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# ASSESSING THE FOREST MANAGEMENT IN THE NOVI PAZAR REGION (SOUTHWEST SERBIA)

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## ABSTRACT

To address the question of whether stands are managed sustainably in the Novi Pazar region (Southwest Serbia), this study compares the quantity of standing wood biomass in the Debeljak–Medenovac unit at the beginning and end of a ten-year study period. The ecological and energy value of wood biomass as compared with other types of fuel were evaluated. The carbon credit benefits for the area of the studied forest management unit were also estimated. The results show that in the study period the planned cutting volume was in line with the volume planned within the ten-year plan. The data obtained and calculated from the measurements indicate an increase in volume at the end of the study period. The wood volume exploited over this period amounted to an average of 2,361.20 $m^3$/year, i.e. 96.51% of the planned cutting volume, meaning that not all of the planned volume was utilised. In addition, it was determined that biomass is the highest-ranked renewable source of energy. The effects of carbon storage are equally important, considering that in the study period the loss in $CO_2$ storage on the barren land of the forest management unit was 255,000 EUR. It was concluded that the forest management on the sample area was based on the principles of sustainability.

**KEYWORDS:**
Biomass, Environment, Growth, Wood Production, Carbon Credit Benefits

## INTRODUCTION

Agenda 21 states that "forest resources and forest land should be managed sustainably to fulfil social, economic, ecological, cultural and spiritual needs of present and future generations" [1]. Although "sustainable" is a notion introduced in forestry over one hundred years ago, ecologists have recently adopted and defined it within the concept of sustainable development [2]. As a result, the adjective "sustainable" is presently also recognised as renewable [3]. Forests are a renewable natural resource that can be exploited in many ways, depending on their location and the stage of development [4], but if we want to preserve the sustainable stand benefits, forest biomass can only be exploited as much as the increment allows. Over the last three centuries, forests have been managed based on the principle of maintaining the balance between forest yield and exploitation [5]. This principle of sustainable yield was the first defined stance on the usage of natural resources in general [6], and the first significant contribution to the protection and improvement of the environment [7].

Biomass is plant or animal material used as fuel to produce electricity or heat. Examples of biomass are wood, crops and waste from forests, yards, or farms [8]. Forest biomass includes all parts of a tree, not only the trunk but also the bark, the branches, the needles or leaves, and even the roots. Forests are the terrestrial ecosystems that produce and store most biomass, which explains why biomass for energy has been derived mainly from forests for a long time [9].

Direct combustion of solid biomass is the oldest energy production technology used by man [10]. It is a well-developed commercial technology for energy production applied in almost all developed and developing countries [11]. In developed countries, wood-based energy, used mostly for heating and production of electric energy [12], has gained significance and usage over the last decade of the 20$^{th}$ century [13]. The two features that make biomass a primordial source of energy are its availability and uniformity at a global level [9]. Because of its ability to reduce the emission of greenhouse gases, biomass is considered to be an acceptable energy source to replace fossil fuels to a great extent [14].

Forests produce biomass that is mainly removed in final harvests, though in smaller quantities also in silvicultural operations (thinnings and prunings) [9]. In conventional forest exploitation, tree trunks, treetops, and branches with a diameter at the thinnest end above 7 cm are used [15]. As a result, forest exploitation and fire protection produce great quantities of forest biomass that can be used for energy production. The same applies to wind-thrown and diseased trees [16]. Forests can be grouped in two broad types considering the biomass removal for energy purposes: (1) energy plantations, where all

biomass is harvested for energy; and (2) forest systems managed for timber and/or other products and services, where all or part of forest residues can be removed from the stands for energy purposes. Forest biomass varies according to the site, stand structure, topography, climate, disturbances, and management system [9]. Biomass exploitation requires modern technological solutions to reduce and minimize production costs [17]. This primarily relates to technical solutions applied to collection, transport, processing, and exploitation. More broadly, the development of technology for energy production has focused on solving the problems of environmental pollution [18], performance improvement for several types of fuels [19], and the increase of energy efficiency and power [20].

The exploitation of forest biomass as a renewable energy source is gaining more attention throughout the world, which is also expected to be the case in Serbia [21]. Over the centuries, forests in Serbia were managed in an irrational manner [22]. They were cut down to make roads, farming and agricultural land and, consequently, they disappeared in the clear-cut [23]. In the forest regions of the Republic of Serbia, the main aim of forest management is to ensure its sustainability [24]. The basic requirements for the implementation of long-term sustainable forest management are a highly competent labour force, conservation of biodiversity, maintaining forest soil fertility, increase in the productivity and preservation of forest vitality, nature-friendly management, social responsibility and satisfaction of the needs of present and future generations, as well as political will and making positive political decisions [25]. Taking into account the ecological and historical characteristics of forests in Serbia, the methodology of the national forest inventories was based on the experience of European countries with a long tradition, and guidelines and criteria by international organizations involved in the monitoring of forest ecosystems at the regional and global level (United Nations, and Food and Agriculture Organization of the United Nations). The first national forest inventory in Serbia was conducted between 2004 and 2006 for the inventory cycle of ten years [26], whereas the second one started in 2019 and it is still in progress. The obtained data and the ongoing national forest inventory will enable permanent monitoring of forests at the state level, more reliable macroeconomic planning, correspondence with international organizations, assessment of the sustainability of forest management, etc.

In this paper, the forest management in Southwest Serbia was assessed and the present and potential wood production were studied. The study focused on a comparison of volume in one area over time (the Novi Pazar region, the Debeljak–Medenovac unit). This type of comparison has not been done in this region before. The research aimed to quantify the production of wood, its ecological and energy value, its exploitation and standing state expressed in the quantity of wood at the beginning and end of the study period of ten years, and to decide whether the cutting volume obtained from the thinning and tending measures was harvested without disturbing other forest functions. The study determined whether and to what extent biomass may be relied upon as a renewable energy source, how intensive biomass harvesting and exploitation may be, and what is the most rational biomass utilization. In particular, the study had the following objectives: (1) to examine the forest management in the Debeljak–Medenovac unit; (2) to evaluate the ecological and energy value of wood biomass as compared with other types of fuel, and (3) to estimate the carbon credit benefits concerning the area of the studied forest management unit.

## MATERIALS AND METHODS

A ten-year experiment was carried out to examine forest management in the Novi Pazar region (Southwest Serbia), using the forest management unit (FMU) Debeljak–Medenovac as an example.

**Study area.** FMU Debeljak–Medenovac, selected for the research presented in this paper, is located between 43°03' and 43°09' north latitude and between 18°13' and 18°21' east longitude, and organized in 42 compartments, with a total of 1,372.15 ha of forest. It is a state-owned forest area managed by the State Enterprise "Srbijasume". It has a very variable relief, with ranging altitudes from 510 m to 1,348 m. Based on the climate regionalization of Serbia, the area belongs to the B-3-a climate area, characterized by a temperate continental climate in the lower regions, and a mountainous climate in the higher regions [27]. The average air temperature is 6.8°C, relative humidity is around 77%, and annual precipitation is 726.8 mm. In this area, broadleaved trees are more common (86.8%) than coniferous trees (13.2%). The most common tree species is beech (66.3%). High forests make 18.6%, and low forests make 60.7%, whereas plantations make 20.7% of the forest volume in FMU Debeljak-Medenovac. Considering volume by diameter class – the diameter class 2 has the largest share, followed by class 1 and class 3. Arranged by thickness categories (thin, medium, and thick), thin and medium are predominant thickness categories of trees (93.1%), whereas thick trees (diameter above 50 cm) make only 6.9% of trees in this forest management unit. In high stands of beech and Turkey oak and hornbeam, there is a lack of young and a surplus of mature stands. The coppice management area has an age-class structure shifted towards older ages (age classes 6 and 7) [28]. In FMU Debeljak–Medenovac, the harvesting is mostly performed using the assortment method, i.e., the cutting and production of ligneous assortments at the place of felling of trees and their transport to the

depot. The cutting is executed with chainsaws, and the hauling of assortments to a motor road is carried out using tractors equipped with a warping drum. Finally, the assortments are loaded onto trucks and transported to the customer.

**Data and methodology.** In the analysed forest management unit, the changes in wood volume based on the available data for the period from 2000 to 2009 were studied. The wood volume was obtained using the two variable (dominant height and diameter at breast height) volume tables [28, 29]. Forest inventories were in both cases done by the Bureau for Planning and Design in Forestry [28, 29], which gave us the possibility to compare results across time. Harvesting over the ten years was also comprehensively measured. The results were used to analyse the wood volume at the end of the study period against the volume at the beginning of the period, as well as the quantified exploited wood volume planned for forest cutting (the cutting volume) over ten years.

Data on the general characteristics of the site and forest in each compartment were also collected. The number of trees and their diameters and heights, health status, along with the crown classes, stem quality, damaging agents and the extent of the damage, were determined. For this purpose, we used the data collected from 4,545 sample plots that were the basis for the Special Forest Management Plan for the Management Unit Debeljak-Medenovac [29]. The plots were circular in shape, evenly distributed on the area, and 0.01, 0.02, or 0.05 ha in size, depending on the compartment. In this manner, the research included about 15% of the area planned for forest inventory (824.39 ha), which is represented by the total forest area in the forest management unit, excluding plantations and forests not intended for management. This is considered to be a representative sample, sufficiently reliable to apply the results and conclusions of the research to the entire area of the forest management unit.

In addition, to estimate the ecological value of wood biomass, its energy value was compared with the value of other types of fuel based on literature data [30, 31]. The analysis of the possible economic-financial effects of the afforestation process was done based on the area of the forest land suitable for afforestation and the average volume of wood per ha of the studied forest management unit. The economic value of wood was determined as a value of the standing wood volume according to the Price List for Forestry Products of the State Enterprise "Srbijasume" [32]. Possible afforestation costs were calculated based on the data provided by the Forest Administration of Novi Pazar. The conversion of currencies used in the calculations was done according to the official data of the National Bank of Serbia [33]. Also, based on the data for the carbon contents [34] and the volume of wood of each tree species present in FMU Debeljak–Medenovac, and according to the market price of 1 t of $CO_2$ [35], the carbon credit benefits concerning the area of the forest management unit were estimated.

## RESULTS AND DISCUSSION

**Forest management in FMU Debeljak–Medenovac.** An annual overview of wood utilization and the overall wood volume at the beginning and the end of the ten-year study period were made for FMU Debeljak–Medenovac (Table 1, Table 2).

The results at the beginning and end of the study period are presented in Table 1. These show that the planned cutting volume for the period from 2000 to 2009 was 24,746.50 $m^3$, which is in line with the volume predicted through annual plans [28, 29]. The volume increased between 2000 and 2009 by 38,966.46 $m^3$ (28.39 $m^3$/ha) after deducting a felled volume of 23,612.00 $m^3$. Such a significant increase in volume indicates that the actual annual volume increment amounted to 4.41 $m^3$/ha. What needs to be taken into account is the diameter structure (diameter at 1.3 m height and above 10 cm) of the forest first time measured in 2009. In the 2000–2009 period, the forest management unit had a growing stock of 133.43 $m^3$/ha, whereas the planned cutting volume amounted to 24,746.50 $m^3$, i.e. 13.50% of the growing stock. This calculation did not include the structure of assortment because firewood makes over 90% compared with timber. Therefore, it will be considered as firewood intended to be used for energy production.

Table 2 presents the period and scope in which the volume planned for forest cut was used. The wood volume exploited over this period amounted to an average of 2,361.20 $m^3$/year, i.e. 96.51% of the planned cutting volume, meaning that not all of the planned volume was utilized. Namely, 1,134.50 $m^3$ of the unexploited volume could have been cut in this

**TABLE 1**
**The state of the parameters at the beginning and the end of the study period.**

| Parameters | Unit | Year | | Difference in wood volume |
|---|---|---|---|---|
| | | 2000 | 2009 | |
| Forest area | ha | 1,372.15 | 1,372.15 | - |
| Growing stock | $m^3$/ha | 133.43 | 161.82 | +28.39 |
| Cutting volume over the ten-year period | $m^3$/ha | 18.03 | 17.21 | -0.83 |
| Area of barren land convenient for afforestation | ha | 164.65 | 164.65 | - |

**TABLE 2**
**Wood volume exploited in FMU Debeljak–Medenovac.**

| | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Wood volume exploited ($m^3$) | 2673.00 | 1352.70 | 2832.30 | 3298.10 | 4080.60 | 3249.50 | 1504.00 | 2913.40 | 1008.20 | 700.20 |
| Average ($m^3$/year) | 2,361.20 | | | | | | | | | |

**TABLE 3**
**Comparative overview of energy value and heating costs by resource.**

| Type of resource | Unit | Energy value (kWh) | Required quantity per unit | Price per unit (EUR) | Overall heating cost (EUR) | Product price (EUR/kWh) |
|---|---|---|---|---|---|---|
| Beech firewood (cords) (V=25%) | $m^3$ | 1,865 | 10.0 | 27.00 | 270.00 | 0.0144 |
| Beech firewood (split wood) (V=25%) | $m^3$ | 2,265 | 8.2 | 32.00 | 263.00 | 0.0141 |
| Wood briquettes | t | 4,680 | 4.0 | 100.00 | 400.00 | 0.0214 |
| Vine wood briquettes | t | 4,500 | 4.2 | 100.00 | 420.00 | 0.0225 |
| Wood pellet | t | 4,800 | 3.9 | 180.00 | 702.00 | 0.0376 |
| Coal | t | 3,750 | 5.0 | 90.00 | 450.00 | 0.0241 |
| Fuel oil | l | 10.70 | 1,743 | 1.00 | 1,743.00 | 0.0934 |
| Electrical energy | kWh | 1.00 | 18,650 | 0.069 | 1,287.00 | 0.0690 |

Note: The comparative overview is presented based on literature data [30, 31]

period. However, this volume was added to the calculations for the next planning period performed in 2009, in which, based on the measurement made by the Bureau for Planning and Design in Forestry [29], the total growing stock of the area was 28.39 $m^3$/ha.

It is important that the utilized volume does not exceed the projected cutting volume [36], i.e. only a limited quantity of wood volume is allowed to be removed from the forest and that quantity should equal the volume generated in the previous period. It is assumed that although the projected felling volume is harvested and used, wood volume will increase if forest stands are managed and tended properly.

**Economic aspects in FMU Debeljak–Medenovac.** Some authors [30, 31] made a comparative overview of various types of fuels that can be entirely applied to FMU Debeljak–Medenovac. The results of this research are presented in Table 3.

As can be seen from Table 3, biomass is the most cost-effective (energy-generating) resource used for heating. It is several times cheaper than oil or electrical energy [37]. The ratio between the high and the low rate of electrical energy is 50:50. Besides being cheaper, one should not forget all the ecological benefits biomass has over other energy-generating products [38]. Biomass is the most ecologically friendly energy-generating product for a household. The use of biomass in households increases independence from the public electro-energy system. Taking into account the prices of resources, it is economically viable to use biomass as a substitute for natural gas or liquid fuels (fuel oil) in the production of thermal energy, which in turn can reduce the import of fossil fuels.

In comparison to fuel oil, where 2.20 kg of wood hold the energy potential of 1l of fuel oil and 1 $m^3$ weighs 750 kg, we can notice that 1$m^3$ of wood has the same energy value as 340.90 l of fuel oil. In other words, the planned cutting volume for ten years of 24,746.54 $m^3$ is worth as much as 8,436.09 t of fuel oil. If we take into account the price of fuel oil, which amounted to 143.00 RSD/l (RSD is the currency in Serbia; in March 2014, 1 EUR was 116 RSD) [33], the value of wood volume obtained from FMU Debeljak–Medenovac over the ten years and calculated based on the price of fuel oil, being a fossil fuel, was 1,206,361,654.49 RSD, i.e. 1 x $10^9$ EUR. Still, to realize the mentioned quantity of wood as a renewable source of energy, activities need to be organized to ensure supply from the forest to the consumer. These activities include cutting, extracting to road infrastructure, collection at temporary storages, and transport to the buyer. All these activities require some sort of energy, mostly from fossil fuels, such as oil, which needs to be calculated in the cost of biomass as a renewable source of energy.

Greater production of biomass can be achieved through an increase in forest areas and adequate forest management approaches. Long-term sustainable forest management requires long-term planning, rational utilization of forests and forest resources, improvement of forest tending as a prerequisite for its existence, protection and regeneration of existing forests, as well as forest establishment (mostly through afforestation, but also through natural regen-

eration). When analysing the possible economic-financial effects of the afforestation process, and the conditions precedent to it, it may be argued that the wood production requires, first of all, a certain land area whose characteristics contribute to the success of the production process, or volume increment per unit area. In the studied forest management unit, there is 164.65 ha of forest land suitable for afforestation. At first glance, it does not seem to be a large area, although it makes 12% of the total area of the whole forest management unit. Still, the loss in volume due to the failure to make the land productive is great. If the average volume of wood per 1 ha for FMU Debeljak–Medenovac is 161.82 $m^3$/ha, it may be argued that over the whole area suitable for afforestation, after the maturation period (at the end of a rotation length of maximim mean annual increment), it would be reasonable to expect the volume of 26,643.00 $m^3$. If this entire volume was taken as fuelwood, which is the cheapest product line, and if the economic value was determined as the value of the standing wood volume, the whole study area would after the maturation period produce volume worth 26,643 $m^3$ x 2,242 RSD = 59,733,606 RSD, i.e. 515 x $10^3$ EUR (unit value according to the Price List for Forestry Products of the State Enterprise "Srbijasume", effective for 2014) [32]. To obtain this value, it is necessary to apply contemporary methods in the field, invest labour and certain financial funds in the afforestation of this area. These are not low or negligible costs at the very beginning, but this investment is certainly worthwhile in a long term. According to the calculations by the Forest Administration of Novi Pazar based on afforestation in 2013, the afforestation per 1 ha would require: (1) planting material (2,500 pcs x 15.00 RSD = 37,500.00 RSD); (2) labour force (25 per diem/ha x 1,600.00 RSD/day = 40,000.00 RSD); and (3) other costs, preparation of planning documents and supervision (7,750.00 RSD). Thus, the total required per 1 ha is 85,250.00 RSD/ha, and for the total area of 164.65 ha, it is required to provide 14,036,412.50 RSD, i.e. 121 x $10^3$ EUR. It should be afforested as soon as possible so that the land becomes functional in terms of wood production and contributes to other well-known and useful forest functions. Tending measures are expected to increase the number of trees with diameters above 10 cm at breast height (1.30 m), which will significantly increase the quantity of wood of this forest management unit.

**Carbon credit benefits in FMU Debeljak–Medenovac.** Biomass has an important role in environmental protection, primarily in the reduction of $CO_2$ emissions to the atmosphere. Hence, some researchers insist on accomplishing more than just sustainably managed forests – they want to realize the forest full carbon storage potential [39]. At the very beginning, there is a value invested in forest growing, which continuously grows through biomass and other multiple forest benefits. Most certainly, one of the most important benefits is the storage of $CO_2$, which grows in time as the volume grows. Sustainably managed forests can have a lower biomass carbon density than unmanaged forests, but the younger forests can have a higher growth rate, and therefore contribute stronger carbon sinks than older forests [39]. Considering the Kyoto Protocol [40], primarily the emission trading mechanism, this is significant potential.

Twelve years ago, the market price of 1 t of $CO_2$ amounted to 29 EUR [35]. Carbon reserves concerning the total FMU Debeljak–Medenovac forest area amount to 53.38 t/ha. It means that the loss in $CO_2$ storage on the barren land in FMU Debeljak–Medenovac amounts to 53.38 t/ha x 164.65 ha = 8,789.01 t. When the value per 1 t amounts its maximal price of 29 EUR or 3,364 RSD, the loss over the total area is 8,789.01 x 3,364 = 29,539,317.64 RSD, i.e. 255 x $10^3$ EUR. Since the price of carbon credit varies greatly, according to the analysis of sensitivity, the carbon credit benefits range between 255 x $10^3$ EUR and 64 x $10^3$ EUR for the area of 164.65 ha (according to actual price), as shown in Table 4. If we add the value of expected volume to the value of carbon credits, there is no doubt that it is necessary to make additional investments in forestry, and increase wood volume.

## CONCLUSION

The results lead to the conclusion that biomass is the highest-ranked renewable source of energy of all. It is not only currently popular, but there are conditions for its long-term utilization as a renewable source of energy with the rational utilization of forest resources. For more significant biomass utilization, preconditions need to be met, such as national policy framework, and strategies for its development. The effects of carbon storage are equally important. The research conducted on the sample area of FMU Debeljak–Medenovac proves that forest management was based on the principles of sustainability. The wood volume in this forest management unit was greater in 2009 than in 2000, despite the planned cutting volume, because its final goal was not to take more than the forest can produce through its natural growth. The analysed environmental and other forest benefits, which may or may not be quantified in monetary terms, indicate that there is no alternative to investments in afforestation and establishment of forests. Based on the obtained data, it will be possible to plan the increment growth, make long-term plans, and calculate the yield from the total wood volume at the level of the forest management administration.

**TABLE 4**
**Carbon credit benefits in FMU Debeljak–Medenovac at breakpoints.**

| Time | Apr. 2005 | Dec. 2005 | May 2006 | Sept. 2007 | May 2008 | Dec. 2008 | May 2011 | Jan. 2012 | March 2013 | Apr. 2015 | Expected in future |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Carbon credit (EUR/t $CO_2$) | 10 | 29 | 15 | 0 | 28 | 11 | 16 | 5 | 4 | 7 | Increase |
| Total benefit ($10^3$ EUR) | 88 | 255 | 132 | 0 | 246 | 97 | 141 | 44 | 35 | 64 | Increase |

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