 740 kg in weight and we could obtain 300 kg of small joists and 160 kg of boards, with a residual of 280 kg (Figure 3). To this percentage we would have to add a biomass which was eliminated before

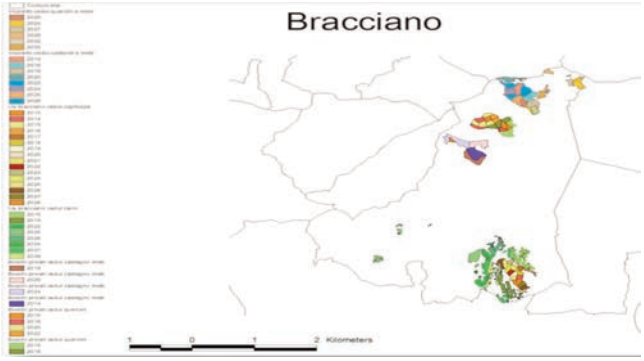

Figure 1. Map of Bracciano with the location of biomass supply.

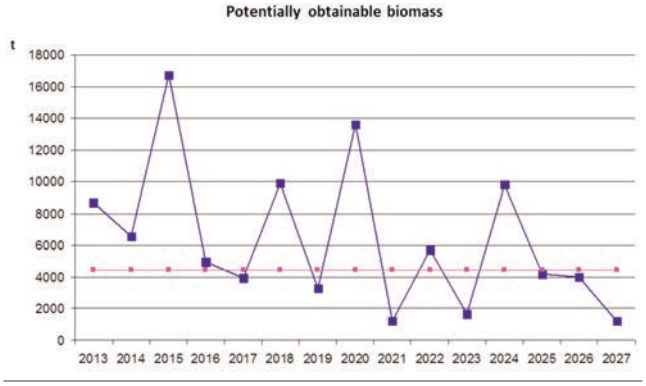

Figure 2.

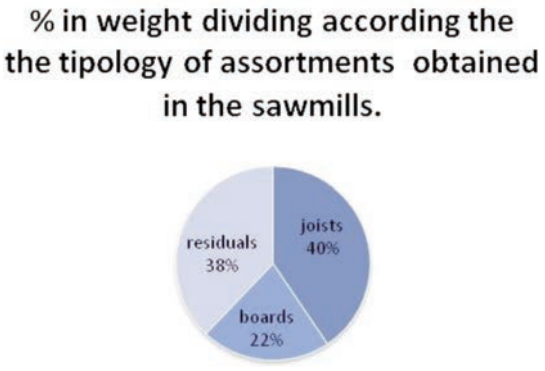

Figure 3. Assortment in the sawmills.

Conclusions

Available residual biomass - obtained from database and our case study can be successfully considered as a real economic opportunity to be used as forest biomass in Tuscia Romana. The large quantities can supply the growing energy demand and can be efficiently used in domestic or district heating. But many information is lacking to have a more reliable biomass estimation which can be used for energy purposes. The first information and may be the most important are the possible roads which can be used for forest harvesting, they can limit the biomass supply really available for energy purposes.

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