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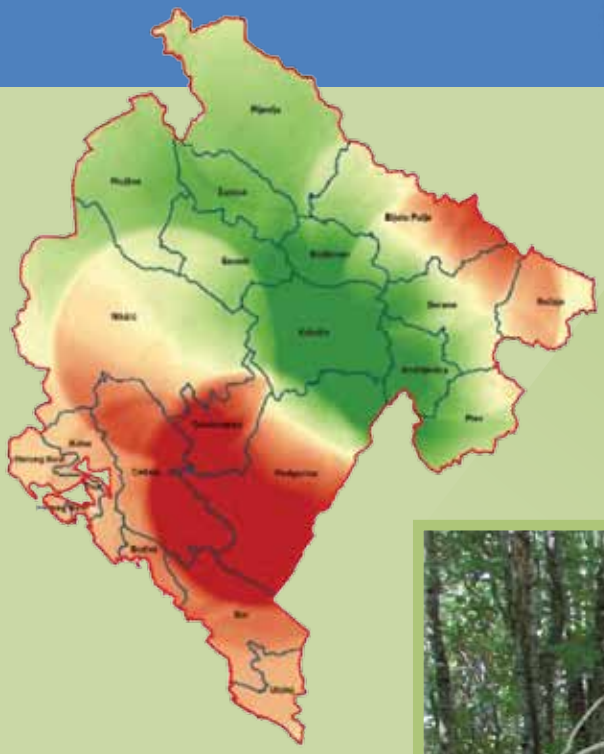
Woodfuel Integrated Supply and Demand Overview Mapping (WISDOM) for Montenegro



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WISDOM MONTENEGRO

Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM)

This publication was prepared by the United Nations Food and Agriculture Organisation (FAO), in co-operation with the Forestry Unit of the Ministry of Agriculture and Rural Development of Montenegro and Luxembourg Development Agency - FODEMO project.

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WISDOM Montenegro

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FOREWORD

The **Woodfuel Integrated Supply and Demand Overview Mapping (WISDOM)** in Montenegro form part of a series of initiatives undertaken by FAO to promote strategic wood energy planning and policy formulation. As in many countries all over the globe the wood energy sector suffers from a widespread lack of recognition in national planning contexts, especially in forest and energy policies. The complex cross-sectoral character of wood energy, which touches energy, forestry, agriculture and rural development, often translates into fragmentation of institutional competencies, thus leaving the wood energy issue "nobody's child".

WISDOM, which was developed by FAO, takes into account particularities of national wood energy systems and meets the needs for a planning tool that integrates relevant socio-economic information and data on woodfuel production and consumption provided by forestry and energy agencies. Thus, WISDOM is an effective tool to enhance the recognition of the wood energy issue and to make this complex issue more readable to policy makers.

The results of the WISDOM project open the prospects of developing a holistic vision and a clear definition of priorities related to wood energy, formalizing wood fuel trade, as well as streamlining the collection and analysis of information on wood fuel demand and supply.

The FAO Regional Office for Europe and Central Asia wishes to express its gratitude to the Ministry of Agriculture and Rural Development of Montenegro and Statistical Office of the Government of Montenegro for their kind support.

This WISDOM Montenegro was made possible by the Government of the Grand Duchy of Luxembourg as part of the FODEMO II (Forestry Development in Montenegro) project implemented in the framework of a bilateral agreement between the Government of Montenegro and the Government of the Grand Duchy of Luxembourg.

Vladimir Rakhmanin
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Summary

Forests cover 59.9% of the Montenegrin territory, and barren forest land additional 9.9% (results of the National Forest Inventory - NFI). This certainly represents a significant potential for utilisation of wood biomass, as an ecological and affordable form of renewable energy source.

With the aim to identify sustainable solutions for utilisation of wood biomass as fuel, FODEMO Project, co-funded by the Government of Montenegro and the Grand Duchy of Luxembourg, and FAO launched the Woodfuel Integrated Supply and Demand Mapping Overview in Montenegro project (WISDOM).

WISDOM project's (GCP/MNE/001/LUX) overall goal is to offer assistance to institutions in Montenegro by providing integrated, spatial and numerical insight into potentials and consumption of wood biomass as fuel.

WISDOM Montenegro has been implemented by using special methodology developed by FAO. Use of WISDOM methodology included an overview, harmonisation and grouping of all available information related to supply and demand of wood biomass as fuel at the lowest possible administrative level, which is specifically the level of a municipality in the case of Montenegro.

Use of WISDOM methodology implied the following steps:

- Definition of spatial units and their analysis (spatial distribution and market analysis).
- Supply module development.
- Demand module development
- Integrated module development and definition of priority areas for future investments.

As **input information**, the Project included data from the National Forest Inventory, data from forest management planning and other existing databases with data on potentials, quantities and spatial distribution of wood biomass in Montenegro.

The methodology also included data from statistical yearbooks, data and geographical organisation of the wood industry, as well as data on existing road infrastructure, consumer centres and settlements, characteristics of the terrain, protected areas and other spatial and time related analyses.

The results are output data in the form of complex maps that show ideal zones for investments in wood fuel production with strong potentials and promising market, or zones where significant enhancement of the current wood industrial activity is feasible.

Visualisation (mapping) of all relevant segments of consumption of wood as fuel, as well as of supply sources, with the aim to have a better overview of these relations, is an important component of this method.

Thus the project, in line with defined methodology, conducts a detailed analysis through analytical conclusions and zoning of areas by their potentials for utilisation of wood biomass as fuel, and provides recommendations to future investors based on the existing market and raw material potentials with guidelines where to invest in putting up new plants for production of wood fuel from biomass or in cogeneration plants.

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1 INTRODUCTION

1.1 Background

According to the 2010 National Forest Inventory (NFI), Montenegro is characterised by high forest cover of 59.9% (826,782 ha). Forest land accounts for 9.9% (137,480 ha). Overall standing volume estimation is 122 million m^3, with current volume increment of 2.9 million m^3.

Judging by forest cover, Montenegro ranks among top countries in Europe, which certainly represents a significant potential for utilisation of wood biomass, as an ecological and affordable form of a renewable source of energy. In addition to the Scandinavian countries, with 1.3 ha per capita, Montenegro is namely one of the countries in Europe with the highest forest cover. It has the highest forest cover in the Balkans: Slovenia's forest cover is 58% (0.6 ha per capita); Croatia's 37% (0.47% ha per capita); Serbia's 27% (0.3 ha per capita); Bosnia and Herzegovina's 41%.

In order to spatially present inter-sectoral data on wood biomass as fuel, spatial distribution, quantity, accessibility, etc, as well as data on needs and consumption of this fuel in the best possible way, WISDOM (Woodfuels Integrated Supply/Demand Overview Mapping) methodology has been used.

More than a decade ago, FAO's Wood Energy Programme (WEP) launched a process to develop a wood energy strategy in line with the plans for sustainable forest management (SFM) defined in activities off the Ministry's Forestry Unit. It is expected that these strategies will also be correctly integrated with other rules set by energy and environment organisations.

Main actions have been focused on building capacities of the Ministry's Forestry Unit, its activities and inter-sectoral cooperation. Within this effort, UEP, FAO, in cooperation with Instituto de Ecologia of the National University of Mexico developed WISDOM project (Woodfuel Integrated Supply-Demand Overview Mapping), a diagnostic project for elaboration of situations related to potentials and utilisation of wood biomass energy.

For Montenegro, this assistance has provided an excellent opportunity to improve inter-sectoral communication and coordination between sectors of energy, renewable energy sources, environmental protection, forestry, waste management and others.

Demand for wood energy has been analysed through a prism of previous research, which were based on examining existing situation of wood utilisation by households, public institutions, as well as on analysing the wood energy market in Montenegro.

The project has been based on previous results and data from the Forestry Unit of the Ministry of Agriculture and Rural Development, Forestry Administration and their partner - FODEMO project, funded by the government of the Grand Duchy of Luxembourg. Real Estate Administration also provided data related to road infrastructure (roads of all categories, railways, bridges and tunnels), waterways, slopes, and network of settlements (cities, towns, villages and hamlets) in Montenegro. Data are also based on the results of surveys conducted by the Statistical Office of Montenegro (MONSTAT) and published in statistical yearbooks, as well as the data and publication methodology on fuel wood consumption in Montenegro that is adapted to local conditions and allowed compilation and analysis of current data for households and business entities, as well as data at the municipal level.

A challenge to overcome has been the following: how to combine the existing information in the best possible way and obtain valid and usable results and present them in a visually understandable manner in order to be useful to as many beneficiaries as possible.

1.2 Goals

Ministry of Agriculture and Rural Development of Montenegro, in cooperation with FEDEMO and FAO, has launched WISDOM Project activities with the aim of getting a realistic picture of spatial distribution of the raw material and positions for improved utilisation of biomass for energy purposes.

Obtained results can be used as a basis for planning activities for utilisation of wood biomass energy potential in Montenegro, taking into consideration potentials, infrastructure, and market related aspects.

The main goal of this support has been to provide assistance to institutions, entrepreneurs and investors in Montenegro in overcoming the lack of relevant data and information related to the potentials, consumption and contribution of wood biomass to the energy balance.

The WISDOM methodology, already proven and tested, will provide the following:

- Spatial and numerical information on the consumption of wood fuel in Montenegro and a balance between supply and demand for biomass as fuel by categories (households, industry, etc.) at the municipal level;
- Balance between supply and demand of timber residue from forests, agricultural production and wood processing in Montenegro and expected potential markets;
- Scenario on where investments in forest roads infrastructure would be most cost-effective.

The project's scope has included support to the Ministry of Agriculture and Rural Development of Montenegro to create a basis for planning in the area of wood biomass utilisation for energy purposes, as well as to formulate the sector's policy by means of establishing and developing proper spatial and statistical IT basis.

Specifically, the tendency has been to contribute to the establishment of Montenegrin wood biomass system and to develop a number of thematic maps related to potentials and utilisation of wood biomass products, including processed wood fuels such as wood charcoal, wood chips, pellets and briquettes.

By applying the WISDOM methodology, this approach should eventually provide a basis for:

- GIS database with modules for supply, demand and integrated data - including different scenarios for forestry sector development;
- Information system on wood biomass (quantities, accessibility, spatial distribution, and consumption) which can be used by those who are not GIS experts (policy makers, investors), and which can easily be updated (for example, with new data on households, wood processing investments, changes in infrastructure, etc.);
- Report on options for marketing wood processing by-products for processed wood fuels (wood charcoal, wood chips, briquettes, pellets).

The overall project goal was to enhance the capacity of the Forest Administration and the Ministry of Agriculture and Rural Development to formulate, assess and develop consistent bio-energy strategies, programmes, and projects, compatible with sustainable management in forestry, energy and agriculture sectors.

The project has covered a broad area that included all relevant segments of biomass utilisation for energy purposes in Montenegro. The following elements have been covered through this project:

- Mapping and cartographic representation of elements important for wood biomass utilisation,
- Setting of a basis for wood energy utilisation information system,
- Macro and social and economic aspects of wood energy,

- Wood biomass market analysis,
- Wood based energy technologies,
- Wood fuel production, trade and utilisation aspects,
- Knowledge expansion and raising public awareness.

In other words, the goals require understanding of the real potential of wood energy as economically and ecologically renewable source of energy important for Montenegro.

Key questions that needed answers were about quantities and locations of current production and consumption of wood biomass in Montenegro and its spatial distribution; quantities and spatial distribution of remaining production potentials, which could be used in a sustainable manner; relation and distance of potentials from road infrastructure and consumer centres; marketing, competition, and market prices of these products.

All these parameters have been taken into consideration as a basis for identifying locations suitable for new investments in production of pellets, briquettes or production of wood biomass based heat or electricity.

Objectivise of these activities were the following:

- To integrate different information, relevant for planning wood energy utilisation in Montenegro, into spatial and explicit data;
- To provide necessary information with regard to consumption of wood fuels by different categories of users on the one hand, and on the other to clearly define spatial and quantitative potentials of wood biomass supply sources (forests, wood processing industry, etc);
- To identify areas most suitable for development and implementation of projects, including plants for pellets production, etc;
- To prepare a basis for the Montenegrin Wood Energy Information System by providing relevant data on production, consumption and trade in fuel wood, wood charcoal, pellets, briquettes, etc.

2. MATERIAL AND METHOD OF WORK

WISDOM is a methodological project, created to provide forms for spatial representation of wood fuel supply and demand.

Collection and analysis of data on wood biomass potentials and its current utilisation in Montenegro has been based on implementation of Woodfuel Integrated Supply/Demand Overview Mapping -WISDOM.

The data are grouped into following four categories:

1. Administrative data and spatial plans
2. Supply related data
3. Wood fuel demand/consumption related data
4. Data integration

In essence, WISDOM is a spatial and explicit method to support strategic planning in the wood biomass energy sector, as well as to help policy formulation, through integration and analysis of existing supply and demand of wood biomass as fuel, relevant information and indicators. The basic idea behind WISDOM methodology is to combine existing data and provide new relevant / qualitative values, such as risk zoning or threat ranking.

WISDOM serves as a tool for evaluation and strategic planning that would be based on identification of locations suitable for specific activities aimed at valorisation of potentials of wood biomass as fuel.

Implementation of WISDOM methodology implies the following steps when using these data:

- Definition of spatial units and their analysis;
- Supply module development;
- Demand module development;
- Development of the integrated module and definition of investment priority areas.

Implementation of the WISDOM methodology includes an overview, harmonisation and integration, at the lowest possible administrative level, of all available information with regard to supply and demand of wood biomass that can be used for energy purposes. Visualization (maps) of the current wood fuel consumption level and supply sources and identification of priority areas for bio-energy sector development are also important.

Studies completed with this methodology thus far show that the WISDOM methodology is flexible and adaptable to specific needs and different levels of bio-energy sector development of each country. In all studies to date, the main idea has been to consolidate fragmented knowledge and to provide an integrated picture of wood fuel potentials, production / consumption.

3. WISDOM METHODOLOGY

The basic goal and manner of using WISDOM methodology is to integrate available data on wood biomass potentials and the current level of wood biomass utilisation in Montenegro, as a basis to prepare the Montenegrin information system in the area of wood biomass energy. This system should serve as a practical tool for policy makers and should contribute to the development of biomass energy sector. In order to accomplish this goal, it was necessary to use previous research, in cooperation with many public institutions, as well as to harmonise and use all available data.

The data within WISDOM methodology are grouped into 4 sets, of which the first three groups include collected data, while the fourth group includes data derived through comparative analysis:

1. Administrative data/spatial plan:
   Municipality number and name, population, areas; transport infrastructure, etc.
2. Data related to potential:
   Forest supply; total standing volume and increment; annual allowable cut and its structure; standing volume from agricultural sector, timber residues from wood processing industry;
3. Woodfuel supply/consumption related data:
   Population/number of households using firewood/wood fuel,
   Surface area of flats using fuel wood,
   Estimated annual consumption of fuel wood;
   Data on existing biomass systems, such as remote heating systems,
   Combined use of fuels and so on.
4. Data integration - results:
   Balance between consumption and supply.

The final biomass analysis was conducted based on raster data of medium resolution. Selected raster cell of 20m (1 cell - 0.05 ha) have allowed sufficiently detailed spatial analysis, so that information are proper not for strategic planning only, but for operational planning at the local level as well.

3.1. Administrative data / spatial plan

Overview, harmonisation and grouping of all available information on supply and demand for wood biomass as fuel has been done at the level of municipalities, which consequently represented basic spatial units used for setting up the data base.

Thus, the territory of Montenegro has been divided into 21 units and this division is compatible with demographic, social and economic, and energy data collected by Statistical Office of Montenegro (MONSTAT) and by Real Estate Administration.

MONSTAT's data at the level of municipalities and settlements (1,192 settlements in total) were used to map spatial distribution of population by municipalities and settlements (picture 1).

Part of the forestry related database that includes data on structure, potentials and level of forest exploitation will also be presented at the municipal level. Spatial components have been created mostly by using data and results of the National Forest Inventory (13,869 units), as well as other available space and time analyses received from the forestry sector.

Spatial plan will subsequently represent a primary base to which all other analysed data within WISDOM Montenegro will be linked.

Picture 1. *Municipalities and settlements in Montenegro as basic spatial units* (map: Pisek R.)

3.2. Supply module

3.2.1. Forests

Forests are one of the most important natural resources in general. Wood biomass is a basic raw material for the timber industry, it is a basic household heating fuel, and there are also non-timber forest products giving significant contribution to the lives of people in many rural communities. There are numerous possibilities how to use areas under forests and valorise their social functions. However, any basic consideration of their economic importance is still primarily viewed through the standing volume.

Montenegro is seen as a country with very high forest cover. As studies used as a basis for developing this document were completed at different times and took different sources for inputs, this section will offer a comparative overview of the most relevant parameters for the forests in Montenegro:

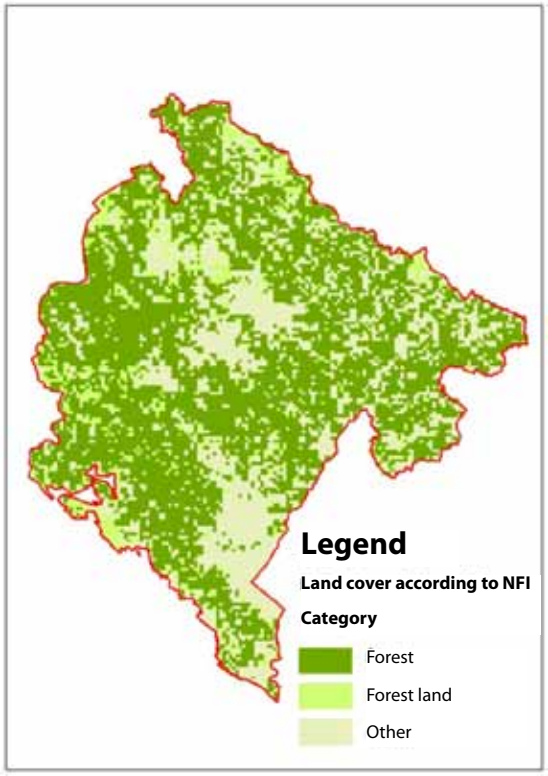
Of the entire territory of Montenegro, given the statistical data used in the **National Forest Policy** adopted in 2008, the total of 45% of the territory (621,609 *ha*) is covered by forests. Forest land, which according to international definition includes brushwood, bushland, maquis and garrigue, covers 9% (123,000 *ha*) in total, which together amounts to 54% (743,609 *ha*) of the entire Montenegrin territory.

We can find a different insight into the forest cover of Montenegro in **FRA *(Forest Resources Assessments)* and FAO *(Food and Agriculture Organization of the United Nations)*** reports by specific periods, and they were obtained by analyzing data from 1990 to 2010. According to this source, forests cover 39.3%, forest land 12.7%, while together they cover 52% of the Montenegrin territory.

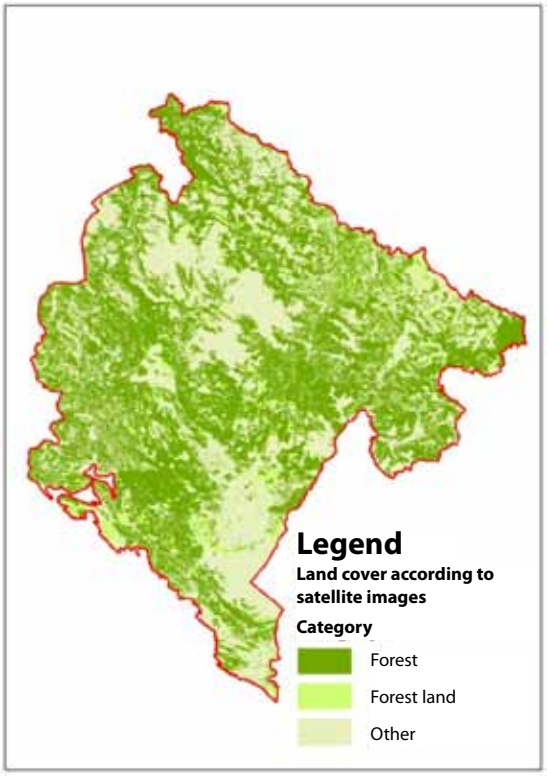
Table 1: Categories of surface areas according to NFI and LANDSAT images

category	**NFI**				**LANDSAT**		
	unit	*Surface area (ha)*	*%*		*unit*	*Surface area (ha)*	*%*
Forest	8.318	826.782	59,5%		11.565	705.605	50,8%
Forest land	1.364	137.480	9,9%		16.514	102.712	7,4%
Other	4.214	421.400	30,6%		34.290	581.326	41,8%
SUM		1.389.600				1.389.643	

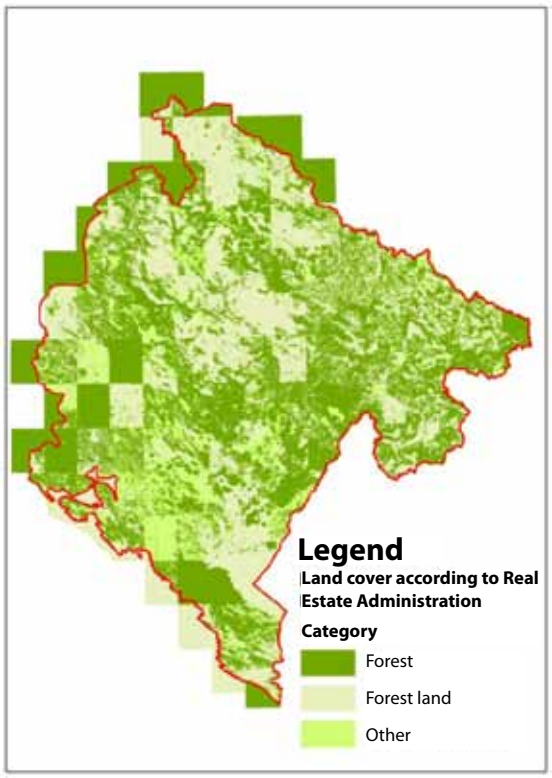
Based on **the First National Forest Inventory 2009-2011** results, forests cover 59.5% (826,782 ha), forest land 9.9% (137,480 ha), while together they cover 69.4% of the Montenegrin territory. Other categories (urban areas, water areas, agricultural land, wastelands, etc.), which are not forests and forest land, account for 30.6% of the state's surface area. Taking into account the population, we get the forest cover of 1.3 ha per capita. Differences are also obvious when data from NFU are compared to the data derived from satellite images (LANDSAT) (table 1).



Picture 2: Land categories – NIŠ (map: Borota D.)



Picture 3: Land categories based on LANDSAT images (map: Borota D.)



Picture 4: Categories according to Real Estate Administration data (map: Borota D.)

Picture 5: Comparison of NFI (1x1 km) and LANDSAT data (map: Borota D.)

The National Forest Inventory was taken as the most relevant document, given the fact that, unlike other documents, it was based on field research with clear methodology and observed all principles of statistics when collecting data.

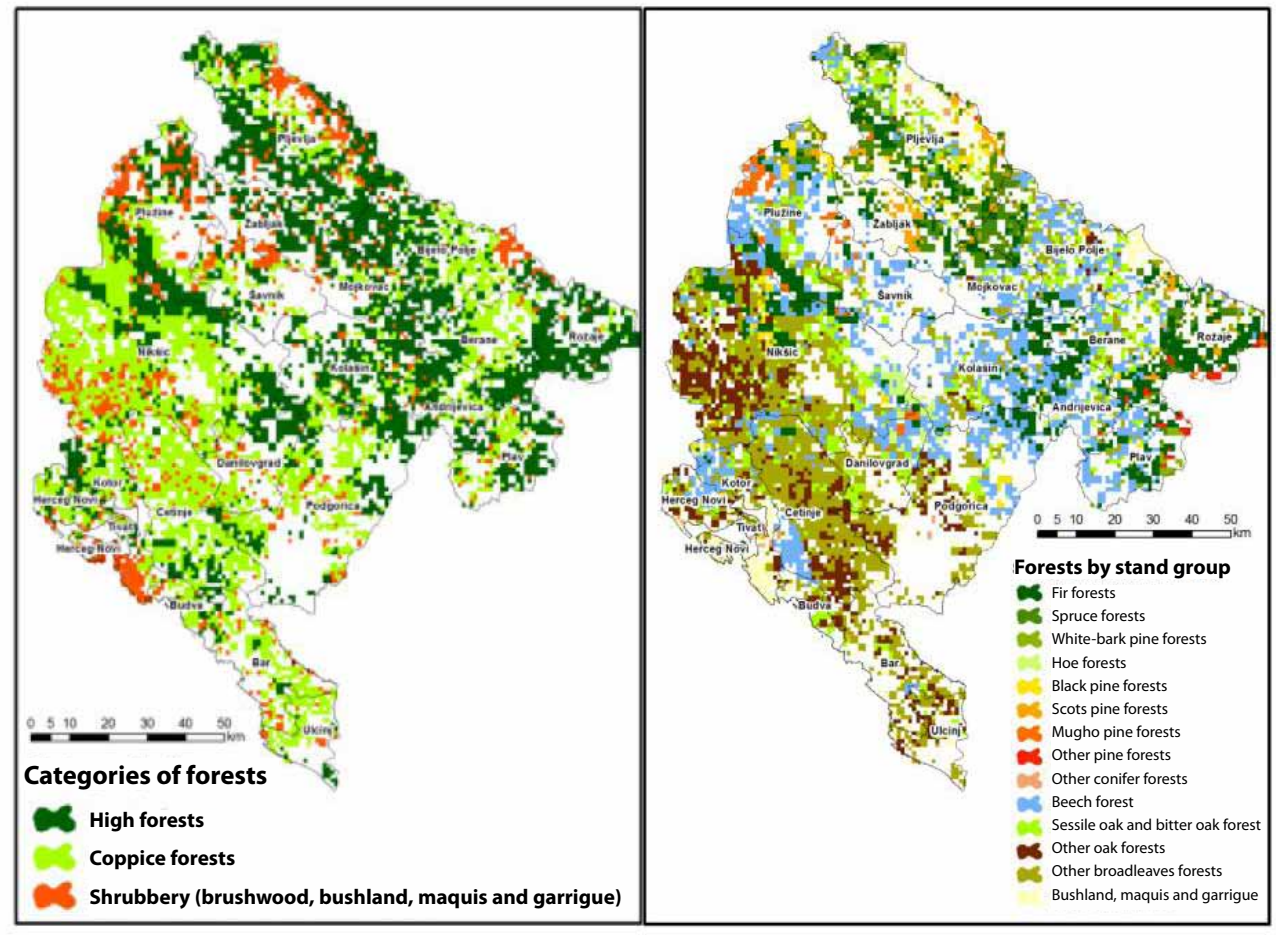
3.2.1.1. Diversity of forests

The National Inventory registered 68 tree species (57 broadleaves and 11 conifers), which indicates a great diversity of forests in Montenegro.

Share of individual species in the forest supply is uneven.

Viewed by area, beech dominates with 19.8%, followed by bitter oak with 7.3% and sessile oak with 2.0% of areas covered with forests.

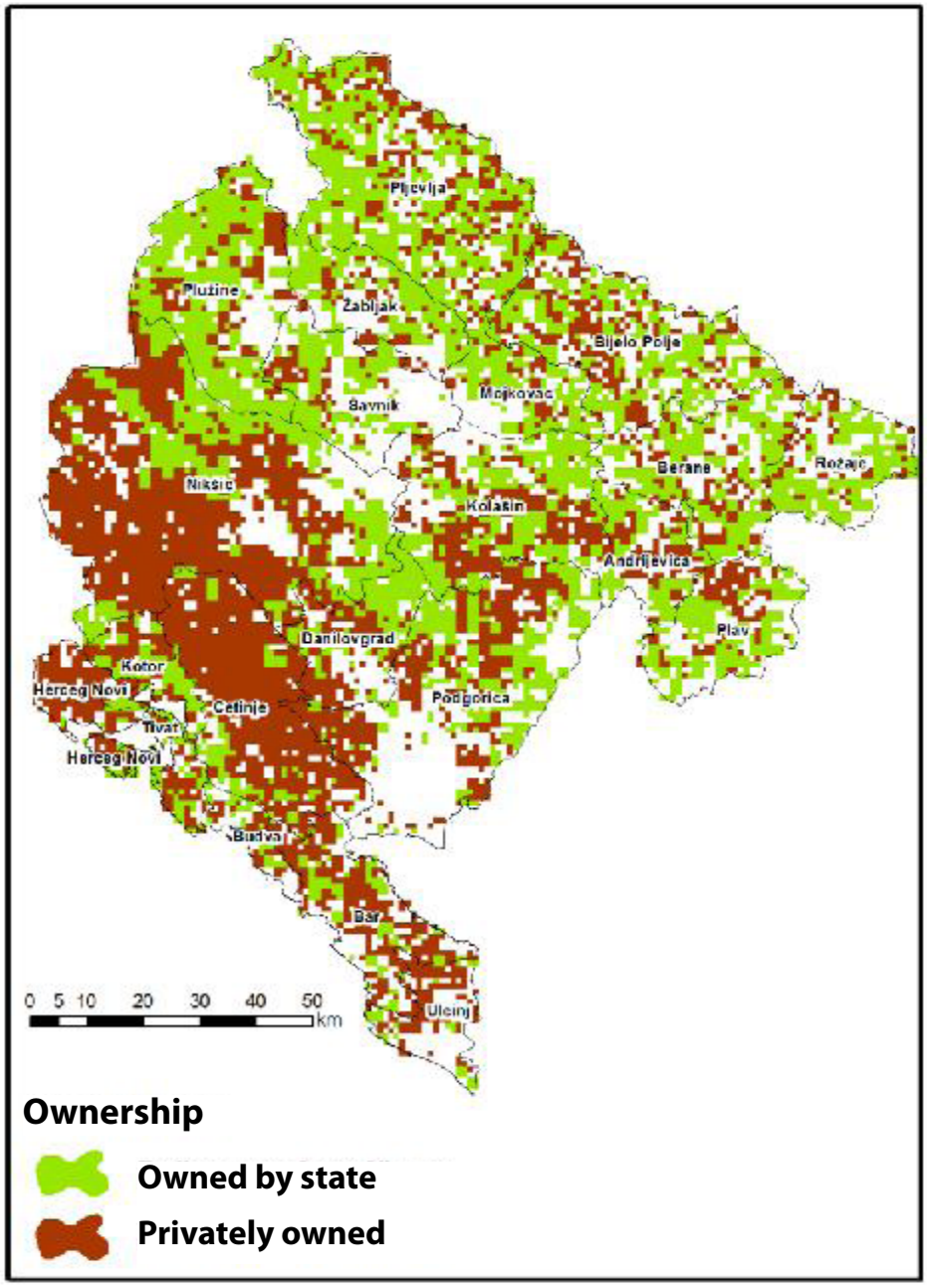
Hardwood broadleaves cover 10.4% of the area under forests, softwood broadleaves 2.9%, while share of valuable ('noble') broadleaved trees is also significant with a share of 8.3 % of the total area under forests in Montenegro. As for conifers, the most common is spruce with 8.5% of the covered area of Montenegro, fir with 4.1% and black pine with 1.6%.



Pictures 6 and 7. Main categories of forests. Source: NFI 2013 (map: Borota D.)

3.2.1.2. Ownership

Share of state-owned forests, according to NFI, is 52.3%, and private 47.7%. As for forest land, private ownership dominates with 58.0%.



Picture 8. *Forest ownership* (map: Borota D.)

It should be noted that the restitution process has not been completed yet, nor the rearrangement of cadastre data for Montenegro by the Real Estate Administration, and consequently ownerships assessment for sample areas during NFI was made based on data available at that moment.

The structure of state-owned forests is much better when compared to private forests, which is best reflected by the quantity of standing volume per spatial unit, being much lower in privately owned forests. State-owned forests have larger average volume of 227.9 m^3/ha compared to 88.7 m^3/ha in privately owned forests and account for 72.7% of the entire volume.

Privately owned forests are also characterised by fragmentation. According to the study conducted by the Netherlands Development Agency (SNV), 57% of private estates fits in the size category of 5 hectares, 27% in the category of 6 to 20 hectares, and 13% in the category of 21 to 50 hectares.

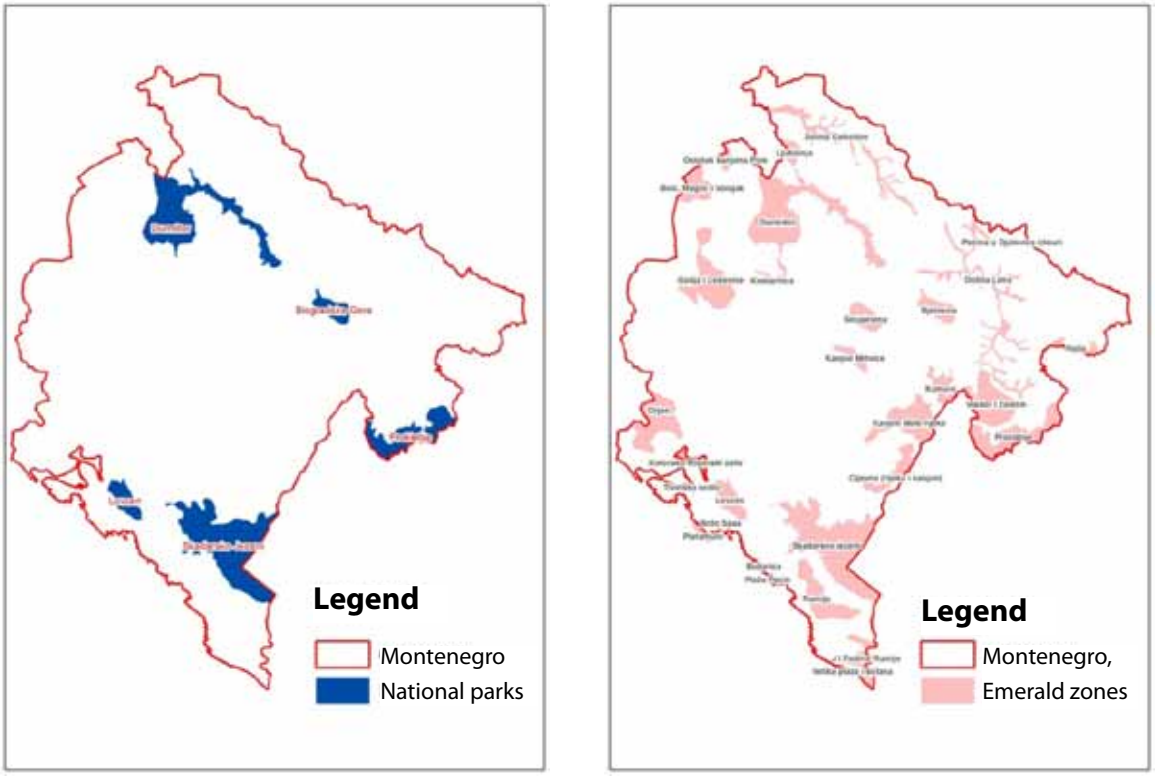
Only two thirds of forest owners utilise their forests (for harvesting), and just over half of that standing volume (53%) is for own needs (predominantly fuel wood).

3.2.1.3. National parks, NATURA 2000 and Emerald areas

According to the NFI, forests classified as potential Natura 2000 habitats from Annex I cover 38.7% of the available forest area and 7.5% of accessible forest land area.

Large parts of forests and forest land are protected under law, 5.2% of forest areas are located in national parks, and 14.6% in Emerald zones.

Forests in national parks, Emerald zones and in inaccessible areas account for 23.5% of the total forest cover in Montenegro, while the share of areas with primarily protective function within forest land is 22.2% of the entire area.



Picture 9 and 10. *Protected areas in Montenegro* (map: Borota D.)

3.2.1.4. Standing volume, increment and harvesting

The National Forest Inventory has shown that the total standing volume in forests in Montenegro is 122 mil. m^3, or 159,6 m^3/ha on average.

Average volume is larger in state-owned forests (227.9 m^3/ha) and its share in total volume is 72.7%, compared to privately owned forests (88.7m3/ha), whose share in total volume is 27.3%

High forests cover 51.1% (with 253.1 m^3/ha), and coppice forests 48.9% (with 62.6 m^3/ha) of the total area under forests.

Development phases of maturing stands, young crops, seedlings and pole stands dominate, and together they cover 60.5% of the area under forests.

A large share of stands have poor crowns. Namely, 48.2% of forest stands have a crown of 60% and lower.

Consequently, this situation resulted in low average volume of 159.6 m^3/ha (of accessible forest, relative standard deviation 2.3%) in Montenegrin forests.

Most forests in Montenegro (78.7%) are mountain forests, located at the altitude of 800-1800 m, and slopes with 6-35 gradient (87.2%).

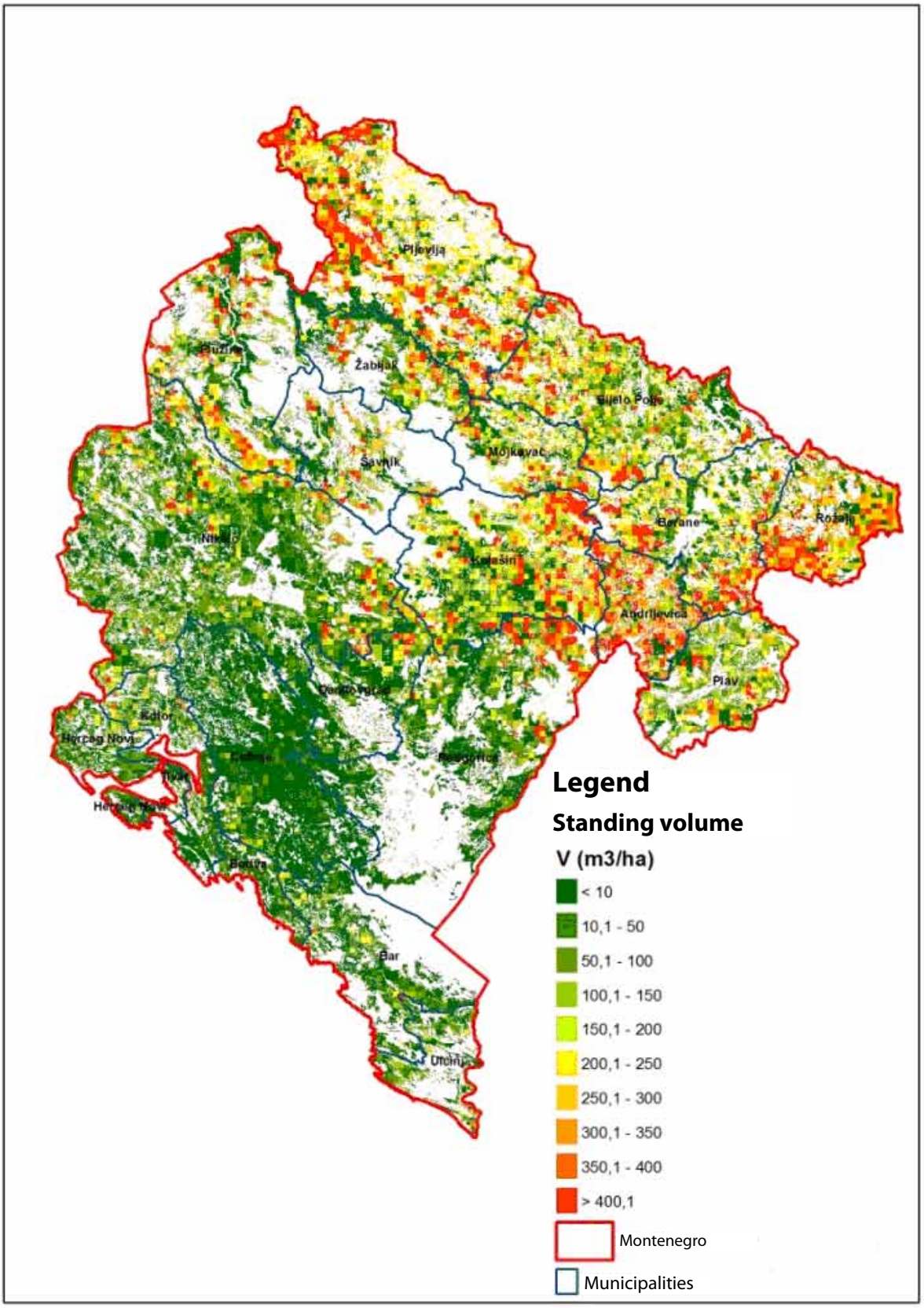
Average volumes higher than 200 m^3/ha are present between 1,200 and 2,000 m above sea level, while in low altitude regions they are much lower.

Montenegro is characterised by dominance of broadleaved trees, their forests covering 76.2% of the surface area. Volume per hectare for broadleaves is only 136.3 m^3/ha. In contrast, that of conifers is 293.5 m^3/ha.

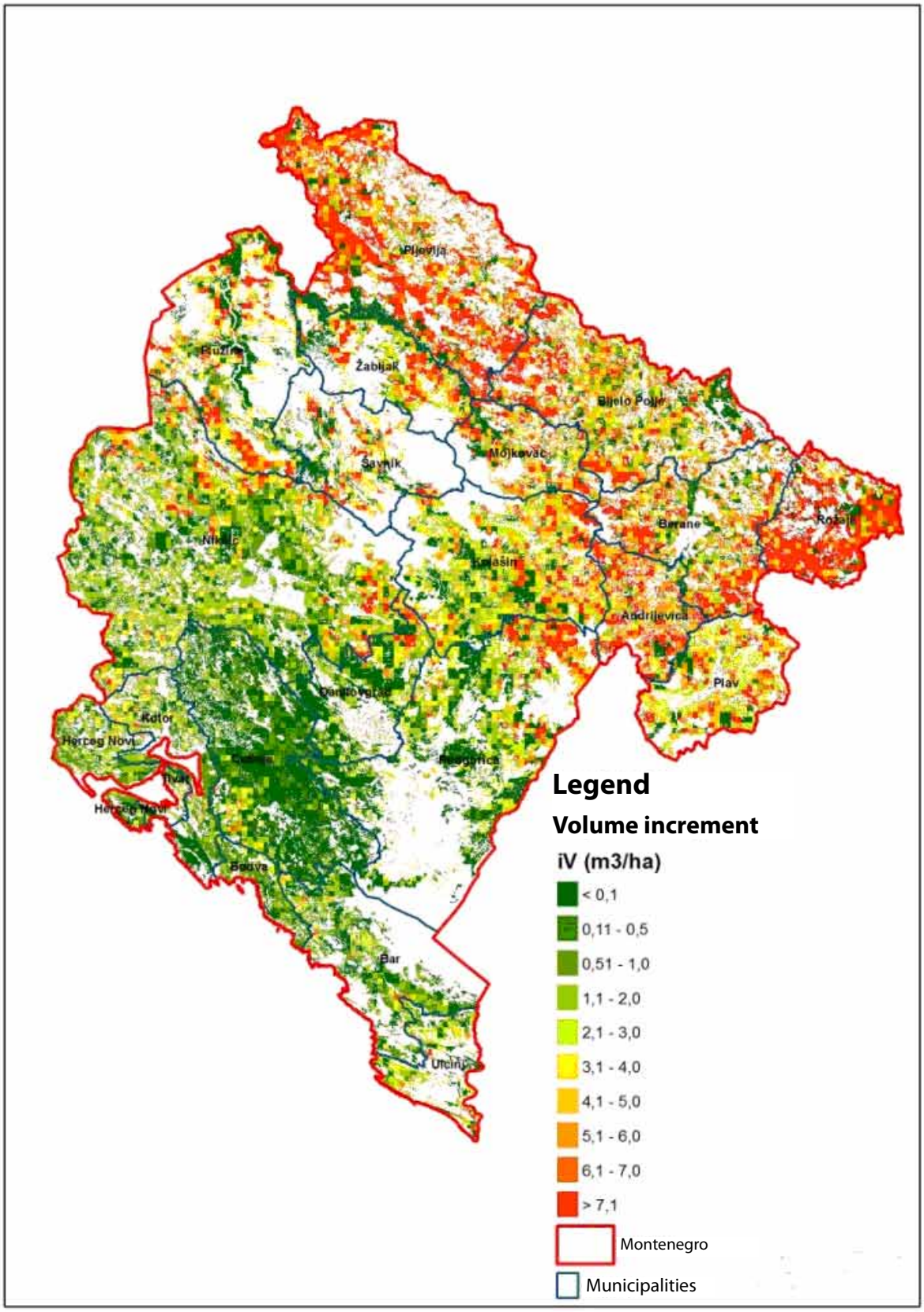
Conifers' share in total volume is 40.2%. Conifers' volume increment is 8.1 m^3/ha and it is significantly higher than that of broadleaved trees, which is 2.9 m^3/ha. Conifers account for 46.6% in overall volume increment.

Overall volume is dominated by beech with 34%, followed by fir with 32%, spruce with 11%, bitter oak and sessile oak with 5.5%, while other broadleaved trees account for 6.7%. If we take into account the configuration of forests, and particularly significant share of conifers, then the average volume of 159.6 m^3/ha with current increment of 2.9% mil. m^3 is certainly far from potential capacities of habitats, and it is a consequence of historical circumstances and frequently irrational attitude towards this potential in the previous period.

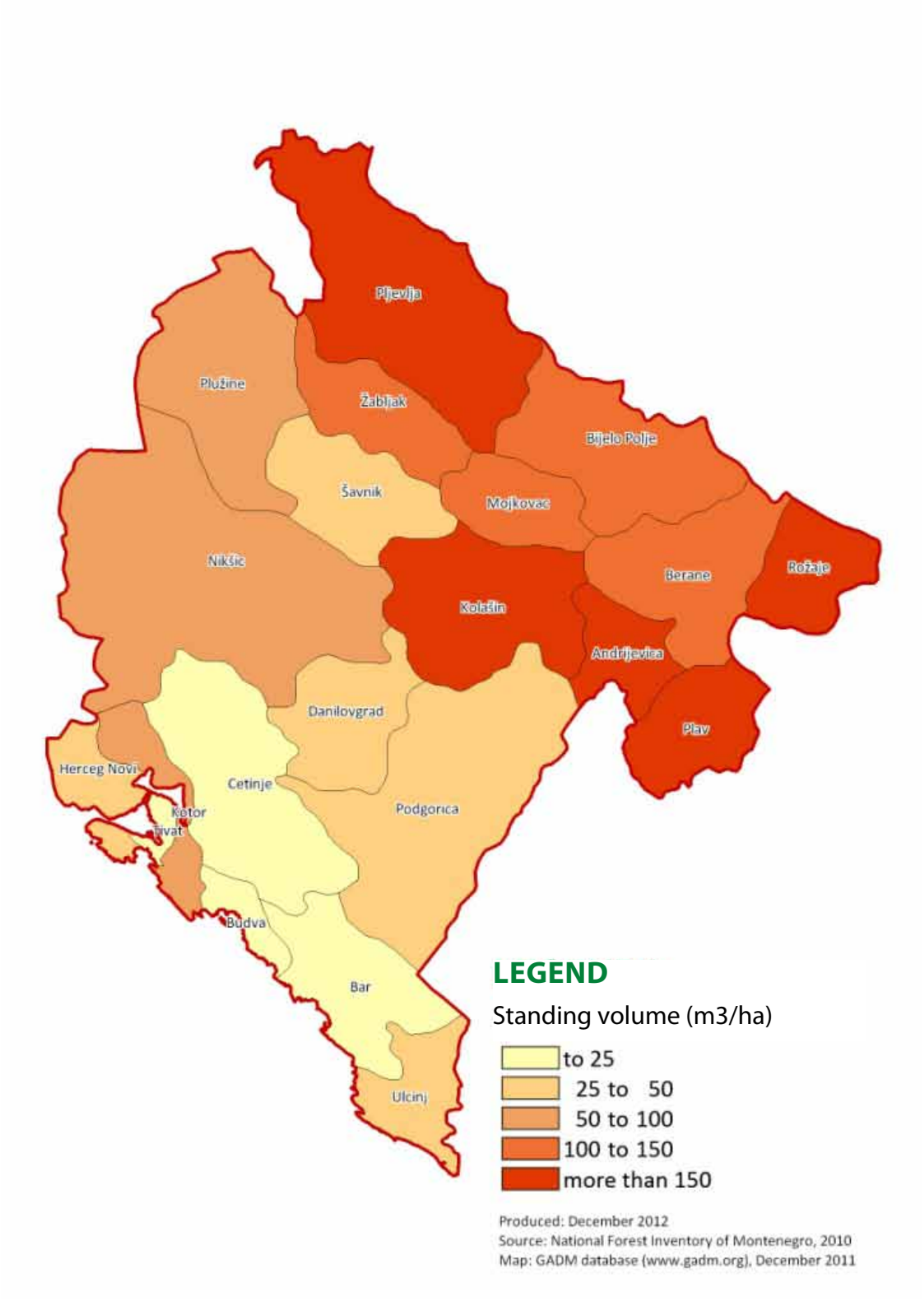
The previous claim is also supported by an insight into the structure of stands in Montenegrin forests, where thin and medium thick trees dominate, with much smaller share of trees with largest dimensions. This conclusion also indicates a potential assortment structure and some related economic analyses and plans in the forestry sector, as well as potentials for wood mass utilisation.



Picture 11. Standing volume (V) of trees per hectare (map: Pisek R.)



Picture 12. Current annual increment per hectare (map: Pisek R.)



Picture 13. Average standing volume by municipalities (map: Borota D.)

3.2.1.5. Accessibility of forests

Uneven treatment through management so far has been common for all categories of forests. Management units were opened unevenly. In accessible forest areas, and those are dominantly forests in lower and middle regions, high intensity harvesting was conducted, particularly in vicinity of forest communications, and therefore repairing current condition is the top priority of future management, together with forestation, particularly in sloped terrains near roads.

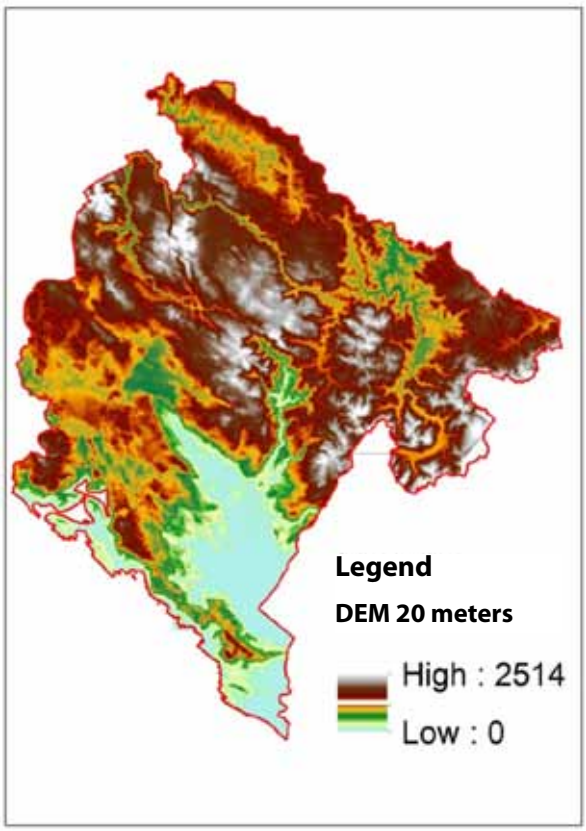
Contrary to these areas, a number of management units with poor accessibility have average standing volume that is above the balanced one, with significant share of over-matured large volume trees in poor health and of small yield.

Given the real size of good classes, average standing volume is lower than the optimal one in forests in lower, middle and upper regions. Forests in high and partially in upper regions share characteristics of virgin forests with volume above average.

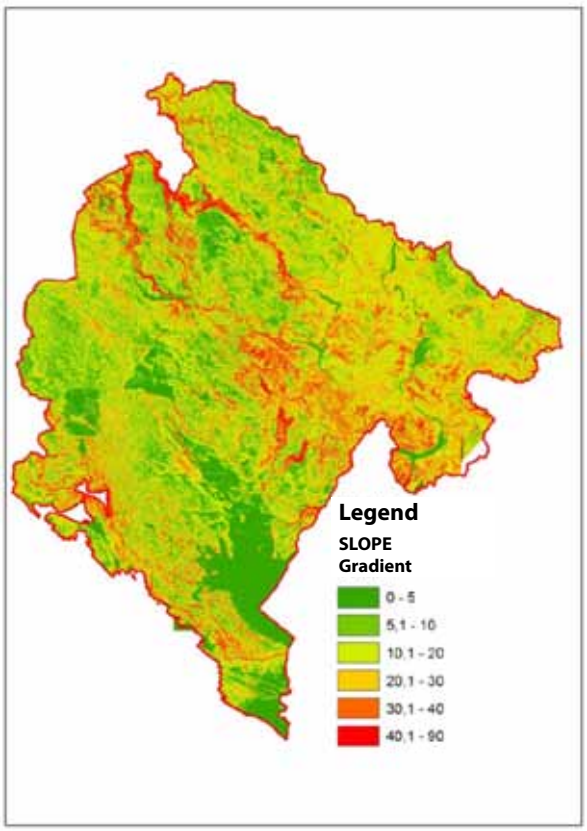
Available raw material forestry resources, with proper processing capacities, can significantly participate in the overall domestic product, export and employment.

Better wood biomass utilisation is another important potential of forests. Utilisation of entire biomass has significant social and economical impacts, which should be taken into account when doing an assessment.

In sloping mountainous terrains, which are predominant in Montenegro, (pictures 14 and 15), network of forest roads is a key prerequisite for selviculture of forests and their economically efficient utilisation.



Picture 14: Altitude of terrain
(map: Borota D.)

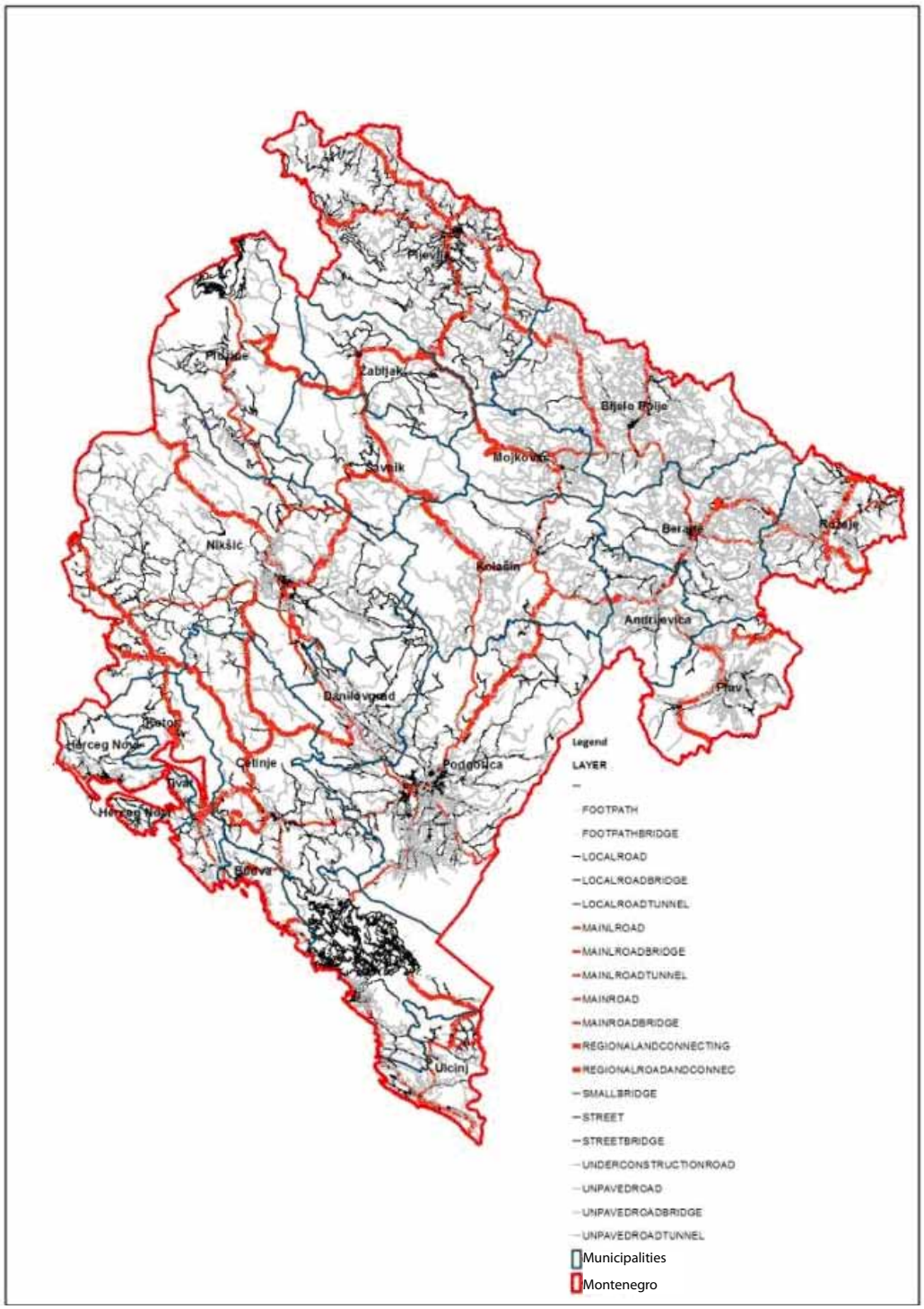


Picture 15: Slope map
(map Borota D.)

Forest roads (picture 16) are essential infrastructure, without which intensive forest management, rational utilisation of forests, as well as comprehensive protection of forest areas cannot be imagined.

Works aimed at improvement and utilisation of the growing stock require optimal and quality

road infrastructure that allows reduction of the cost of works, use of modern forestry machinery and use of new work related technologies.

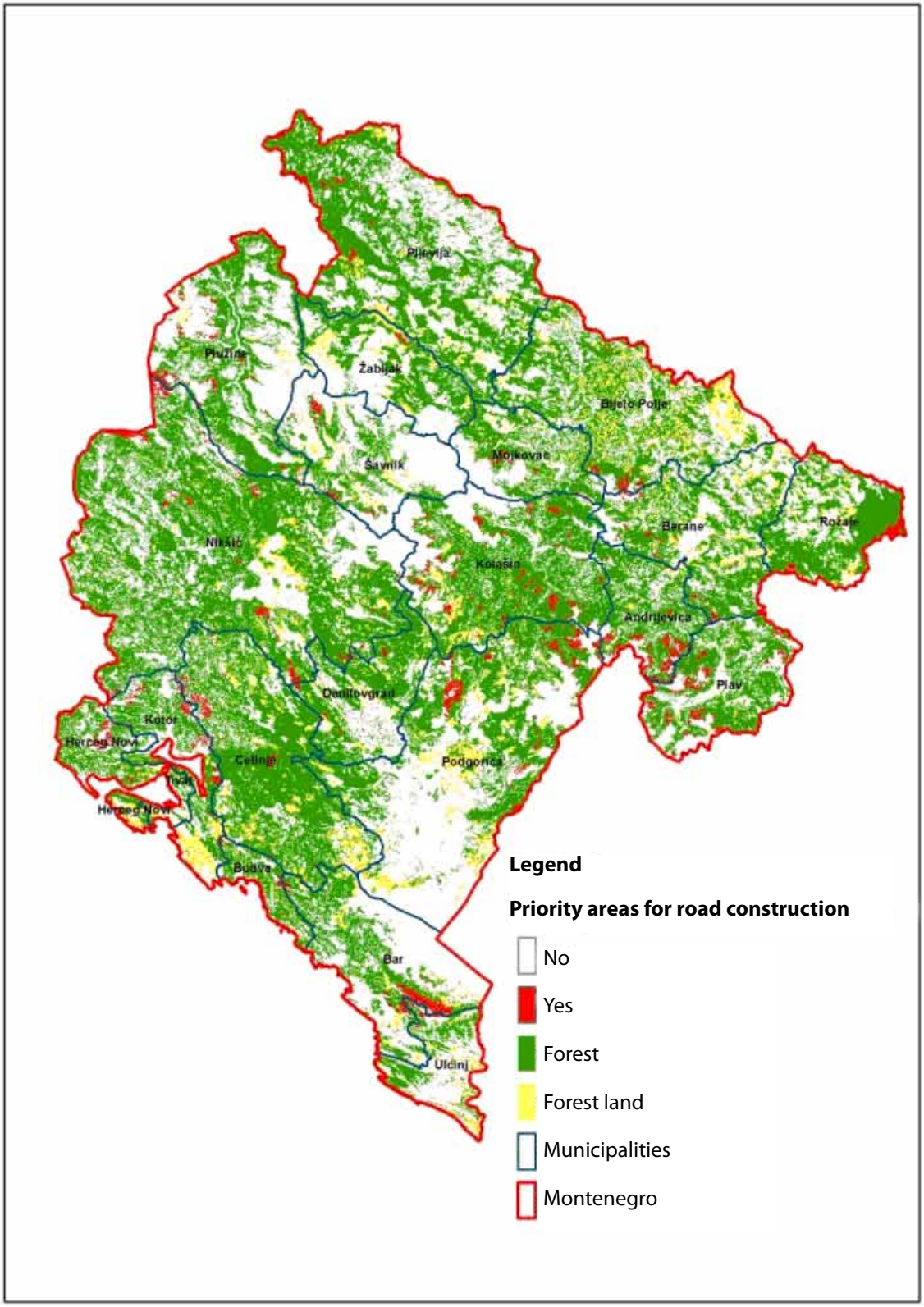


Picture 16: Network of roads (map: Pisek R., Lučić S.)

In order to ensure forest management sustainability, good accessibility needs to be provided even to the forests that are not easily accessible today. Without those investments, a long-term decrease of annual harvesting may occur.

An analysis of existing road network, terrain slope and standing volume has been done and an

overview of locations where interventions aimed at improving road infrastructure would be most effective has also been provided (picture 17).



Picture 17: Priority locations for road infrastructure interventions (map: Pisek R., Lučić S.)

3.2.1.6 Allowable cut – different scenarios

In accordance with the Law on Forests, most of the state-owned forests in Montenegro are given for utilisation by means of concessions. Funds from concession fees are Forest Administration's revenue, which it uses in line with approved Government's programme.

Harvesting of **678.499 m³** in private and state-owned forests is set as a plan in 2013 Annual forest management plan of the Forest Administration**.**

In order to get a more realistic overview, wood fuel consumption level in Montenegro presented in 2013, which referred to 2011 wood fuel consumption according to the Statistical Office's study, was also taken into account for calculations..

The studies showed that the **overall consumption** of wood biomass for energy and non-energy purposes in Montenegro in 2011 was **1.06 million m³**, of which **732,900 m³ as fuel wood** or 69.1%, and **326,600 m³ as industrial round wood** or 30.9%, while the overall production was **1.16 million m³**, which is bigger than consumption, as part of produced wood fuel and industrial round wood was exported from Montenegro.

Similar harvesting data were also set in 2011 programme, as well as in 2013 programme, but obviously consumption was almost 2 times bigger than planned, and this piece of data was therefore taken into account when making projections.

It should be noted that the data on the quantity of harvested industrial round wood of 397,332 m^3 (326,600 m^3 processed in wood processing plants in Montenegro and 70,000 m^3 of round wood that was exported) match in all observed sources (Forest Administration, Customs Administration, MONSTAT, FODEMO studies), while some differences arise in the quantities of consumed fuel wood.

Draft Strategy, with a plan for development of forests and forestry in Montenegro in the next decade, projects an increase in harvesting the standing volume of smaller dimension trees, which primarily means increase in the supply of fuel wood.

As set in the draft Strategy, there are no potentials to increase supply of technical round wood for processing purposes in the forthcoming period, but it won't be reduced either.

Picture 18: Standing volume in harvested area, Pljevlja (photo: Stijović A.)

In order to make calculations with realistically expected quantities, 2 scenarios have been developed. The first is related to the current level of overall harvesting with intensified silviculture and improved forest communications, and the second that includes planned increase of harvesting in the forthcoming period.

- Scenario 1: based on the existing forest management programmes, with a prerequisite to carry out necessary investments in forest roads and intensify silviculture and care of young forests, as well as conversion of sprout into high forests. According to this scenario, overall harvesting stays at the current level with utilisation of the entire planned annual allowable cut.
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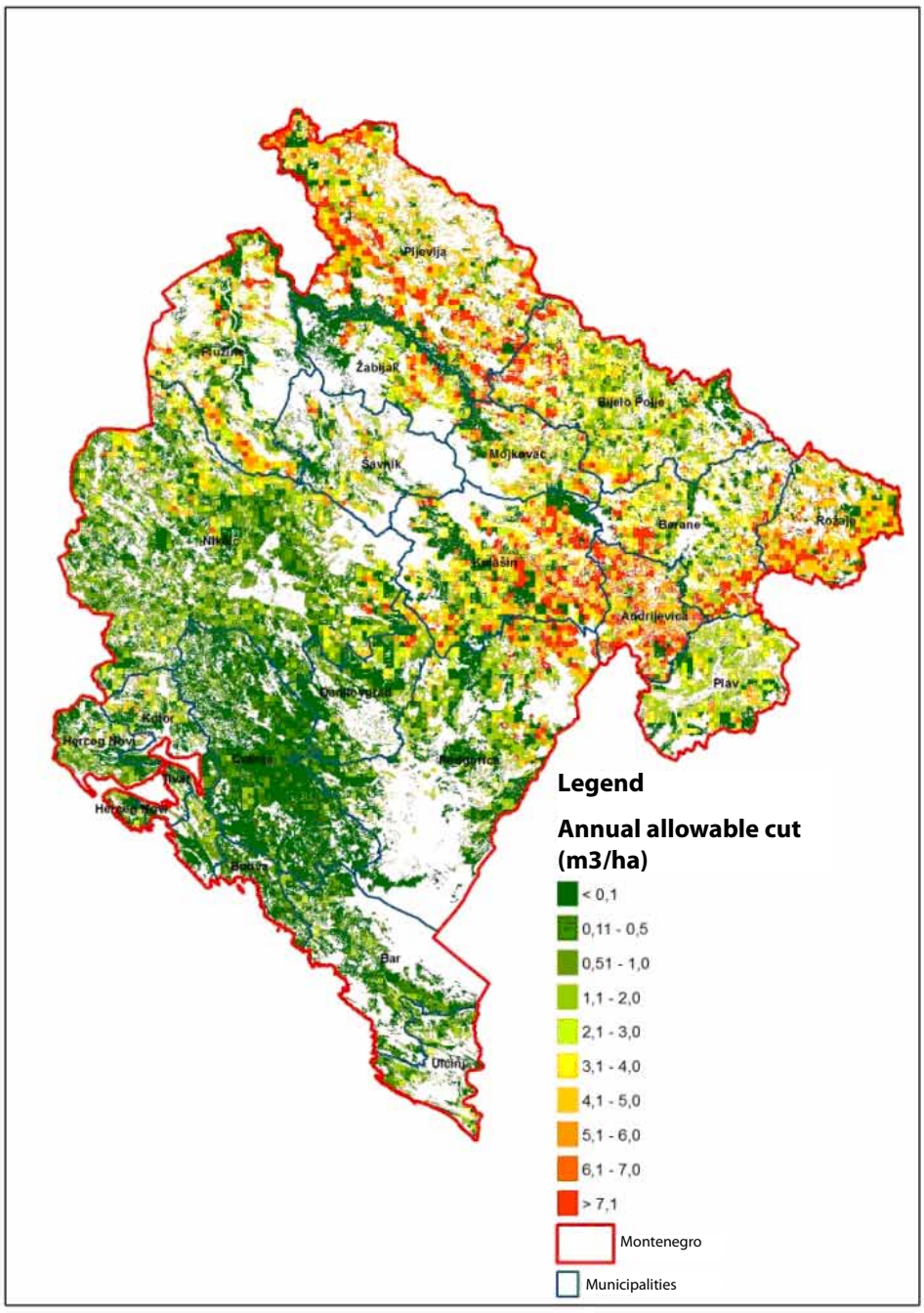

Picture 19. Scenario 1 harvesting level (map: Pisek R.)

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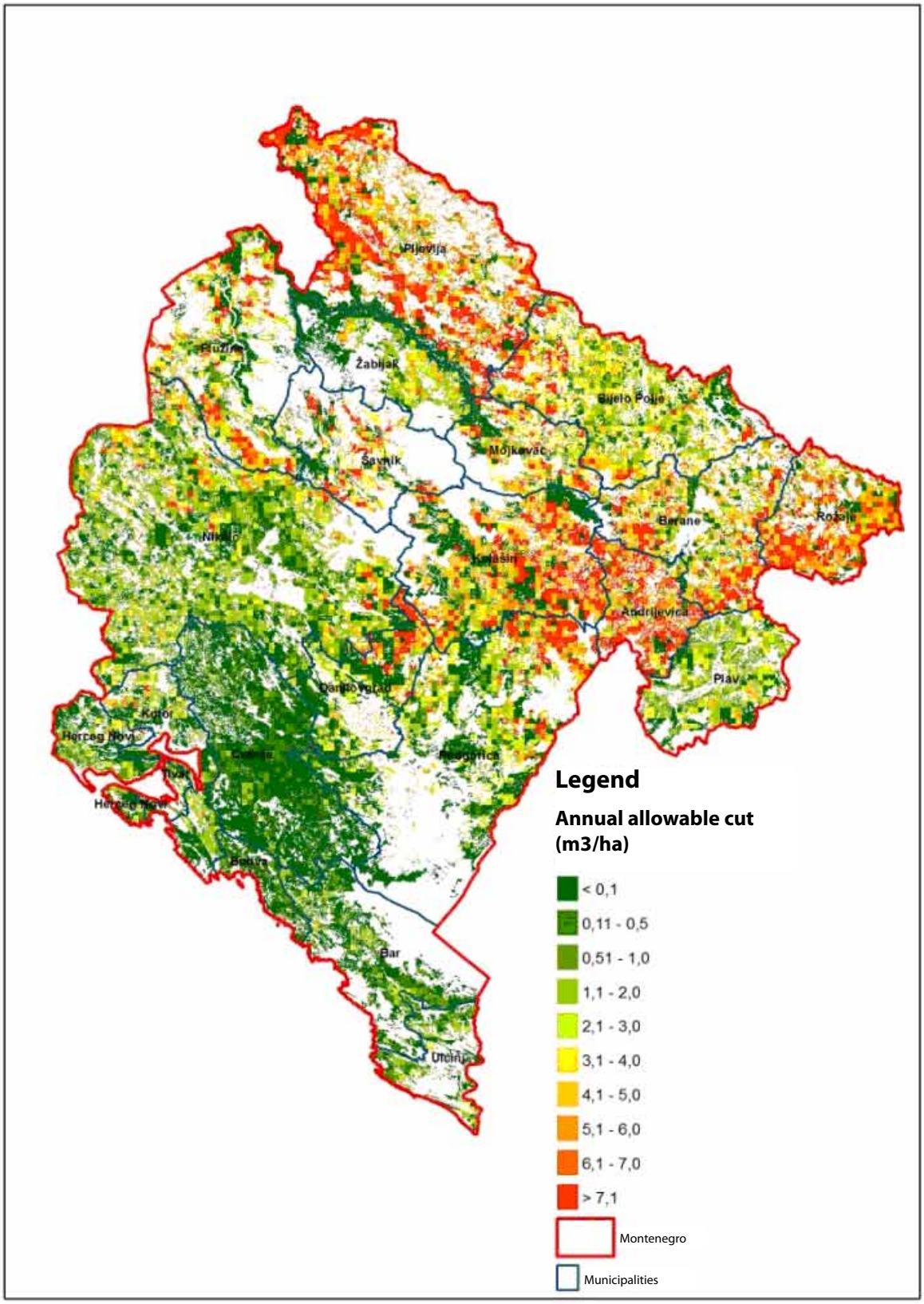
- Scenario 2: based on gradual increase of harvesting, improved utilisation of annual increment and more intensive silviculture of all forests.



Picture 20. Scenario 2 harvesting level 2 (map: Pisek R.)

In the case of the first scenario, overall harvesting stays at the currently planned level, but utilisation of the standing volume from silvicultural works and less valuable forests increases, as calculated in plans so far but not used. Thus, annual harvesting in the field would increase, but within pre-planned framework.

In the case of the second scenario, there will be an increase in annual harvesting compared to the current.

So, both scenarios imply increase, to a lesser or greater extent, of annual harvesting compared to the current. Despite this increase, the harvesting level would be lower than the current increment.

According to Scenario 1, 30% of increment will accumulate in state-owned forests, and 50% in private forests.

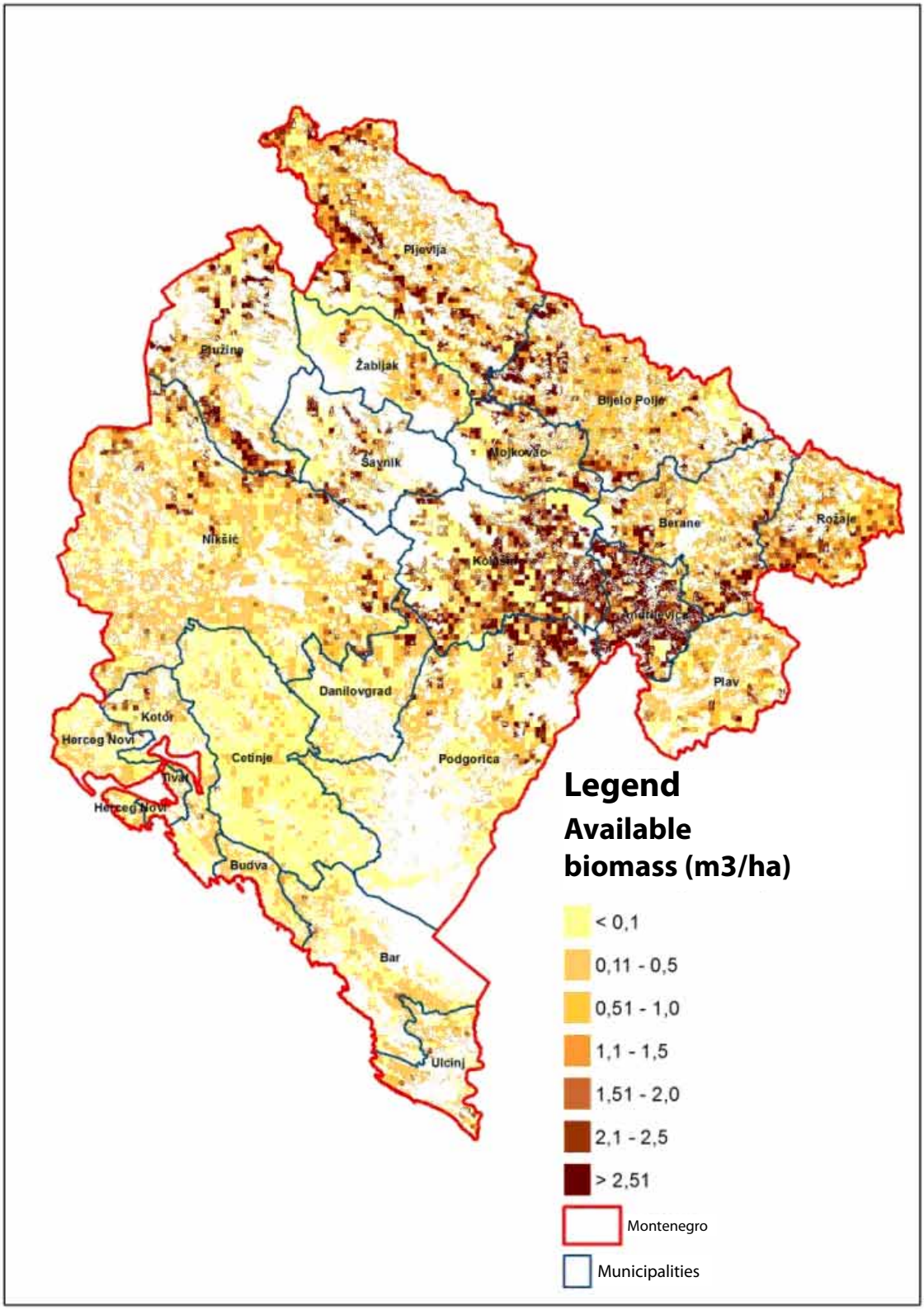
In Scenario 2, accumulation in state-owned forests would be only 10% of the increment, and in private forests, based on this scenario, 30% of increment should be left for accumulation.

Table 2 shows projected overall annual increment in m^3 based on these two scenarios.

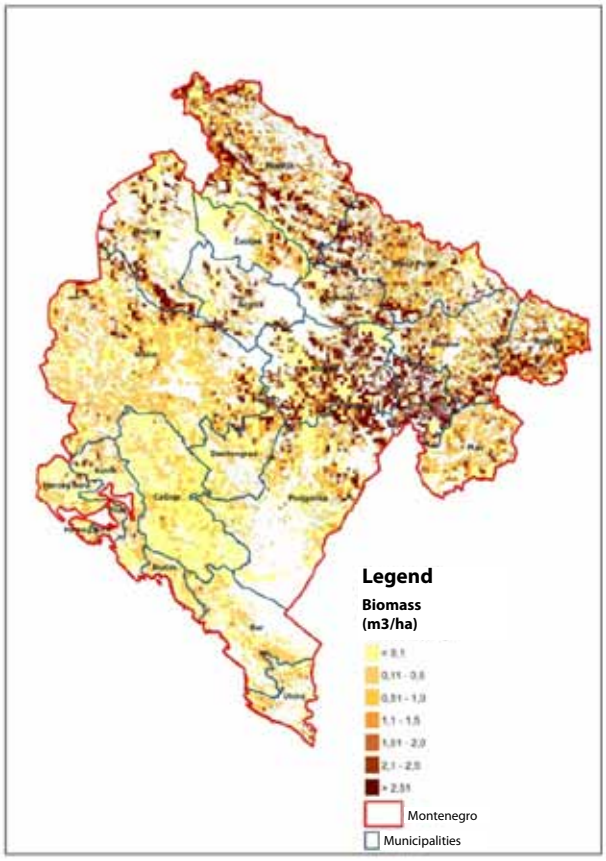
Table 2. Projected overall annual increment based on 2 expected scenarios

Scenario	**Ownership**	**Total** (m^3)	**Technical round wood** (m^3)	**Fuel wood and other**(m^3)
Scenario 1	**Total**	**1,224,894**	**543,831**	**681,063**
	State forests	912,555	444,935	467,620
	Private forests	312,340	98,896	213,444
Scenario 2	**Total**	**1,574,623**	**759,452**	**815,171**
	State forests	1,195,421	627,640	567,781
	Private forests	379,202	131,812	247,390

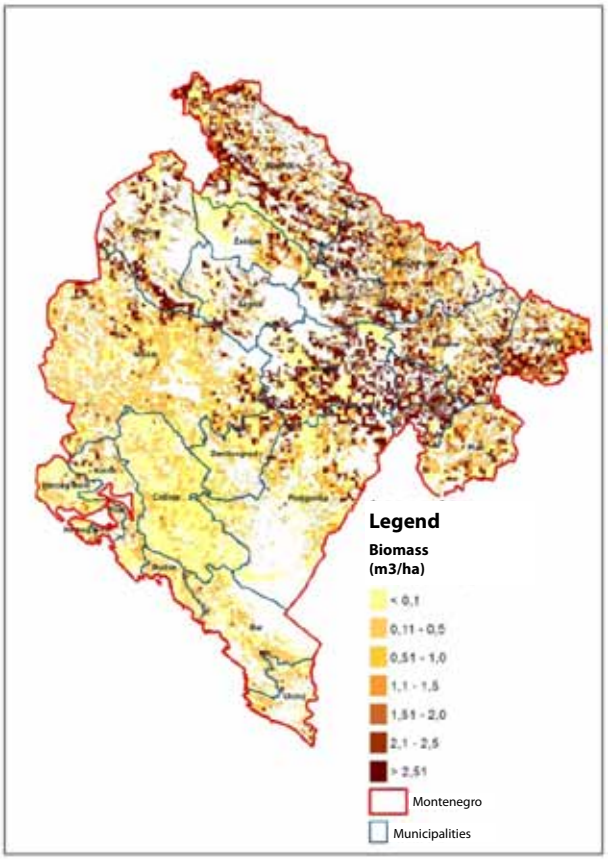
An overview of potentials for wood biomass as fuel for entire territory of Montenegro is provided based on these scenarios.



Picture 21: Current level of available forest wood biomass as fuel (map: Pisek R.)



Picture 22: Scenario 1 level of wood biomass as fuel (map: Pisek R.)



Picture 23: Scenario 2 level of wood biomass as fuel (map: Pisek R.)

3.2.2. Timber residue

Picture 24: Timber residue, Žabljak, Njegovuđa (photos: Stijović A.)

Quantities of timber residue are classified according to the source of raw materials, as follows:

- Forestry biomass (harvesting residue: tree branches, stumps, leaves, crotches, root-swells, cross-cutting residues, etc.)
- Urban forestry biomass
- Wood processing residue
- Residues from trimming crop plants, orchards and vineyards, etc.

So far, there have been only isolated attempts in Montenegro to utilise existing quantities of timber residue, mostly by using dry sawdust and wood processing residues.

In order to exploit entire biomass, preparations for energy exploitation are necessary first, which includes gathering of biomass, transport, its further processing and utilisation.

Effects of this production, through an increase in energy efficiency of the country, could be large. However, before that a detailed study should be conducted, which would also entail projection of gathering costs and raw material transport, as well as processing.

We should also mention complementary effects, such as:
- Cleaning forests from timber residue,
- Reduction of possibility of insect infestation,
- Reduction of possibility of infestation by phytopathological carriers,
- Improvement of wildfire protection,
- Reduction of fuel wood harvesting,
- New jobs

3.2.2.1. Wood biomass residue in forestry and wood processing

Major quantities of timber residue generated in the harvesting and forest assortment production process currently remain and decay in forests. 2012 Annual Forest Management Plan of the Forest Administration of Montenegro includes harvesting of 678.499 m^3 in private and state-owned forests. Based on findings of numerous studies conducted in the region, realistically 10-11% of timber residue could be used for energy purposes. Approximately 70,000 m^3 of timber could thus be used as fuel, provided that planned annual allowable cut is fully implemented.

Given the fact that planning documents, results of the National Forest Inventory, results of the MONSTAT's survey on the consumption of wood in Montenegro and achieved level of harvesting in practice by years differ significantly, we need to be very cautious when discussing potentials of timber residue from forestry that can be used for production of wood fuels, primarily wood chips.

The quantity of technically available annual timber residue from forestry ranges from 39,332 m^3 to 143,661 m^3, when three basic elements are taken into account: projection of future harvesting from the National Forestry Strategy, planning documents and achieved scale of harvesting in practice in 2012 .

In addition to timber residue from forestry, some quantities of timber residue from industrial wood processing are also used for wood fuel production, as well as for energy generation.

In mid 2012, there were in total 152 wood processing companies active in Montenegro (including companies and entrepreneurs involved in furniture production). The most common activity of these companies, viewed by their number, is sawmill wood processing. There were 107 active sawmills in 2012.

Overall quantity of industrial and technical round wood processed in companies for primary wood processing in 2011 was 326,649 m^3, of which 81% or 264,586 m^3 were conifers, and the remaining 19% were broadleaves.

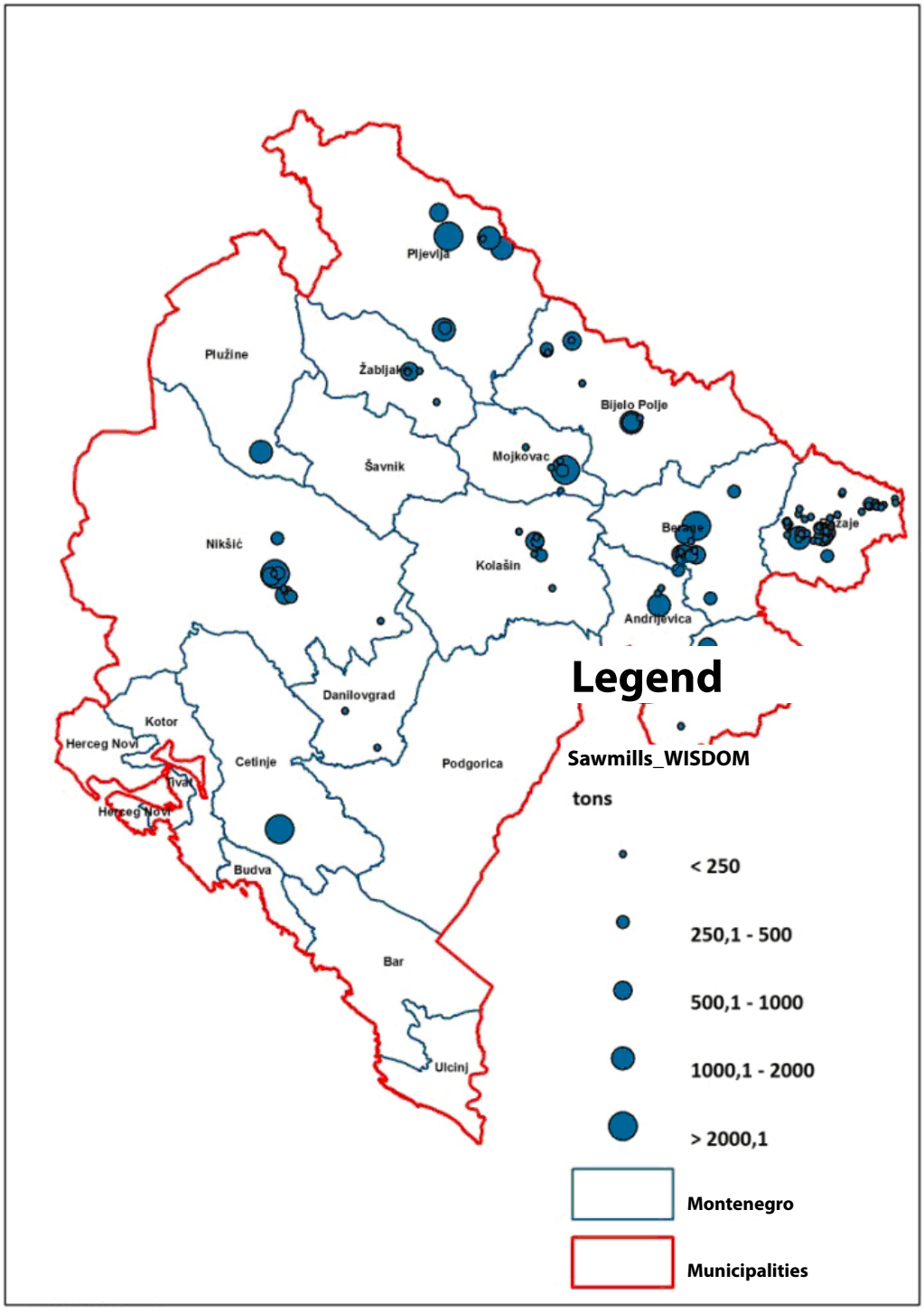
The biggest quantities of processed round wood originated from state-owned forests (72.4%) while 86,964 m^3 or 27.6% of round wood came from private forests.

Industrial and technical round wood exported in 2011, 60,804 m^3 of conifers and 9,879 m^3 of broad-leaves, should be added to the aforementioned figures, too. This means that the overall production of industrial and technical round wood (harvested as technical timber) in 2011 amounted to 397,332 m^3, of which 325,390 m^3 of conifers and 71,942 m^3 of broadleaves.

In primary wood processing in 2011, the total of 119,453 m^3 of timber residue was generated, of which 77.769 m^3 of chunky (bark, slabs) and 41,684 m^3 of fine residue (sawdust). Of this quantity, only 27,983 m^3 or 23.4% was used to meet companies' own needs.

Some quantities of chunky timber residue were marketed to local population and other users (30.581 m^3), and 40,495 m^3 or 33.9% was exported. Poor situation with regard to utilisation of timber residue is additionally worsened by the fact that 20,394 m^3 (mostly sawdust) was deposited in landfills.

The aforementioned data show that in 2011 more than half, or more specifically 51% of the total timber residue generation in industry was not utilised in Montenegro at all. Reasons are numerous, and a major one is a lack of burning machines and poor condition of those machines in companies that do have them.

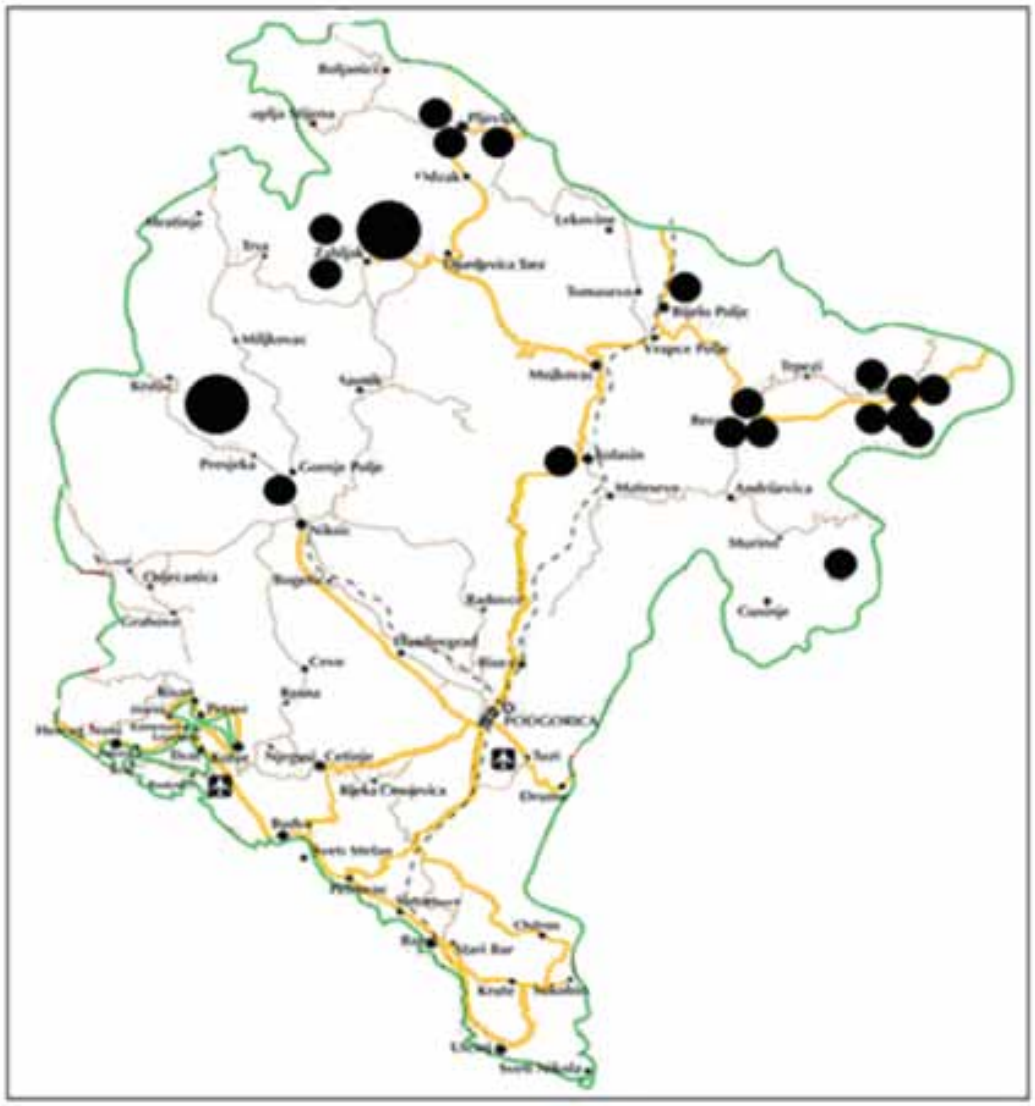


Picture 25. Sawmills in Montenegro and wood biomass residue quantities (map: Pisek R., Lučić S.)

Based on results of previous analyses, a conclusion can be drawn that there are potentials in Montenegro for utilisation of timber residue from industry to the quantity of 91,470 m^3.

If technically available potentials of residue from forestry are added to this, then we get total residue potentials in the range of 130,802 m^3 to 235,131 m^3 annually.

There are several black spots (sites) in Montenegro that represent a serious environmental problem as the quantities of timber residue (mostly sawdust) there are so big that their removal will require significant financial resources.



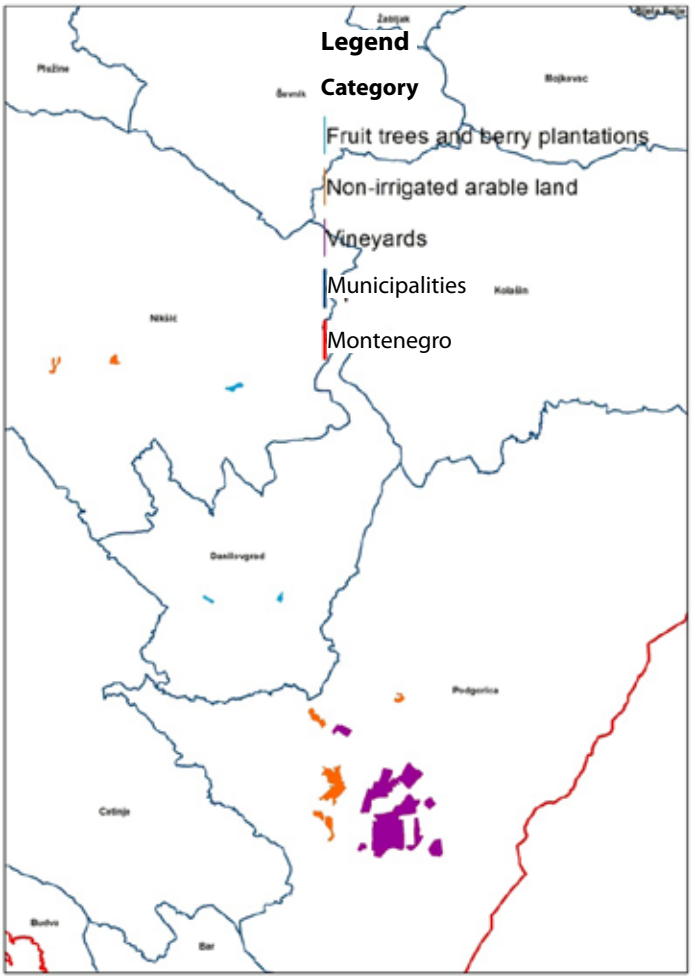
Picture 26. Map of sites in Montenegro that are a major environmental problem from the aspect of timber residue quantity (map: Glavonjić B.)

Current situation with regard to utilisation of wood biomass residue in Montenegro can be evaluated as unsatisfactory, primarily the segment of utilisation of timber residue originating from forestry and wood processing. This is confirmed also by the fact that, of the total quantity of timber residue originating from wood processing (primarily sawdust) in entire Montenegro, only 600-800 tons of briquettes are produced annually, and production of pellets has only started recently, in a plant near Andrijevica. On the other hand, many wood processing companies face problems of timber residue disposal, as its disposal in public areas, as well as burning in open spaces and dumping into rivers is strongly prohibited.

3.2.2.2. *Wood biomass residue from agriculture*

Quantities of timber and non-timber plant residue in picking sites is estimated and mapped based on the following data:

- Land use based on Corine Land Cover data, used to calculate surface area under specific crops (vineyards, orchards, and other crops),
- MONSTAT agricultural production statistics for 2010
- Structure of agricultural holdings (2011),
- Biomass potential data (Draft action plan for wood biomass).



Picture 27. Section of the map showing timber residue in agriculture (map: Pisek R.)

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. All data are also presented as vectors.

Due to the dispersion of residue and relatively small quantities and consequently their limited usability, these parameters are not viewed as important and will not be taken into account in further WISDOM analyses.

3.2.3. Biomass energy potential and impact of wood biomass utilisation on climate changes

Biomass can be used in its original form, but also when its processed into solid, liquid and gaseous fuels.

European Union member states are today aware of the importance of biomass and other renewable sources of energy. The European Commission sets goals and adopts directives that are binding for member states, and launches numerous programmes of financial and institutional support.

However, many of these countries do not wait until binding deadlines. Thus Finland meets one fifth of its energy needs from biomass, Denmark has been intensively developing its programme for power plants using straw, and Austria breaks records in selling pellet furnaces.

In Vienna, the largest European biomass power plant was built - Simering. Forestry residue is used for electricity and thermal energy generation.

Within a radius of 100 kilometres from the capital of Austria, wood biomass is gathered and transported to the wood grinding plant and then to Simering.

It should be noted that numerous studies and estimates of biomass potential as fuel have been made in our country, with big discrepancies in final results and differences in estimated potential.

Overall biomass energy potential in Montenegro is estimated at:

- 1.645 GWh (Ministry of Economy 2011)
- 4.200 GWh (Nikčević, V. 2010)
- 3341 GWh (CRES – Hellenic-USAID)

An estimate of biomass energy potential based on land use categories was also made (CETMA 2007). Possible thermal share of wood biomass is estimated at 949 GWh according to the study Biomass Potential for Montenegro (Ministry of Economy 2011), while CRES estimated it at 920 GWh.

According to CRES study for Montenegro, a possibility of intensive plantations in areas not used for agricultural productions represents the biggest potential.

Fast growing types of trees of short rotation could be cultivated in energy plantations for energy generation purposes. Based on different methodologies, this potential is estimated at about 500 GWh, with maximum estimates of as much as 2,000 GWh.

This remains to be examined in some further analyses, because in addition to benefits it also has the other side, such as environmental impact, large environment footprint of this production, changes in the natural character of landscapes, etc. Energy plantation environmental impact may affect quality of water and soil, animal habitats, CO_2 emission and biodiversity protection.

In estimations of possible utilisation of entire biomass with residue (sawdust, big and small tree branches, top logs, etc.), there were major uncertainties in identifying theoretical and calculation potential, technically usable potential and economically justifiable utilisation. Utilisation of entire biomass would have significant social, economical and environmental consequences, which should be taken into account when estimating the potential.

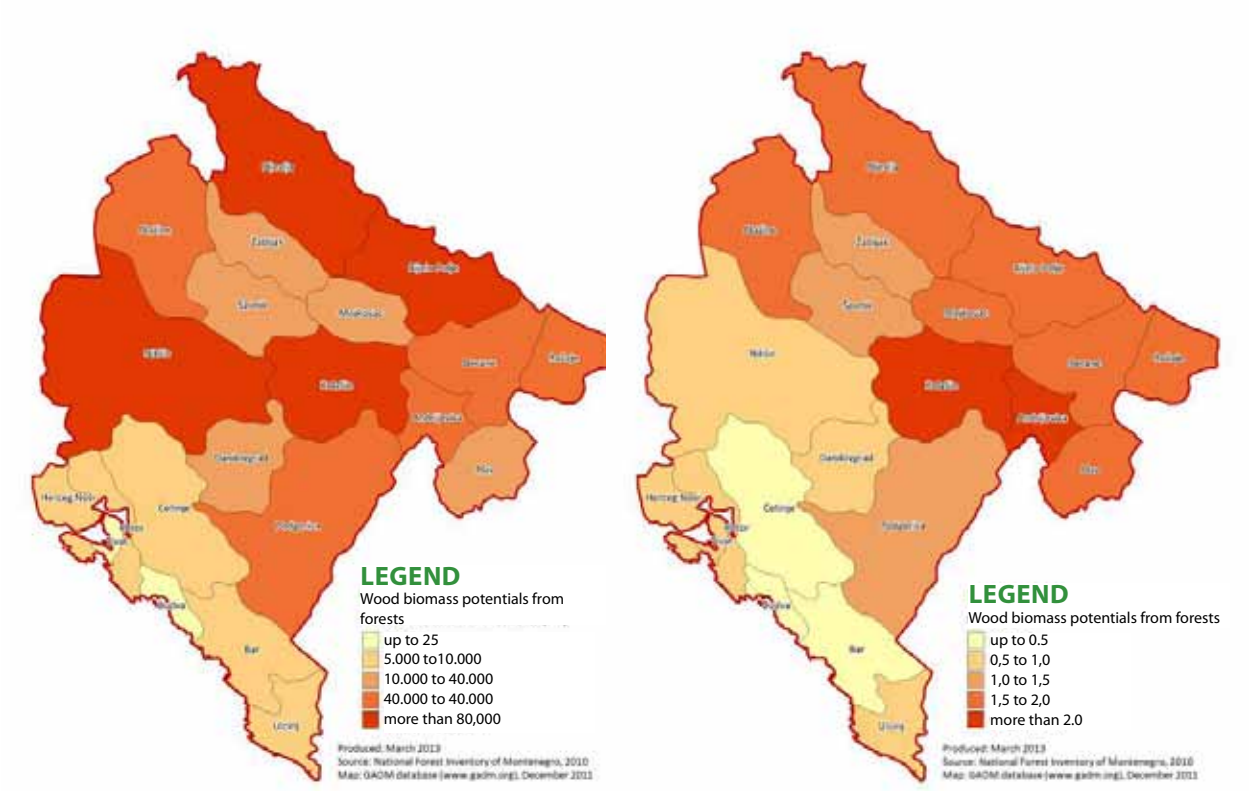
Production of wood fuels such as briquettes and pellets in Montenegro is in its infancy for the moment, and those are small capacities, so it is not possible to offer an estimate of quantities for this type of fuel for the next period. Still, there has been an upward trend in the consumption of these fuels, particularly pellets, in Montenegro.

Using different sources, calculations were made that between 27% and 46% of primary energy produced in the country comes from renewable sources, of which hydro energy accounts for 21%-37% (relates to the production from large hydro power plants only). Contrary to other renewable energy sources, wood biomass may be described as a conditionally renewable source of energy. Basic precondition to meet in that regard includes sustainability of raw material utilisation.

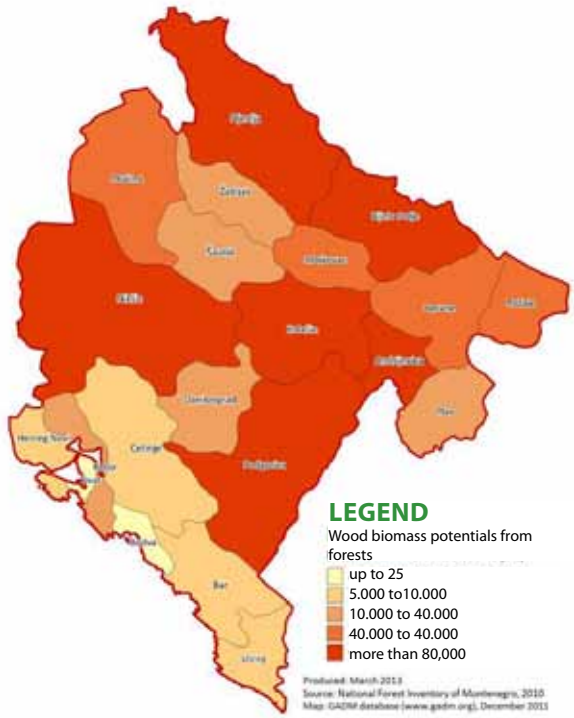
There are certain discrepancies in official data and calculations that can be derived from the field data when estimating existing quantities of used fuel wood, as well as utilisation of forests for commercial purposes. Namely, information on the number of entities using wood for heating and on utilisation of forests for commercial purposes and their consumption indicate much bigger use of wood as fuel than that suggested by official figures.

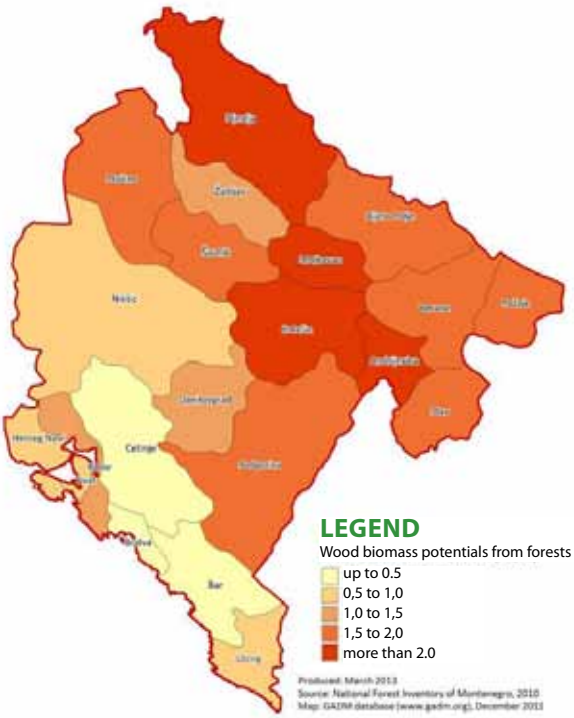
In order to overcome this problem, FODEMO team joined MONSTAT in an effort to develop a new methodology for gathering data, as well as for field gathering and analysis of data on consumption of fuel wood in Montenegro. New methodology was designed through this project and it allowed gathering, compilation and analysis of current data for households and business entities, as well as data from the municipal level. Advantage of this approach is that this methodology has now become a regular survey of the Statistical Office of Montenegro and will be repeated periodically every 3 years.

Cartographic representation of potentials of entire wood biomass from forests at the level of municipalities, as well as of wood biomass potential by spatial unit (ha) for both previously defined scenarios, was necessary for a more complete understanding of wood biomass potential in space.



Picture 28 and 29. Wood biomass potentials by municipalities, Scenario 1 (map: Borota D., Pisek R., Lučić S.)





Pictures 30 and 31. Wood biomass potentials by municipalities, Scenario 2 (map: Borota D., Pisek R., Lučić S.)

One of imapcts of forests in climate changing process is related to carbon sequestration through photosynthesis. CO_2, together with other greenhouse gases, is the main cause of greenhouse effects, resulting in global warming and big climate changes..

By using timber as a natural material, negative effects of climate changes could be mitigated and slowed.

A tree's feature is that with the help from solar energy and carbon dioxide from the atmosphere, through the photosynthesis process, it sequesters carbon in its tissues, and emits oxygen essential for life into the atmosphere. On the other hand, sequestered carbon in the form of carbon dioxide is emitted in the atmosphere when burning wood. Emitted quantities of carbon dioxide resulting from burning wood are sequestered again by other trees through the process of growing, which means that there is no surplus of carbon dioxide in the atmosphere as a result of using wood as fuel, which is why wood is considered a neutral material from the aspect of carbon dioxide emission.

Amount of sequestered carbon dioxide (CO_2) is presented as emissions with a 'minus' symbol.

The fact that CO_2 sequestration has a direct impact on a final balance of national emissions serves as another argument for setting up the wood processing industry in a cost-effective and environmentally sustainable manner, because better utilisation of timber residue for energy purposes and replacement of fossil fuels are important from this aspect as well.

3.3. Consumption module

Based on the Forest Administration's sources, 542,729 m^3 was harvested in 2011. However, these data and the system for collecting them have been challenged and were not considered complete.

Since there were no reliable statistical data in Montenegro on production and consumption of wood fuels, and since numerous studies dealing with the topic of wood biomass were based on experts' estimates and existing statistical and other data published by some institutions and organisations, it became necessary to conduct one comprehensive survey with the aim to get an overview of actual consumption and related share of energy from wood in the final energy consumption balance in Montenegro.

Under the auspices of official statistics, the Ministry of Agriculture and Rural Development and the Ministry of Economy, with support from the Luxembourg Development Agency, a special project has been implemented with a goal to improve the single system of statistical monitoring of timber harvesting and consumption and identify actual consumption of wood and wood fuels in Montenegro.

The results of implemented project have shown that the overall consumption of wood for energy, industrial and technical purposes in Montenegro in 2011 was 1.06 million m^3, of which 732.900 m^3 or 69.1% as fuel wood, and 326,600 m^3 or 30.8% as industrial round wood. 251 m^3 of wood biomass in the form of timber residue was consumed by charcoal producers and households.

In order to have a better overview of the actual situation with regard to overall production, exported quantities of 70,683 m^3 of industrial round wood and 8,693 m^3 of fuel wood, as well as smaller quantities of charcoal, chips and pellets should be added to the aforementioned quantities of wood consumed in Montenegro. Calculated in m^3, the overall production (harvesting) in 2011 was about 1.16 million m^3 of the standing volume.

In addition, draft Action plan for wood biomass utilisation in Montenegro has been produced. It is also based on these surveys and will be approved as a separate document or as a part of the Action plan for renewable energy sources via Energy Unit of the Ministry of Economy.

The following reporting units were included in the survey of wood fuel consumption and results of their consumption in 2011 were presented:

- Households, - 703,571 m^3
- Facilities of public interest (kindergartens and schools), - 5357 m^3
- Commercial facilities (bakeries (10,821 m^3), roast and barbecue shops (154 m^3), restaurants (9,007 m^3) and car repair shops (1,236 m^3)), - 21,218 m^3
- Industrial companies – 326,649 m^3
- Wood fuel producers (producers of char coal, briquettes, pellets...) - 2,765 m^3

Current situation in the segment of wood fuel consumption in households in Montenegro characterises the fact that the following types of wood fuels are used for heating purposes:

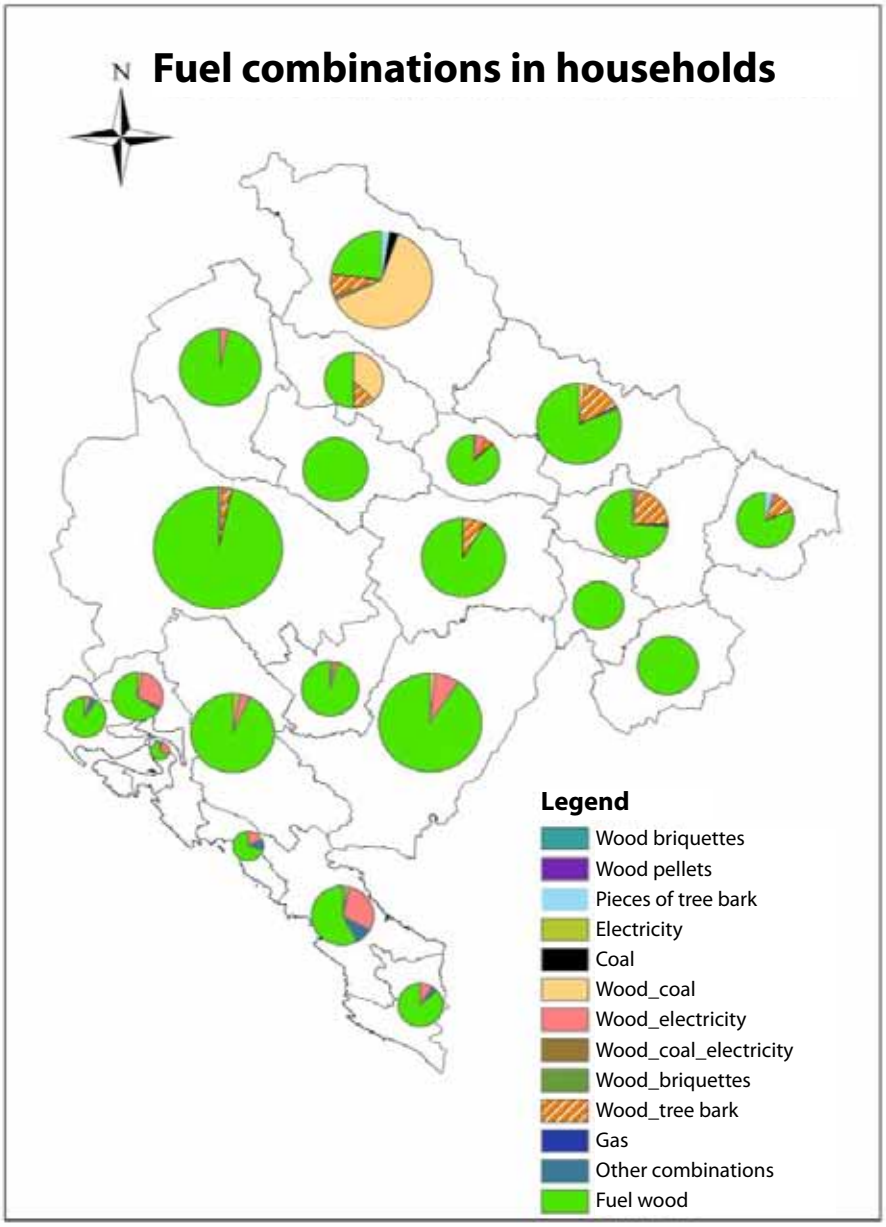
- fuel wood,
- pieces of tree bark from sawmills,
- wood briquettes and
- wood pellets.

In addition to wood fuels, the following combinations of wood and other fuels are also used: wood/coal, pieces of tree bark/coal, wood/electricity and other combinations of wood and other fuels.

According to 2011 population census, there are 192,911 households in Montenegro in total.

Most of the households are in rural areas, 126,550 or 65.5%, while urban households account for 34,5% (MONSTAT, 2012).

Results of 2011 population census showed that 32.09% of the overall number of households in Montenegro use other fuels for heating purposes, mostly electricity, and 67.91% of households or 131,004 use solid fuels for heating, such as wood, coal, briquettes, pellets and combinations of solid and other fuels.

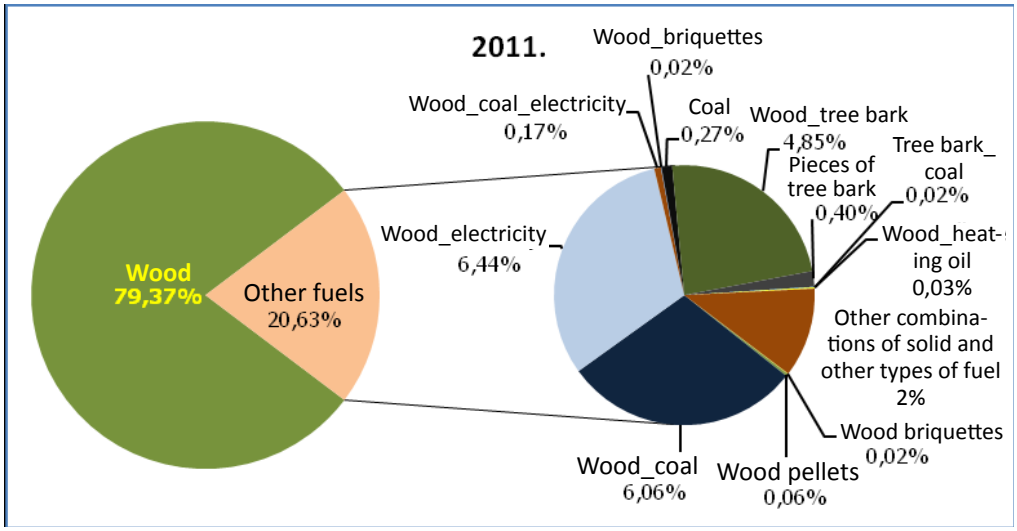


Picture 32. Share of individual types of solid fuels in household heating by municipalities in 2011 (map: Glavonjić B.)

Solid fuels are predominant in municipalities in the northern and central part of Montenegro (including Podgorica), while other fuels are predominant in coastal municipalities (Ulcinj is an exception).

Given that most households (131,004) in Montenegro use solid fuels (a single one or in combination) for heating purposes, from the perspective of calculating overall quantities of wood fuel consumed in Montenegro in 2011, an analysis of data from the survey was made of the share of individual types of solid fuels at the level of municipalities and at the level of entire Montenegro.

The results of analysis on the share of individual types of fuels in household heating at the level of Montenegro are shown in graph 1.



Graph 1. Share of individual types of solid fuels in household heating in Montenegro in 2011

Data from graph 1 show that almost 80% of households, which used solid fuels for heating, actually used wood, while combination wood/electricity accounted for 6.44%, and combination wood/coal for 6.66% of households.

3.3.1. Consumption of individual types of wood bio-fuels in Montenegro

From the point of understanding importance of individual categories of consumers for consumptions of individual types of wood fuels, results of their share in overall consumption, separately for each type of wood fuel, are shown below.

3.3.1.1. Fuel wood

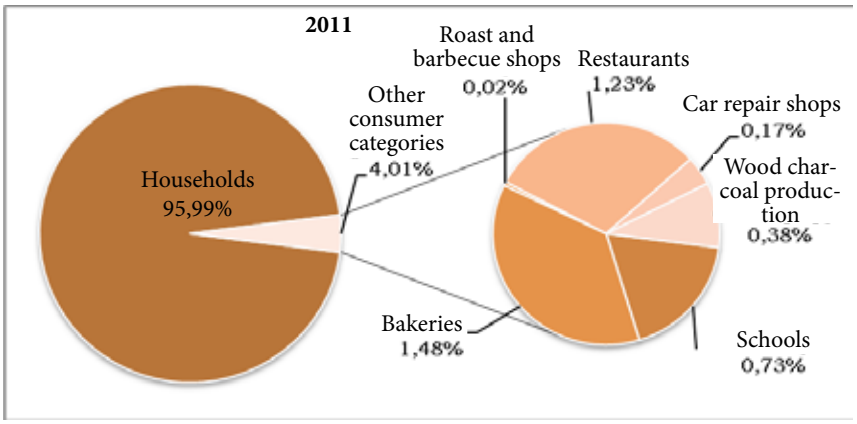
Fuel wood is the most common fuel used for heating and cooking purposes in Montenegro.

The most important fuel wood consumers in Montenegro are households, with the share of 96%, followed by bakeries, restaurants and schools (table 3) (graph 2). Share of other categories is under 1%.

Table 3. Consumption of fuel wood by individual consumer categories in 2011

Consumer category	Consumption in m^3
1	2
Households	703,571
Schools	5,357
Bakeries	10,821
Roast and barbecue shops	154
Restaurants	9,007
Car repair shops	1,236
Charcoal production	2,765
Total fueel wood	732,911

Source: MONSTAT, 2013.



Graph 2. Share of individual consumer categories in overall consumption of fuel wood in Montenegro in 2011

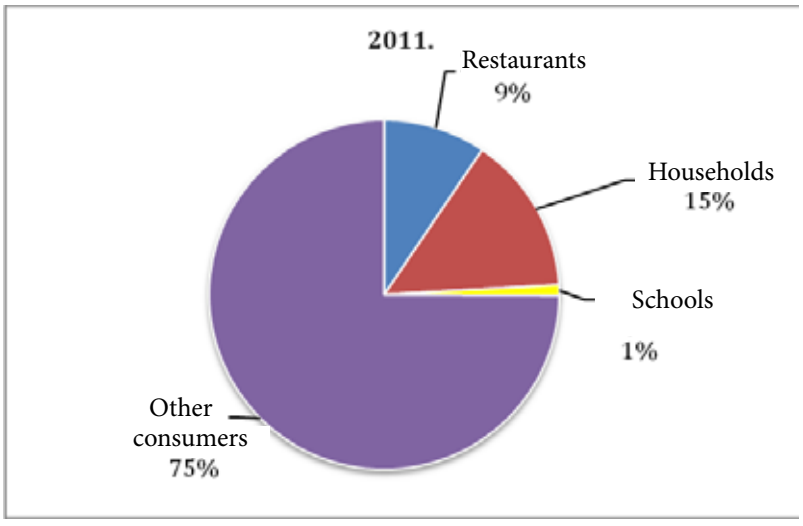
3.3.1.2. Wood briquettes

The overall consumption of wood briquettes in 2011 was 423 tons, of which 48 tons was imported, and 375 tons was domestic production. The most important category of consumers were other consumers, which included commercial facilities, followed by households and restaurants (table 4) (graph 3).

Table 4. Consumption of wood briquettes by individual consumer categories in Montenegro in 2011

Consumer category	Consumption in tons
1	2
Households	62
Schools	4
Restaurants	40
Other consumers	317
Total	423

Source: MONSTAT, 2013.



Graph 3. Share of individual consumer categories in the overall consumption of briquettes in Montenegro in 2011

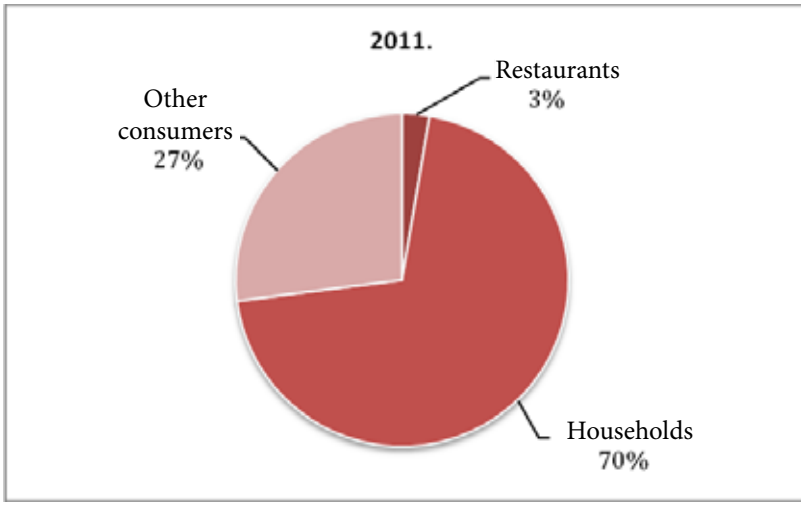
3.3.1.3. Wood pellets

The overall consumption of wood pellets in 2011 was 948 tons, and entire consumption relied on their import. The most important category of pellet consumers are households with consumption of 667 tons, followed by other consumers and restaurants (table 5) (graph 4).

Table 5. Wood pellet consumption by individual consumer categories in Montenegro in 2011

Consumer category	Consumption in tons
1	2
Households	667
Restaurants	25
Other consumers	256
Total	948

Source: MONSTAT, 2013.



Graph 4. Share of individual consumer categories in the overall consumption of pellets in Montenegro in 2011

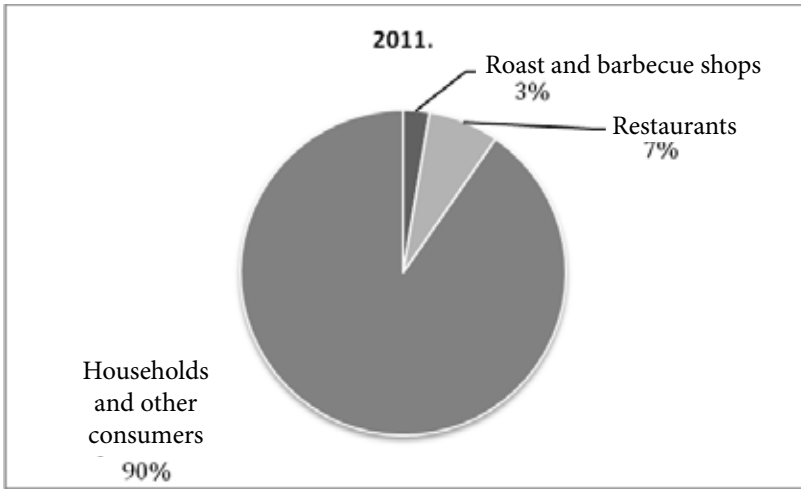
3.3.1.4. Wood Charcoal

The overall consumption of wood charcoal in 2011 was 1,039 tons, of which 599 tons was imported, and the rest is domestic production. Households and other consumers account for about 90% of the overall wood charcoal consumption, and restaurants and roast and barbecue shops about 10% (Table 6) (Graph 5).

Table 6. Wood charcoal consumption by individual categories of consumers in Montenegro in 2011

Consumer category	Consumption in tons
1	2
Households and other consumers	939,2
Restaurants	73,3
Roasting and bebecue shops	26,5
Total	1.039

Source: MONSTAT, 2013.



Graph 5. Share of individual consumer categories in the overall wood charcoal consumption in 2011

3.3.2. Wood fuel consumption in households in Montenegro

As for fuel wood as the most common wood bio-fuel in wood biomass consumption in Montenegro, the results of surveys conducted through FODEMO/MONSTAT project show that households are the most important consumer category with quantity of 703.571 m^3 and 96% share in the overall consumption of this bio-fuel.

The current situation in consumption of wood bio-fuels in households in Montenegro is characterised by the use of the following types of wood fuels for heating purposes: fuel wood, pieces of tree bark from sawmills, wood briquettes and wood pellets.

The results of 2011 population census showed that 67.91% or 131,004 households use solid fuels, such as wood, coal, briquettes, pellets or a combination of solid and other fuels for heating purposes.

According to this project's results, the overall fuel wood consumption in Montenegro in 2011 was 732,911 m^3 or 5.49 m^3/household.

Consumption of wood in households largely depends on a geographic area and its climate. In that regard, the lowest household wood consumption is recorded in municipalities in the coastal zone, a bit higher in the central, and the highest in the north of Montenegro. Average household wood consumption in coastal zone municipalities is 3.79 m^3 (5.42 prm/household), and this consumption is almost equal in all coastal zone municipalities, as it ranged from 3.11 m^3/households in Kotor to 4.24 m^3/household in Ulcinj.

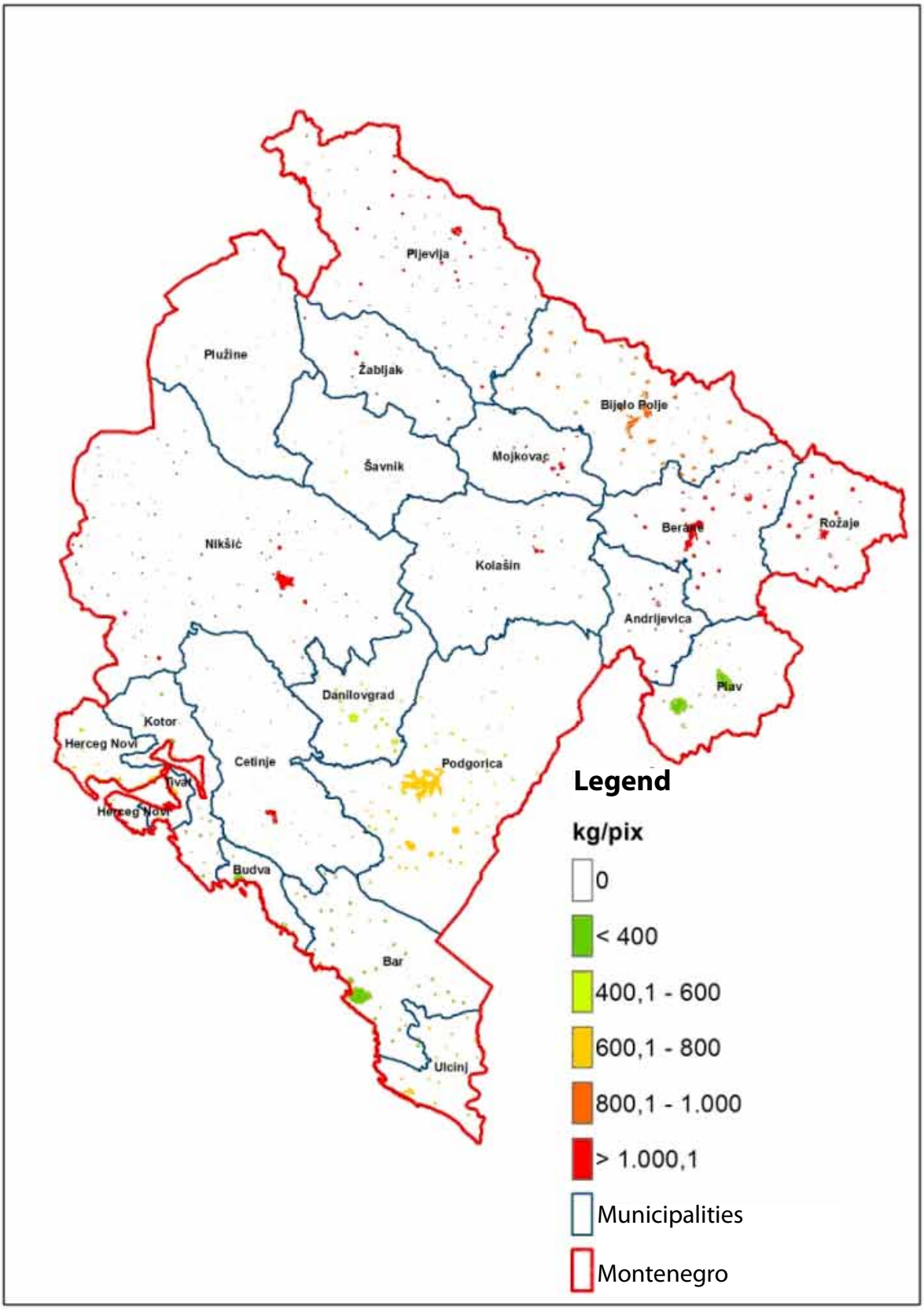
In the central zone, which includes municipalities of Danilovgrad, Cetinje, Nikšić and Podgorica, average fuel wood consumption per household is 5.02 m^3 (7.18 prm) and it is 32.5% higher when compared to average consumption in coastal municipalities. The highest average consumption in this zone, 5.41% m^3 (7.73 prm), is recorded in households in Cetinje, and lowest in Danilovgrad, 4.76 m^3 (6.81 prm).

Wood consumption in households in municipalities in the north of Montenegro is characterised by significantly higher average consumption compared to coastal and central zones. Average wood consumption in the north of 6.74 m^3/household (9.64 prm/household) is 1,8 times higher compared to the average household wood consumption in the coastal zone, and 1.35 times higher compared to the average consumption in the central zone. The highest wood consumption, 9.0 m^3/household (12.88 prm/household), is recorded in households in Žabljaku, and lowest in Pljevlja 5.17 m^3 (7.39 prm). Use of coal is the basic reason for relatively low average fuel wood consumption in households in Pljevlja.

At the level of entire Montenegro, average fuel wood consumption is 5.49 m^3 (785 prm) per

household and as such most adequately reflects relatively low consumption in the coastal zone and high consumption in the north of Montenegro. Compared to other countries in the region, average fuel wood consumption in Montenegro of 5.49 m^3 per household is significantly lower compared to average consumption in Serbia of 7.3 m^3/household (10.4 prm) and in Slovenia 6.5 m^3 (9.3 prm).

In addition to fuel wood and combinations of fuel wood and other wood fuels, relatively large quantities of chunky sawmill residue, i.e. pieces of tree bark from sawmill production, as well as briquettes and pellets were used for heating purposes in Montenegro in 2011. Based on survey results, overall consumption of individual wood fuels for household needs in Montenegro in 2011 is shown in tables 7 and 8.



Picture 33. Fuel wood consumption in households (map: Pisek R., Lučić S.)

Table 7: Consumption of individual types of wood fuel in households in Montenegro in 2011

type of wood fuel	Measurement Unit	Overall consumption in measurement unit	Overall computer costs in EUR
Fuel wood	m^3	703,571	37,043,228
Pieces of tree bark from sawmills	m^3	36,510	381,759
Wood briquettes	tons	62	8,268
Wood pellets	tons	667	121,343
Wood residues from construction sector (casings), packaging wood, pellets and other	m^3	5,254	3,583
Charcoal	tons	939.2	...
Residue from grapevine pruning	prm	1,075	...

Source: MONSTAT, ŠUM BIO 1 Survey, Podgorica, 2012.

Table 8. Types and fuel wood consumption for household heating by municipalities (MONSTAT 2013)

Municipality	Population	Households	Pellets	Briquettes	Fuel wood	Sawmill residues	Other wood fuel	Total	Average consumption per household	Average consumption per household
	N	*N*	*tons*	*tons*	*m^3*	*m^3*	*m^3*	*tona*	*prm*	*m^3*
Andrijevica	5,071	1660			10,837			5,870	9.34	6.53
Bar	42,048	6769	21	21	26,323		3,008	15,930	5.56	3.89
Berane	33,970	9488			64,712	13,528		42,381	9.75	6.82
BijeloPolje	46,051	12364	403	20	83,009	6,678		49,005	9.60	6.71
Budva	19,218	1317	38		5,260	46	651	3,265	5.71	3.99
Cetinje	16,657	4357			24,529			13,287	7.73	5.41
Danilovgrad	18,472	5020			23,897			12,945	6.81	4.76
Herceg Novi	30,864	3832			13,981		180	7,671	5.22	3.65
Kolašin	8,380	2773			20,675	1,156		11,825	10.66	7.46
Kotor	22,601	2937			9,144		426	5,184	4.45	3.11
Mojkovac	8,622	2653			17,129	653		9,632	9.23	6.46
Nikšić	72,443	18554			97,926	2,172		54,221	7.55	5.28
Plav	13,108	3473			27,390			14,837	11.28	7.89
Pljevlja	30,786	9440			48,790	7,280		30,372	7.39	5.17
Plužine	3,246	1088			7,829			4,241	10.27	7.20
Podgorica	185,937	29463		20	142,686	28	502	77,597	6.93	4.84
Rožaje	22,964	5107	103		40,248	4,234		24,198	11.27	7.88
Šavnik	2,070	674			4,781			2,590	10.14	7.09
Tivat	14,031	1675			6,138			3,325	5.24	3.66
Ulcinj	19,921	4106	102		17,426		487	9,805	6.07	4.24
Žabljak	3,569	1206			10,860	735		6,281	12.88	9.00
Total	**620,029**		**667**	**62**	**703,571**	**36,510**	**5,254**	**404,462**	**7.85**	**5.49**

Table 9: Wood biomass consumption by individual types in Montenegro in 2011

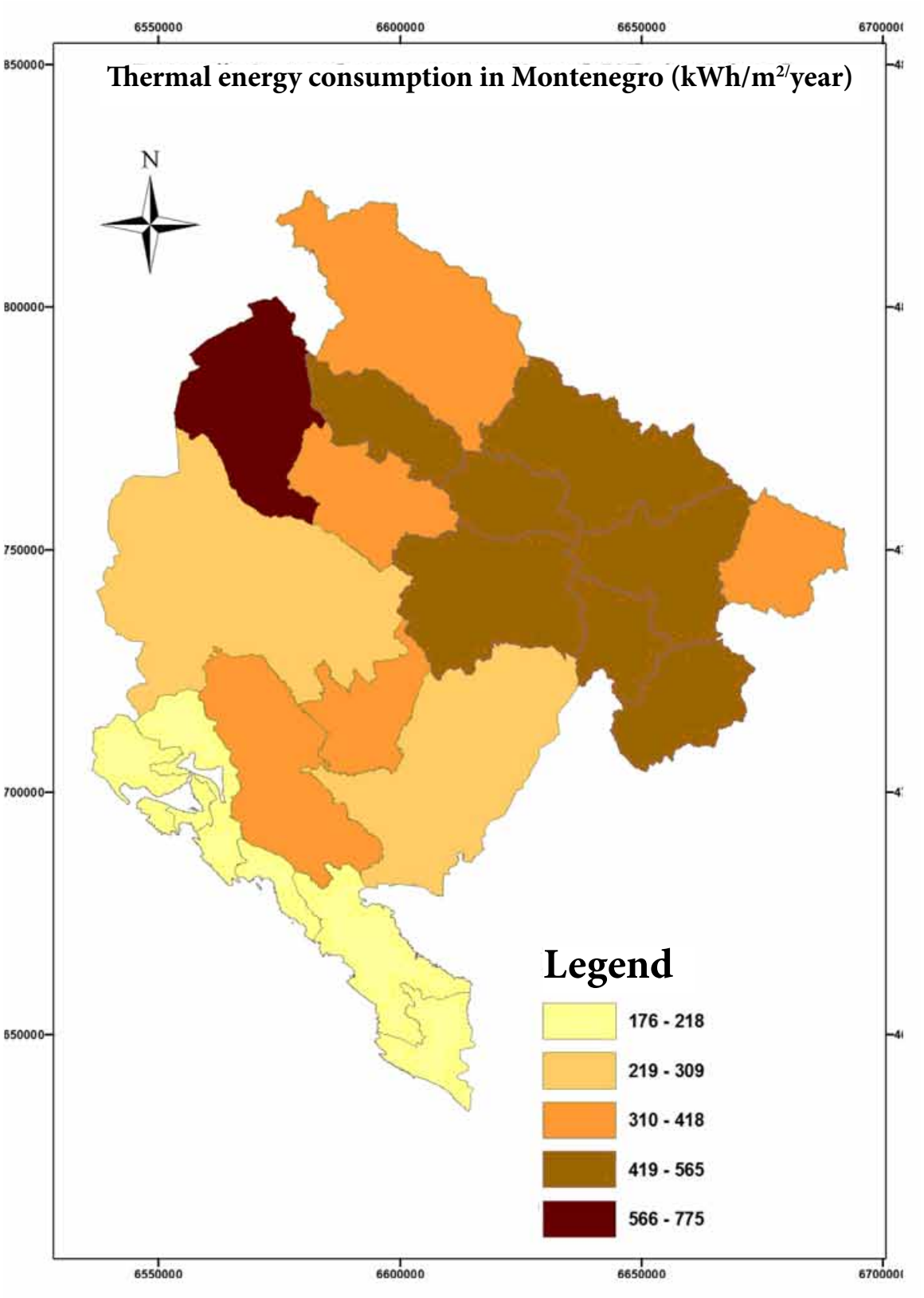
Forms of wood biomass	Measurement units	Main consumer categories										TOTAL MONTENEGRO
		Households	Bakeries	Roast and berbecue shops	Restaurants	Car repair shops	Charcoal Producers	Briquette producers	Wood chips producers	Schools	Wood processing companies	
Fuel wood	**m³**	**703,751**	**10,821**	**154**	**9,007**	**1,236**	**2,765**			**5,357**		**732,911**
Timber residue from forests, orchards	m³						251					**251**
Chunky wood residue form industrial wood processing (pieces of bark, slabs...)	m³	36,510			76	155			20,574	99	22,084	**74,498**
Fine wood residue form industrial wood processing (sawdust,...)	m³							763		33	5,899	**6,695**
Wood briquettes	Tons	62			40					4		**106**
Wood pellets	Tons	667			25							**682**
Wood residues from construction sector	m³	5,254										**5,254**
Charcoal	Tons	939.2		26.5	73.3							**1,039**
Residues form grapevine pruning	Prm	1,075										**1,075**
Logs	m³										326,649	**326,649**

Sources: 1. Consumption of wood fuels in Montenegro in 2011; calculations by professor Branko Glavonjić, PhD

Given the predominance of wood stoves that are more than 20 years old, with very low burning efficiency, consumption of energy in kWh per m^2 of surface area being heated is extremely high (picture 34).

Average consumption of thermal energy per $1m^2$ of surface area being heated in households using fuel wood in Montenegro is 331.9 kWh per year.

When average consumption of thermal energy per $1m^2$ of surface area being heated in Montenegro is compared to the consumption in key EU countries, a conclusion could be drawn that according to that indicator energy consumption in Montenegro is several times higher, which in itself indicates a very poor situation with energy efficiency in households.



Picture 34. An overview of energy consumption in kWh/m^2/year in households that use fuel wood, for individual municipalities in Montenegro (map: Glavonjić B.)

3.3.3 Industrial consumption

Wood processing companies are key consumers of wood based fuel from the industry sector. Sawmills are the most common units in the wood processing sector. Most of 107 active sawmills are based in the municipality of Rožaje (51, of which 9 produce sawnwood and wooden houses), then in Berane (14), Bijelo Polje (8) and Pljevlja (7). Small companies with very limited equipment are predominant in the structure of companies involved in wood processing. There are six big companies that processed 97,380 m^3 of technical round wood in 2001, which was 29.8% of the total quantity of round wood processed in Montenegro.

In 2011, the overall quantity of industrial and technical round wood processed in companies for primary wood processing was 326,649 m^3 of which conifers accounted for 81% or 264,586 m^3, and broadleaves for remaining 19%. Most of the processed round wood originated from state-owned forests (72,4%), while 86,964 m^3 or 27,6% originated from private forests. Quantities of industrial and technical round wood exported in 2011, more specifically 60,804 m^3 of conifers and 9,879 m^3 of broadleaves, should be added to the above figures. This means that the overall production of industrial and technical round wood in 2011 was 397,332 m^3, of which 325.390 m^3 of conifers and 71,942 m^3 of broadleaves.

3.3.4. Public interest buildings

In order to better perceive effects of replacing fossil with wood fuels in heating systems of public interest buildings, a comparative analysis of fuel consumption by quantity and value in five public buildings was made. The comparative analysis has shown that there are significant financial benefits in terms of savings in heating those buildings if wood fuels (wood chips, briquettes and pellets) are used instead of fuel oil (mazut), as well as savings in conversion of coal with wood chips and briquettes. Generally speaking, all three types of wood fuels are cost-competitive to oil fuel, and wood chips and briquettes are cost-competitive to coal.

Wood pellets are not cost-competitive to coal due to their relatively high price.

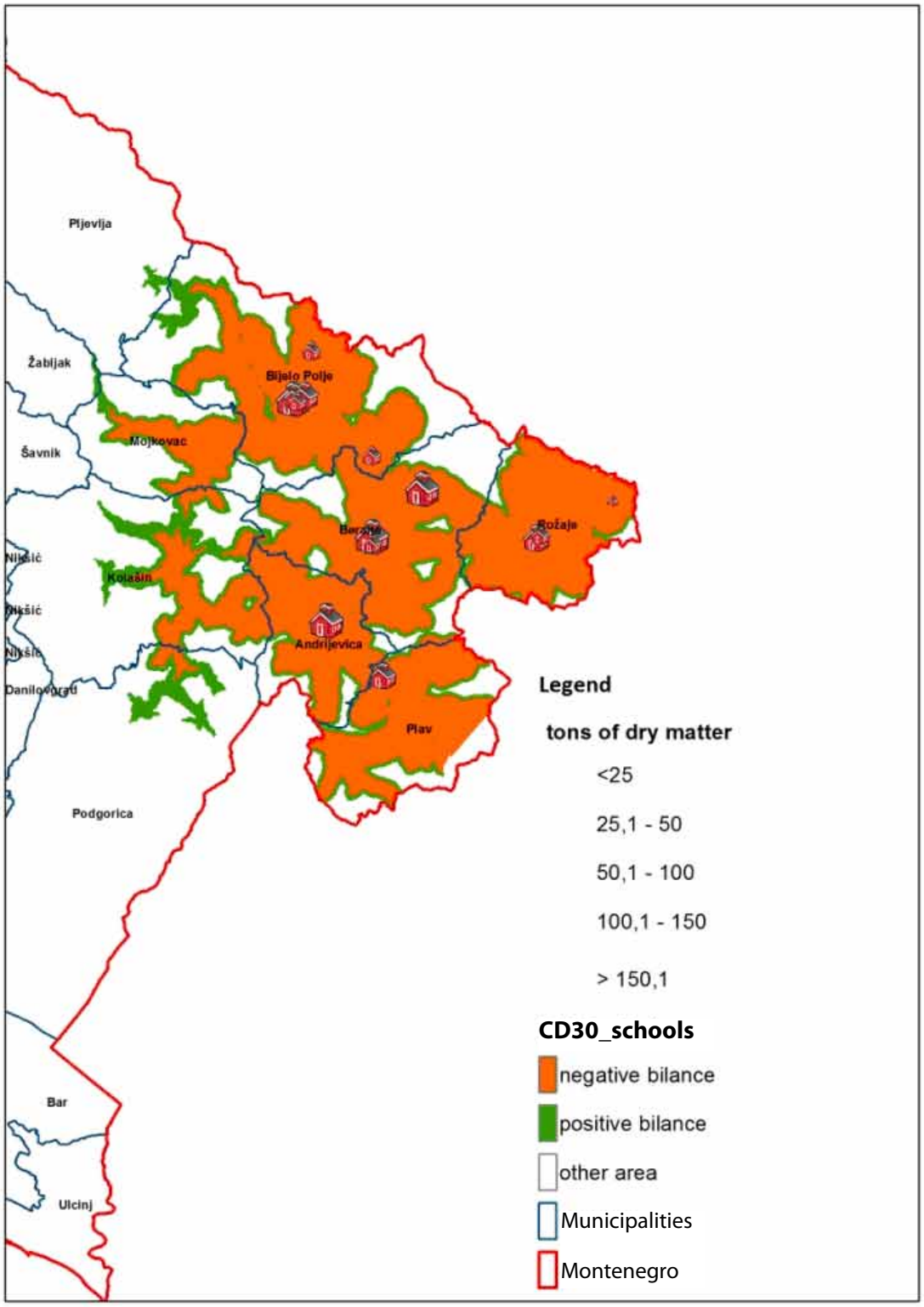
Bearing in mind other elements of wood fuel utilisation (low CO_2 emissions), solution for environment related problems such as wood waste disposal, small quantities of ash and negligible costs for its disposal compared to the ash generated by burning coal, a general conclusion can be drawn that wood based fuels are non-cost competitive compared to two predominant types of fossil fuels - coal and oil fuel.

The process of renovation of public interest buildings (schools, hospitals, health care centres, government buildings, etc.), currently being conducted through several credit lines used by Montenegro, is an early opportunity to start utilisation of wood biomass as fuel to heat these buildings. Within this process, a special emphasis has been put on conversion from fossil fuels (currently used in these buildings) to wood biomass fuels. Also, modernization of the remote heating system in Pljevlja is in the final stage where one CHP (Combined Heat and Power) plant is planned, as well as conversion from coal to wood biomass in two heating plants in this municipality, which is an important opportunity for faster development of wood fuel market. One CHP plant in a factory in Berane, as well as the town heating plant in Kolašin and several dozens of schools and other buildings that entered the renovation programme financed through the credit lines provided by the World bank and KfW Bank should be added to all afore mentioned.

Potentials of this process were examined within this project as well. Potential balance for school heating purposes for appropriate surface area in the north-east Montenegro was analysed.

Balance of available wood biomass and projected fuel consumption for heating in 19 schools in 5 municipalities was examined. Data on planned installation power of boilers for heating these buildings were available, as well as surface areas of premises that would be heated. Average consumption of

0.0649m^3 for heating 1m^2 was also taken into account. Based on this, possible scenarios of increased biomass consumption in this region were analysed.



Picture 35. Appropriate surface areas – schools (map: Pisek R.)

3.3.5. Wood bio-fuel production in Montenegro

The most important types of wood fuels currently being produced in Montenegro include fuel wood, wood briquettes and wood charcoal. In addition to these wood fuels, wood chips are also produced and entirely exported, and there are two lines for production of wood pellets (one in Pljevlja, and the second one in Andrijevica). The production line in Pljevlja is still not operational, while production in Andrijevica plant was in the trial stage in early 2013.

In Montenegro, the biggest quantities of wood biomass as fuel were used for producing fuel wood, while 24,353 m^3 were used to produce other wood fuels in 2011. Of this quantity, 85% was used to produce wood chips, which was entirely exported, and only 3,779 m^3 to produce wood charcoal and wood briquettes. Of 3,779 m^3 used to produce wood charcoal and wood briquettes in total, 763 m^3 of fine wood residue (sawdust) from industrial wood processing was used to produce wood briquettes, and 3,016 m^3 was used to produce wood charcoal, of which 2,765 m^3 was fuel wood and 251m^3 was chunky residue from forests, orchards and other sources.

Basically, of the total consumption of wood biomass for production of wood chips, briquettes and charcoal in 2011, only 15% remained in Montenegro, and 85% was exported.

Charcoal is produced in 23 charcoal plants, of which 20 are masonry facilities, and 3 are made of tin (movable). 440 tons of charcoal was produced in 2011. Most charcoal plants are located and biggest quantities of charcoal are produced in Kolašin municipality, followed by Pljevlja and Nikšić. A map with spatial distribution of charcoal plants in Montenegro is given in picture 36.

Picture 36. Spatial distribution of charcoal plants in Montenegro (map: Glavonjić B.)

As for **production of wood briquettes**, it has been running in three companies (Nikšić, Kolašin and i Bijelo Polje) in 2013, with equipment of modest capacities (picture 37).

Picture 37. Briquette production line in a plant in Bijelo Polje (photo: Glavonjić B., November 2012)

This modest equipment is exactly the reason why the quantity of briquettes produced annually is also modest. In 2011, total production of wood briquettes in these three plants was 375 tons. All three plants produce solid briquettes of 5 and 7 cm in diameter, and 6.5 and 10 cm length. In one of these plants, briquettes are produced from sawdust from sawmill production, and in other two plants from residue originating from production of parquet and wooden structures.

Wood chips production began in Montenegro in 2011, when a producer from Serbia started to process pieces of tree bark with his machine in different locations in Montenegro, and then exported wood chips to Serbia. However, a local entrepreneur involved in sawnwood production launched wood chips production as well in 2012, and thus wood chips production of 16,466 tons in 2011 reached 28,649 tons in 2012.

The local wood chips producer owns a mobile machine with a capacity of about 30 m^3 round wood/hour, i.e. about 90-100 loaded m^3/h of wood chips (picture 38). Most of the wood biomass used for wood chips production originates from sawmill wood processing, and to smaller extent from forests.

Picture 38. A machine for wood chips production (foto Glavonjić B., maj 2013.g.)

In addition to aforementioned types of wood fuels, split wood is also produced in Montenegro and distributed in the local market and partly exported. Split wood production started in 2012, at first in sawmills processing beech round wood (picture 39), and then entrepreneurs who own timber yards of fuel wood in large cities bought equipment and launched production of split wood directly on their timber yards..

Picture 39. A wood splitting line at a sawmill nearby Kolašin
(photo: Glavonjić B., October 2012)

A summary overview of total wood fuel quantities produced in Montenegro in 2011 and 2012 is presented in table 10.

Table 10. production of wood bio-fuels in Montenegro in 2011 and 2012

No.	Types of wood fuel	Measurement unit	2011	2012
1.	Fuel wood	m^3	732,911	765,050
2.	Wood briquettes	tons	375	362
3.	Wood pellets	tons	0	130
4.	Wood charcoal	tons	440	449
5.	Wood chips	tons	16,466	28,649

Sources: 1. MONSTAT, Podgorica 2013.; 2. Wood fuel producers; 3. Calculations B. Glavonjić

As for wood fuel production, Montenegro also has potentials for producing fuel from grapevine residue.

Total surface area of grapevine plantations is about 4.500 ha, giving annually 12,500 tons of biomass as residue from pruning. Until 2011, most of plantation biomass was burnt, and some smaller quantities were used by households for their own needs.

Starting from August 2011, processing of grapevine pruning residue into briquettes started on state-owned plantations of "13. jul" company from Podgorica (picture 40), in a factory that was built at the very edge of this company's plantations (picture 41).

Factory's installed capacities are about 4,000 tons of briquettes per year. Factory management's

plans are oriented towards briquette export, because of their high quality and prices of briquettes in markets of EU countries.

Briquettes produced from grapevines are extensively used for barbecues, due to their special aroma and taste that meat gets when prepared with these briquettes.

Picture 40. Timber yard of residues from grapevine pruning, prepared for industrial processing (photo: Glavonjić B.)

Picture 41. A line for production of briquettes from grapevine residue in the factory nearby Podgorica (photo: Glavonjić B.)

However, due to some problems with the equipment that emerged at the very beginning of production, the factory was mostly not operational in 2012. At the time of this study finalisation, in September 2013, the factory was still not operational.

Based on the aforementioned, a general conclusion that can be drawn about wood fuel production is that it takes place in companies and entrepreneurial plants owning modest equipment, with exception of wood chips producer. Consequently, quantities of wood fuels produced are small and,

with exception of fuel wood and wood chips, are insufficient to meet the needs of the domestic market. This is also confirmed by the results of wood fuel consumption survey presented below.

3.3.6. Wood fuel market

In the wood fuel market, fuel wood is present not only in its original form, i.e. as round wood.

By applying different procedures and using different means, round wood is processed into different forms, also of different energy value, suitable for end use. In that regard, the following forms of wood based fuel are typically offered to consumers:

- split wood
- wood chips
- wood briquettes
- wood pellets and
- wood charcoal.

Split wood

For household heating purposes, split wood is produced in pieces 25 cm and 33 cm long, and in smaller quantities in pieces 50 cm and 1.0 m long, to meet the needs of restaurants, pizzerias, and for burning in fireplaces. Fuel wood is usually sold by volume.

One should pay attention to the following when buying split wood:

- Type of timber,
- Price and measurement unit, taking into account whether the price is for compact wood, stacked wood or pile wood. Depending on the measurement unit and conversion factors, compact wood should be recalculated into cubic meters
- Moisture content (i.e. whether wood is dry or not)

Split wood procurement in Montenegro is performed in different ways, of which the most common include: purchase from an entrepreneur, harvesting in one's own forest, purchase from a private forest owner or from the Forest Administration, and purchase in timber yards.

There are two types of stacks with split wood of different dimensions offered by fuel wood timber yards and fuel wood distributors. Dimensions of a smaller stack are 1x1x1 m, and of a bigger one 1x1x1,8 m. In proportion to the quantity of split wood, the cost of a small stack in Podgorica in September 2013 was 38 €, including transport to buyer's home.

Prices of fuel wood measured in meters vary, depending on who the sellers are and on assortment.

In private forests, prices range from 17-20 €/prm *fco* along forest roads.

Prices of fuel wood offered to end users in cities (households) by private entrepreneurs (truck sales) are higher compared to prices along forest roads and range from €/prm, including transport to buyer's home.

Additional 204 €/prm are paid for sawing wood measured in meters. In addition to fuel wood measured in meters, split wood in pieces 25 and 33 cm long is also offered to consumers at the cost of 37 €/prm (prices in Podgorica in September 2013).

Compared to 2012, prices of split wood at the beginning of 2013/2014 heating season are at the same level or higher for 1 EUR.

Picture 42. Stacks of split wood supplied to the market in Montenegro (photo: Glavonjić B.)

Wood chips

Wood chips is a wood fuel produced by cutting wood into small pieces to be used in automatic boilers. Optimal length of a wood chip ranges from 8 to 30 mm. Optimal wood chip moisture ranges from 20% to 30%. The cost of wood chips for different transport distances from heating plants in selected EU countries (according to: A. Asikainen, Finland, April 2008) ranges from 20-30€/m^3, for a distance of 50 km.

Briquettes

In order to produce briquettes, the moisture level in timber residue cannot be lower than 6% nor higher than 16% of the total inner moisture. Final moisture of finished wood briquettes ranges from 7-10%, and energy value of briquettes with that moisture is such that one ton of this fuel replaces about 3 prm of fuel wood with 35% moisture, i.e. about 2 kg of briquettes have the same energy value a 1 l of oil fuel.

Solid cylindrical briquette is the most common in the market in Montenegro. Typical dimensions of cylindrical wood briquettes are: 5-9 cm in diameter, and 25-33 cm in length. Wood briquettes for industrial use are shorter (about 10 cm).

In addition to briquettes produced purely from wood, there are also briquettes produced from grapevine pruning residue in the Montenegrin market.

Briquettes are usually packed in 35 kg sacks and they cost 100 €/ton. Prices are without VAT in parity *fco* producer. Briquettes are mostly sold to local consumers (households), because that is a more profitable way of selling them than distribution in other cities and towns, which would require additional staff and logistics. Prices in September 2012 were the same as in September 2012.

Pellets

Wood pellets are a refined, homogenised form of fuel made from timber residue produced in wood processing by pulverisation into wood flour, and then by compression in special presses. Their consistent (constant) features (characteristics) make them an ideal fuel for automatic heating systems.

Wood pellets are cylindrical, their diameter ranging from 6 to 12 mm, and length from 10 to 30 mm. Moisture content ranges from 8-10%, and energy value is very high, which puts them among best wood based fuels.

Picture 43. Wood pellets (photo: Stijović A.)

Distributors' prices of wood pellets in Pljevlja are 180 €/ton, depending on quantity being purchased and period of the year when purchase is made. Pellets offered in the market are originally from Serbia.

In Podgorica, prices of wood pellets ranged from 190 to 200 €/ton in September 2012, and in September 2013, from 200 to 210 €/ton.

The wood pallets market is still unregulated and consequently there are numerous examples of complaints by end users, in terms of mismatch between the quality of wood pellets and furnaces for burning them. This is even more the case given the fact that there are imported furnaces offered for sale without proper approvals and certificates (primarily from China).

Wood charcoal

Wood charcoal is produced through thermal decomposition of dry timber (moisture content13 to 18%) without oxygen when heated above 275 ° C in the pyrolysis process.

It is sold in bulk or sacks of 2 kg, 2.5 kg, 3 kg, 4 kg, 5kg, 10 kg and 15 kg.

Prices of wood charcoal are relatively low and range from 3.3-3.6 €/sack to 15 kg, i.e. 0.22-0.24 €/kg in parity *fco* char coal plant.

Prices for end consumers in cities are significantly higher and range from 0.6-0.8 €/kg depending on producer and distributor.

3.3.7. Competitiveness of wood fuels

Competitiveness of wood fuels in relation to other fuels can be observed through an analysis of different parameters.

Two parameters are usually used for that purpose: cost and environmental effects.

Cost competitiveness is typically observed in relation to the cost of 1 kWh of energy. In that regard, table 11 shows results of a cost competitiveness analysis of wood fuel in relation to other fuels in Montenegro.

Table 11. Market prices of wood fuels in Montenegro (August 2013)

Type of fuel	Measure-ment unit	Cost in €/ mea-surement unit	Energy value in kWh/measur. unit	Prices in €/kWh
Fuel wood 1 m long (M=30%)	€/prm	30-32 (Northern Montenegro) 35 (Podgorica)	1840	0.016-0.019
Split fuel wood 33 cm long (M=30%)	€/prm	38 (Podgorica)	1840	0,021
Wood briquettes	€/ton	120-130	4600	**0.026-0.028**
Wood pellets	€/ton	200-210	4900	**0.041-0.043**
Char coal	€/kg	0.58-0.65	7,2	0.08-0.09
Coal from Pljevlja	€/ton	85	2977	0.029
Heating oil	€/litre	1.00	9.79	0.102
Electricity (average for high and low tariff for consumer that consumes 146 kWh of higher and 366 kWh of lower tariff)*	€/kWh	0.074	1	0.074

Sources: Distributors of petroleum products INA and Jugopetrol, Montenegro Power Supply Company (Elektroprivreda Crne Gore), Coal mine Pljevlja; * Average price for households with two-tariff meters in night mode (storage heaters) was taken to calculate electricity price.

A comparative analysis of market prices of wood and other fuels shows that most wood fuels are cost competitive to other fuels, which resulted in an increase in their demand during 2011/2012 heating season.

Despite the cost competitiveness of wood fuels in relation to fossil fuels (heating oil, fuel oil), and significant financial savings in that regard, wood fuels are still not used in systems for heating public interest buildings in Montenegro, as some types of wood fuel are largely exported or disposed to landfills, while imported fossil fuels are used in public interest building.

Overall energy exported in 2011 in the form of wood chips, pieces of tree bark and sawdust was 113.6 million kWh.

That these are significant quantities is best illustrated by the fact that 3.2 million litres of heating oil, with energy value of 34.6 million kWh, was consumed in 102 schools using heating oil for heating in Montenegro in 2012 (Table 12).

Table 12. Costs of individual types of fuel used for heating schools in Montenegro

Fuel	Number of schools	Measurement unit	Consumed quantity in 2011	Purchase price in EUR per measurement unit	Total costs of fuel for heating in schools in EUR	Share in costs
Oil fuel	102	litres	3,232,470	1.09	3,523,392	84.21
TNG	11	litres	215,000	0.62	133,300	3.19
Coal	39	litres	3,159	89	281,151	6.72
Fuel wood	327	m^3	5,357	46	246,422	5.89
Total	479				4,184,265	100.00

According to the data from two biggest distributors of heating and fuel oil for the same year, 1.1 million kg of fuel oil and 1.3 million litres of heating oil with total energy value of about 25.5 million kWh were delivered to meet the needs of a number of facilities within the healthcare system of Montenegro.

This means that all aforementioned buildings could have been heated with the exported wood energy and even 53.5 million kWh would have remain to meet the needs of other buildings (public administration buildings...).

At the same time, the overall financial impact of exporting aforesaid quantities of wood fuels in 2011 was 456,157 €, while the Government of Montenegro spent about 5.4 million € for heating 102 schools with heating oil, as well as for abovementioned quantities of fuel and heating oil for health care facilities.

It is unnecessary to highlight the scale of financial savings that would be achieved by using mentioned wood fuels instead of heating and fuel oil.

Given that fossil fuels are used in many public interest buildings, particularly in the health care system, and bearing in mind the obligation Montenegro assumed by ratifying the Kyoto Protocol with respect to reduction of CO_2 emissions, these public interest buildings are therefore perfectly suitable for conversion from fossil to wood fuels.

From the perspective of environmental protection, table 13 shows effects of replacing heating and fuel oil used for heating schools and a number of health care facilities in 2011 (for required amount of energy amounting to 60,100,000 kWh) with wood fuels, taking into account the following parameters for calculation purposes:

- Total energy generated by burning heating and fuel oil for heating a number of facilities in the health care system: 25.5 million kWh
- Total energy generated by burning heating and fuel oil for heating schools: 34.6 million kWh

Table 13. Environmental effects of replacing heating and fuel oil with wood fuels in schools and some buildings of the health care system of Montenegro

Type of fuel	CO_2 emission in kg/kWh	Total CO_2 in tons for required amount of energy
heating oil	0.269	16,167
Wood chips	0.0212	1,274
Wood briquettes	0.02938	1,766
Wood pellets	0.0267	1,605

If wood fuel were used instead of heating oil to generate required amounts of energy, quantity of CO2 emissions would be lower 9.2-12.7 times, depending on the type of wood fuel that would be used.

This example and results of analysis presented in Table 13 clearly indicate all environmental advantages and benefits that wood fuels make possible, compared to heating and fuel oil. As there are several hundred health care facilities in Montenegro (hospitals, health care centres, accommodation facilities for elderly people), preschool institutions, restaurants and other public and commercial buildings using coal and other fossil fuels, then possibilities for their conversion to wood based fuels are truly enormous.

3.3.7. Export and import of wood fuel

Export of wood fuel from Montenegro has been growing for the past four years. From 121,399 € in 2008, export of wood fuel reached the value of 768,212 € in 2012, which was an increase of 6.3 times (Graph 6).

Share of fuel wood and wood chips in the structure of wood fuel export value in 2012 is dominant (75%), while the share of sawdust and pieces of tree bark from sawmills was 17% (Graph 6).

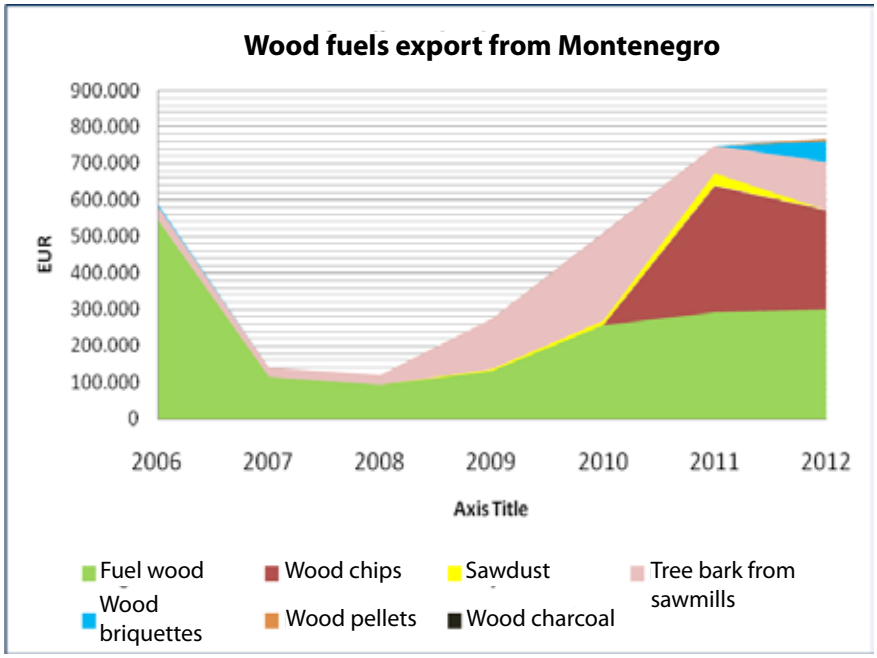
The overall export of wood biomass in the form of wood chips, pieces of tree bark and sawdust in 2011 was 61.069 m^3, of which 20,574 m^3 of wood chips, 25.218 m^3 of tree bark and 15.277 m^3 of sawdust.

If calculated in energy value, with moisture that these wood fuels are exported with, the total exported amount of energy was 113.6 million kWh.

As quantities of briquettes and wood charcoal produced in Montenegro are relatively small, they are fully used to meet the needs of the domestic market.

Export of wood pellets from Montenegro commenced with the launch of their production in 2012.

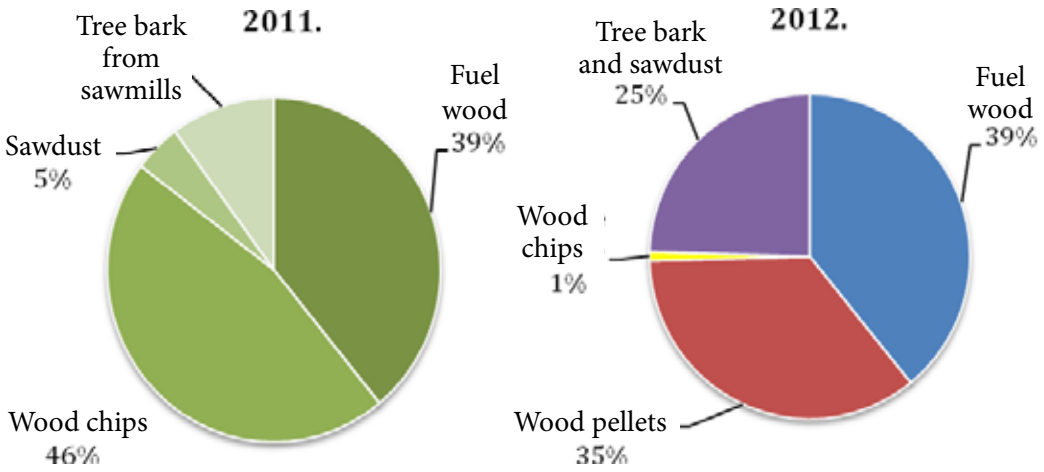
In 2012, 128 tons was exported. The entire quantity was exported to Italy. According to the data from the only pellets producer so far, the entire 2013 production will be placed in the Italian market.



Graph 6. Wood fuels export from Montenegro
(**Sources:** 1.MONSTAT; 2. Calculations by B. Glavonjić)

With rapid growth of demand for all types of wood biomass in Serbia in the past three years, export of tree bark from sawmills and sawdust also grew rapidly, and export of wood chips also started in 2011.

In Montenegro, wood chips are mainly produced from tree bark from sawmills, and to smaller extent from thin industrial round wood and timber residue from forestry. The most relevant markets for wood chips export in 2012 included Serbia and Italy, where 88.2% of the entire production was exported. 4,315 tons were exported to Italy, and 20,966 tons to Serbia.



Graph 7. Share of individual types in total value of wood fuel export from Montenegro in 2011 and 2012 (**Sources:** 1. MONSTAT; 2. Calculations by professor Branko Glavonjić, PhD)

Export of fuel wood in 2012 was worth 300,742 €, of which 193,293 € of export was to Italy, and 51.938 € to Serbia.

When total amount is considered, Serbia is the most relevant market for export of wood fuels from Montenegro.

As for wood fuel import, the total import value in 2012 was 478,303 €, of which value of imported pellets was 308,535 € or 64,5%, and value of imported of wood charcoal was 79.992 EUR or 16,7%.

Serbia is the most important country from which wood pellets are imported, with share of 83% of their total import in 2012, and the rest was imported from Bosnia and Herzegovina and Croatia.

1,928 tons of wood pellets were imported in 2012, of which 1,594 tons from Serbia, and 331 tons from Bosnia and Herzegovina.

Serbia is also the most important country from which wood charcoal is imported. In 2012, 529 tons of charcoal was imported in total, of which 498 tons from Serbia.

3.4 Integrated module

The main product of the integrated module has been presented with analysis of wood fuel potential and consumption balance. Balance hereinafter in the text implies an aggregate relation of wood biomass potential in certain area with aggregate wood biomass consumption in that same area.

Relation of wood biomass potential and consumption at the level of municipalities and at the national level will be examined for the purposes of this document.

If the quantity of potential is higher than consumption for observed spatial and administrative unit, balance will be positive, while in case consumption is higher than potential then balance will be negative and have a 'minus' sign.

Current situation at the national level is taken as balanced in the aggregate, while some differences occur at lower spatial and administrative units, according to the existing situation on the ground.

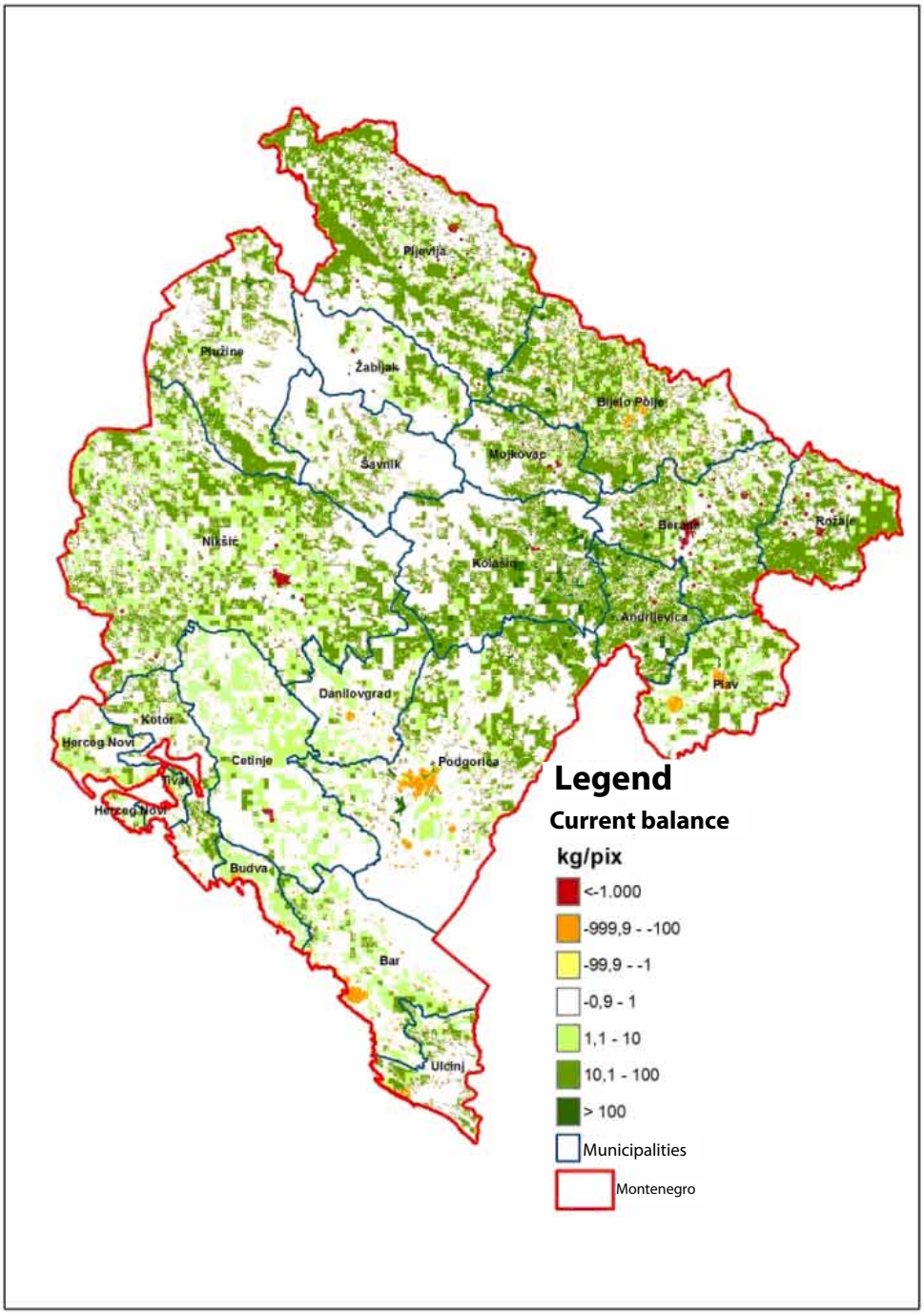
Three balance scenarios were considered, designed based on the criteria for these two scenarios as defined in draft Strategy for Forestry Development in Montenegro, and which are explained in earlier chapters with regard to potential of forests.

Balance scenarios are as follows:
- Real (based on the current wood fuel consumption level)
- Theoretical scenario 1 and
- Theoretical scenario 2

Analysis of supply and demand balance for production and consumption of fuel wood was made at the level of pixels, and may be examined at the level of municipalities / city.

The key parameters in the analysis were as follows:
- Gross annual allowable cut in management plans versus real levels of harvesting some assortments usually used as fuel wood;
- Possible allowed annual cut (Based on Scenario 1) versus potential consumption;
- Increased annual allowable cut based on improved condition of forests (based on Scenario 2) versus potential consumption.

Key results obtained within the integrated module are shown in the following cartographic representations:

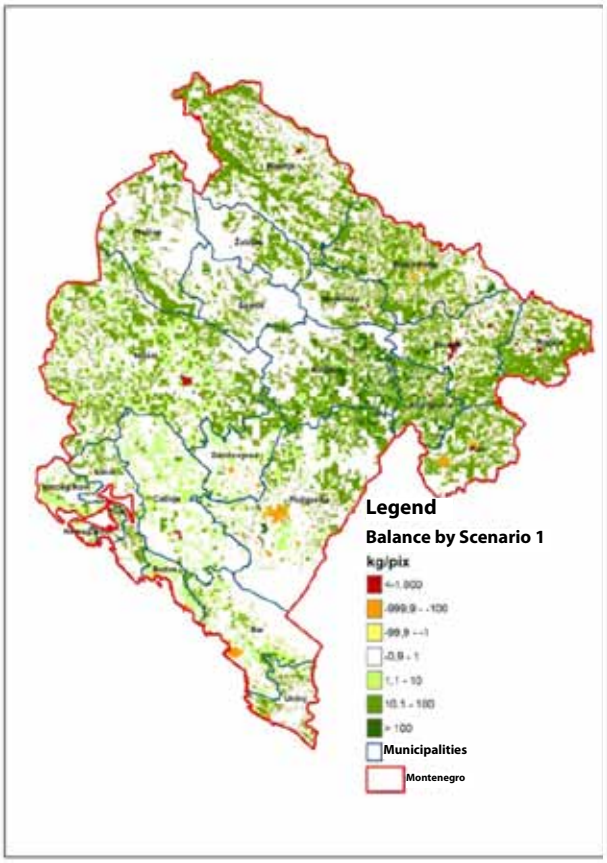


Picture 44. Current balance of wood fuel production and consumption (map: Pisek R.)

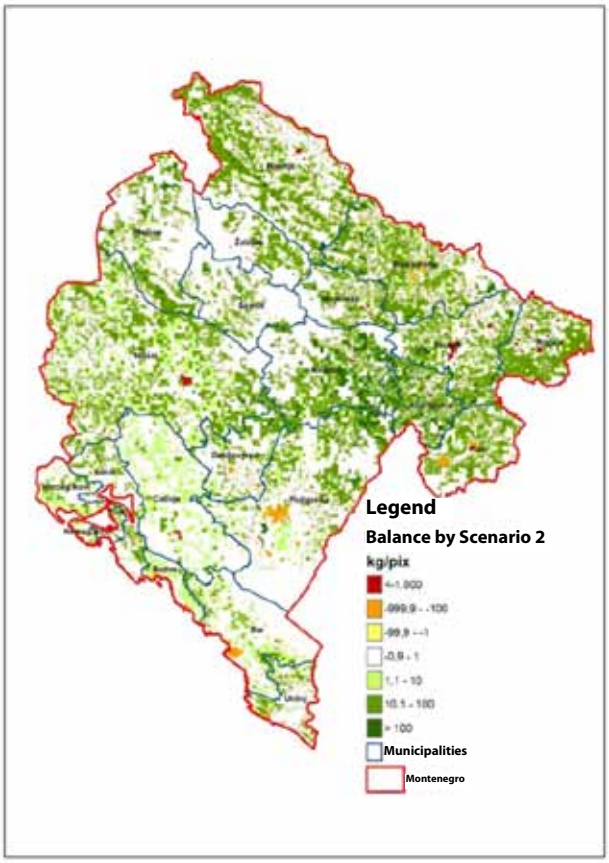
At present, 15 municipalities have a negative balance, while in 6 municipalities it is positive.

The largest positive balance is in the municipality of Kolašin, than in Andrijevica, Pljevlja and Plužine, while largest negative balance is in Podgorica, Berane, Bar and Nikšić.

A positive balance of 48,735 tons is registered in Kolašin, and negative balance of -42,717 tons in Podgorica.



Picture 45. Wood fuel production and consumption balance according to Scenario 1 (map: Pisek R.)



Picture 46. Wood fuel production and consumption balance according to Scenario 2 (map: Pisek R.)

According to "Scenario 1", 14 municipalities would stay with negative balance, and according to 'Scenario 2" 11 municipalities would have a negative difference between fuel wood production and consumption.

For both these scenarios, aggregate balance would be positive. According to Scenario 1, it would be 45,160 tons, while according to Scenario 2, production would be higher than consumption by 140,290 ton.

The biggest difference between the balance of Scenario 2 and current balance would be in municipalities of Kolašin, Pljevlja, Podgorica and Bijelo Polje.

This comparative analysis of actual wood fuel consumption in relation to potentially increased allowable annual cut indicates possibilities of potential increase of 140,300 tons of wood fuels that could be utilised in the future.

Table 14. Wood fuel production and consumption balance

No.	Municipality	Current balance	Balance scenario 1	Balance scenario 2
		tons		
1	Andrijevica	25,723	31,203	37,036
2	Bar	-12,232	-11,453	-10,663
3	Berane	-15,472	-17,794	-12,266
4	Bijelo Polje	-8,957	-2,247	5,535
5	Budva	-2,589	-2,412	-2,362
6	Cetinje	-5,503	-8,920	-8,932
7	Danilovgrad	-6,803	-5,346	-1,291
8	Herceg Novi	-5,353	-4,820	-4,364
9	Kolašin	48,735	61,677	80,291
10	Kotor	-1,098	-196	980
11	Mojkovac	6,312	5,230	8,616
12	Nikšić	-12,136	-7,982	-4,674
13	Plav	-4.303	-2.341	757
14	Pljevlja	23.380	29.607	46.178
15	Plužine	19.336	23.495	31.094
16	Podgorica	-42.717	-36.343	-26.929
17	Rožaje	-2.828	-6.739	-2.755
20	Šavnik	-3.008	-2.925	-2.921
18	Tivat	-6.929	-6,216	-6,221
19	Ulcinj	7,091	9,373	12,258
21	Žabljak	-650	310	928
	Total	**0**	**45,160**	**140.297**

3.4.1. Selection of priority locations

Potential / consumption balance data could also be used to define suitable locations for biomass plants. Municipalities with positive balance are a target group, as they have larger quantity of wood biomass than the one currently being utilised.

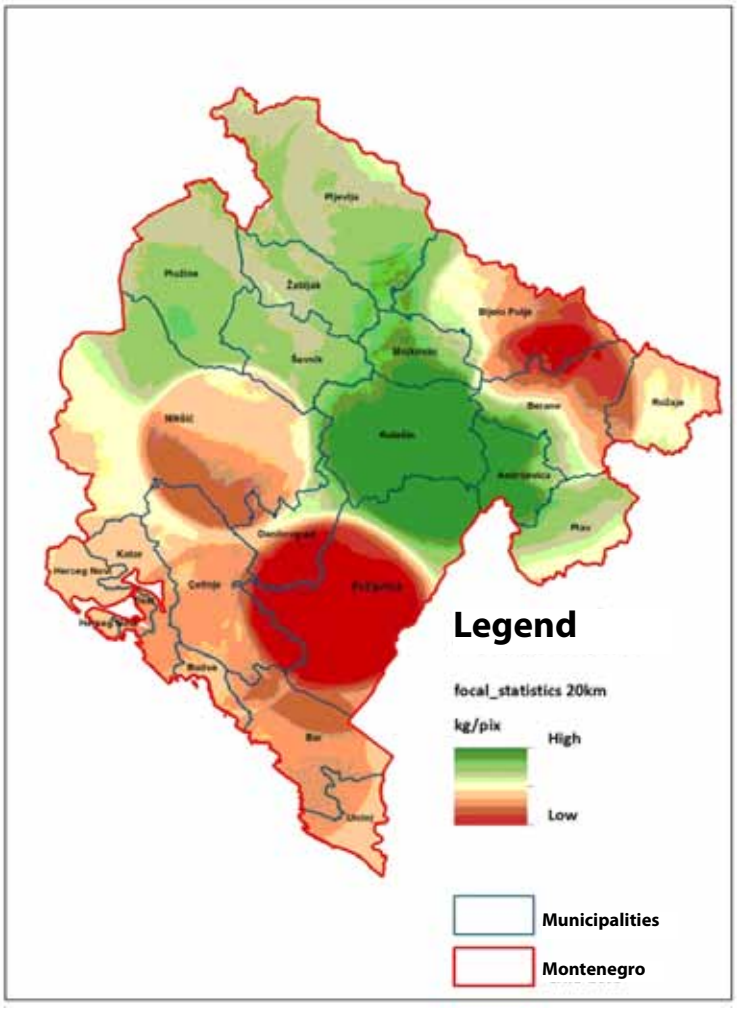
If locations for potential factories for production of bio-fuel from wood biomass have not been previously defined, for technological, political or some other reasons, it is possible to suggest their locations for the country as a whole based on the analysis made here.

Locations will be suggested upon determining supply potential of each point (pixel), assuming specific supply radius.

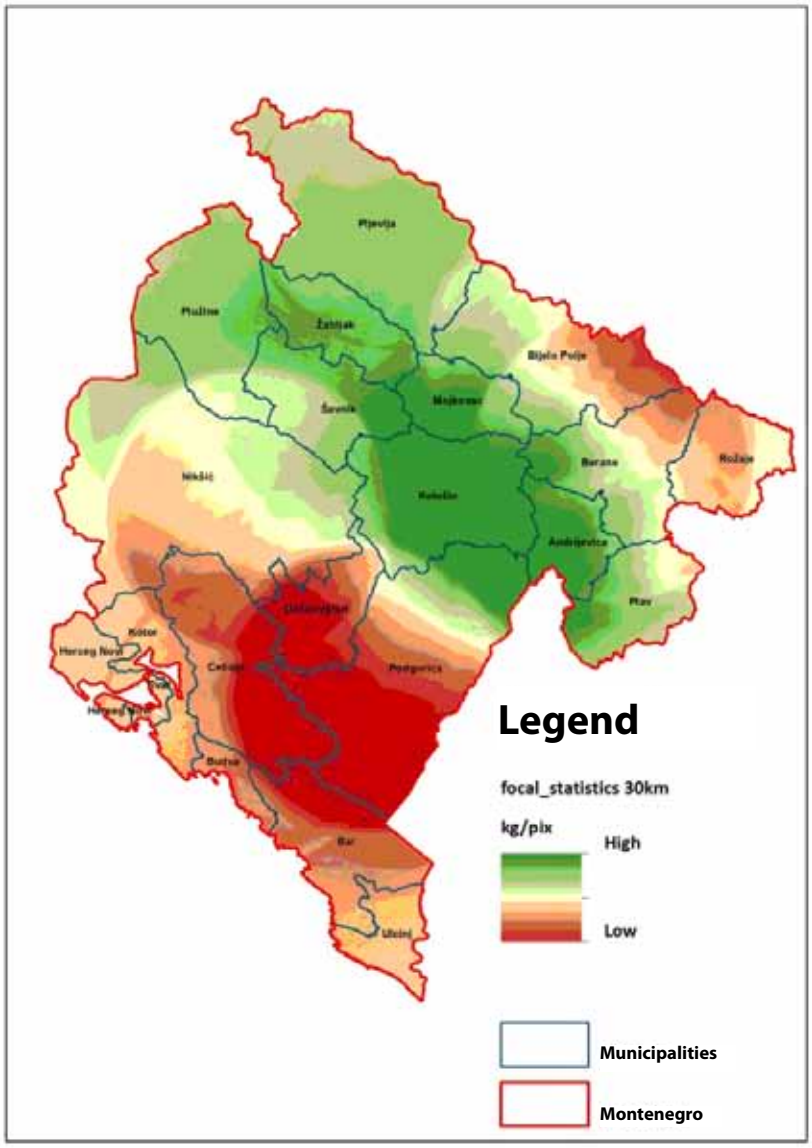
This practically means that the most favourable zones for investments in these factories for production of energy or fuels from wood biomass will be defined by combining all parameters presented so far on potentials of biomass from forestry, wood industry and agriculture, and consumption of wood fuels taking into account slopes, road infrastructure, as well as distance of consumer centres from raw materials based on predefined radii that correspond to maximum allowable profitable transport distances.

Zoning is set with radii of 20 and 30 km, and data on current local consumption and potential for sustainable production have also been combined.

According to this approach to zoning, the highest potential according to focal statistics (expressed in kg/pixel) is in municipalities of Kolašin and Andrijevica, then in Mojkovac, Žabljak, Pljevlja and Plužine. Medium potential has been registered in municipalities of Plav and Šavnik, and lowest in Podgorica, Berane, Bijelo Polje, Nikšić, Rožaje and coastal municipalities.



Picture 47. A map of suitability zones for locating plants (radius 20 km) (map: Pisek. R)



Picture 48. A map of suitability zones for locating plants (radius 30 km) (map: Pisek. R)

According to this approach to zoning, the highest potential according to focal statistics (expressed in kg/pixel) is in municipalities of Kolašin and Andrijevica, then in Mojkovac, Žabljak, Pljevlja and Plužine. Medium potential has been registered in municipalities of Plav and Šavnik, and the lowest potential in Podgorica, Berane, Bijelo Polje, Nikšić, Rožaje and coastal municipalities.

Based on data obtained, pictures 47 and 48 offer an insight into zones suitable for putting up plants for production of wood biomass based fuel.

The results of this analysis can serve as a good tool to policy makers and for policy making in the field of renewable energy sources, as well as to potential investors, as they indicate potentially the best locations for development of production and utilisation of wood biomass fuel in a clear and illustrative manner.

4. CONCLUSIONS AND REMARKS

The topic of bio-energy is essentially inter-sectoral and interdisciplinary. Accordingly, WISDOM approach has allowed single, joint overview based on information from the field of forestry, the key source of data on supply, as well as from agriculture, energy, statistics, industry, market, etc.

By implementing the WISDOM methodology, a broad segment of wood fuel consumption and potential in Montenegro has been examined. Sets of data generated in this study, divided by basic modules of supply and demand and with additional integrated module, offered specific insight into the status, potentials and possibilities of wood biomass utilisation for energy purposes in Montenegro.

Specifically, an insight was given into the balances of supply and demand for the possibility to use wood fuels for heating schools in the northeast of Montenegro. The overview of balances by municipalities offered clear guidelines and a basis for future exploration of the possibility to develop bio-energy potentials in some municipalities, including conversion of existing structures, as well as potential production of wood pellets for the market and local remote heating stations.

Based on existing network of roads, including forest roads, slope and standing volume and increment, an overview of locations where interventions to improve road infrastructure would be most effective has been offered. Data analysis based on WISDOM methodology, zoning and balances calculated according to strategic scenarios, certainly provide a more clearer picture of this sector and could be one of essential starting points for decision makers and policy makers in the field of renewable energy sources, as well as for potential investors. Potentials for utilisation of wood biomass for energy purposes have been presented in a clear and illustrative manner, which was actually the basic goal of this project.

An insight was also given into spatial distribution and quantity of timber residue from wood processing at the level of Montenegro, which could prove crucial when estimating available quantities of wood biomass, when identifying the best location and capacities for future pellets factories and cogeneration plants.

Results of this project will allow decision makers to make correct decisions on wood energy markets. Sustainable and balanced wood fuel market has a potential to strengthen the Montenegrin economy significantly, by reducing dependability from fuel imports, and particularly the rural economy by creating new jobs and increasing revenues that would go to rural areas.

Analytical conclusions and zoning by potentials for wood biomass utilisation for energy purposes, despite comprehensive examination of the topic, should be seen as initial steps in the analysis of this sector, and not as final solutions for processes within this highly complex subject matter.

Collected data and analysis could be beneficial to a large number of stakeholders: from local administrations to business people who want to get involved in the process of better utilisation of this renewable resource.

This study should serve as a good spatial and numerical basis that needs to be updated regularly with information received from all stakeholders. Presented data and completed analyses will be a good starting material for development of local action plans, as illustrated by example of schools where change of heating system and shift to wood biomass as fuel is planned. Presented WISDOM modules should provide a more clearer insight into potentials and consumption of wood biomass as fuel at the local level.

In order to maintain long-term efficiency of WISDOM methodology as a planning tool in Montenegro, further database enhancement is recommended. Comparative analysis with results of some future study based on WISDOM methodology would provide a time component, allow examination of trends and confirmation or denial of some of the conclusions and expectations offered in this study.

5. ANNEXES

A 1: Surface area of forests and forest land according to LANDSAT data

No	Municipality	Total surface area (ha)	Forests (ha)	Forest land (ha)	Number of pixels
1	Andrijevica	33,067	21,234	1,234	826,672
2	Bar	62,531	22,900	3,700	1,563,274
3	Berane	67,536	32,920	7,032	1,688,398
4	Bijelo Polje	92,051	43,108	15,547	2,301,277
5	Budva	12,243	7,439	1,203	306,078
6	Cetinje	89,818	60,363	9,721	2,245,451
7	Danilovgrad	42,632	24,666	3,066	1,065,789
8	Herceg Novi	22,854	12,793	2,185	571,342
9	Kolašin	90,626	55,149	5,011	2,265,650
10	Kotor	33,570	16,097	4,123	839,255
11	Mojkovac	35,873	16,945	2,364	896,824
12	Nikšić	213,537	128,259	9,877	5,338,426
13	Plav	48,329	27,137	1,240	1,208,236
14	Pljevlja	134,157	72,804	6,119	3,353,929
15	Plužine	85,314	37,993	2,143	2,132,845
16	Podgorica	149,478	55,576	13,209	3,736,959
17	Rožaje	43,088	26,229	3,569	1,077,189
20	Šavnik	4,745	14,068	3,046	118,616
18	Tivat	26,044	1,751	909	651,101
19	Ulcinj	55,642	8,153	3,254	1,391,048
21	Žabljak	44,709	18,437	3,865	1,117,728
	Total	**1,387,843**	**704,022**	**102,418**	**34,696,087**

A 2: Standing volume and increment according to the data from the National Forest Inventory (NFI)

No	Municipality	Standing volume (m^3)	Increment (m^3)
1	Andrijevica	7,021,093	132,020
2	Bar	967,490	25,287
3	Berane	8,659,087	216,787
4	Bijelo Polje	10,302,634	273,590
5	Budva	197,093	5,880
6	Cetinje	919,078	26,819
7	Danilovgrad	1,574,247	35,401
8	Herceg Novi	540,460	14,500
9	Kolašin	11,161,601	192,832
10	Kotor	959,682	21,771
11	Mojkovac	3,336,224	82,030
12	Nikšić	9,772,106	239,447
13	Plav	3,764,641	105,383
14	Pljevlja	20,442,571	523,352
15	Plužine	5,680,483	126,726
16	Podgorica	6,446,912	134,269
17	Rožaje	7,451,559	212,538
20	Šavnik	2,181,696	53,185
18	Tivat	86,749	2,561
19	Ulcinj	673,502	18,812
21	Žabljak	2,835,841	82,060
	total	**104,974,746**	**2,525,251**

A 3: Analysis of biomass potentials according to NGI data (Scenario 1) (Action …, 2013, source Jurij Beguš)

No	Municipality	Harvesting according to Sc1(m^3)	Increment/ Standing volume(%)	Increment/ harvesting (%)	F and L logs (m^3)	Roundwood (m^3)	Other assort. (m^3)	Fuel wood (m^3)	Residue (m^3)	Biomass (FW+res) (m^3)	Biomass / harvesting(%)
1	Andrijevica	114,776	1.6	87	1,655	37,303	2,843	55,958	17,018	72,976	64
2	Bar	8,950	0.9	35	12	704	105	6,768	1,362	8,130	91
3	Berane	132.830	1.5	61	1,601	57,985	9,481	44,672	19,092	63,763	48
4	Bijelo Polje	159.560	1.6	58	1,546	51,528	14,316	70,036	22,133	92,169	58
5	Budva	1.553	0.8	26	0	52		1,296	204	1,500	97
6	Cetinje	8.666	0.9	32	9	699	24	6,679	1,257	7,936	92
7	Danilovgrad	23,321	1.5	66	66	6,608	2,354	10,101	4,193	14,294	61
8	Herceg Novi	7,732	1.4	53	59	2,059	310	4,192	1,112	5,304	69
9	Kolašin	202,048	1.8	105	3,615	55,488	1,586	110,167	31,192	141,359	70
10	Kotor	13,961	1.5	64	248	3,905	160	7,878	1,770	9,649	69
11	Mojkovac	52,271	1.6	64	444	16,339	2,311	25,162	8,014	33,176	63
12	Nikšić	131,679	1.4	55	1,014	33,065	6,197	71,923	19,480	91,403	69
13	Plav	45,581	1.2	43	110	17,375	4,412	16,190	7,493	23,683	52
14	Pljevlja	315,011	1.5	60	1,235	152,777	39,528	73,655	47,816	121,471	39
15	Plužine	83,674	1.5	66	1,060	25,506	3,178	41,679	12,252	53,930	64
16	Podgorica	102,031	1.6	76	3,352	30,992	1,566	52,313	13,809	66,122	65
17	Rožaje	112,904	1.5	53	592	54,388	15,878	24,534	17,513	42,047	37
20	Šavnik	28,223	1.3	53	161	5,694	304	18,074	3,991	22,065	78
18	Tivat	1,064	1.2	42		212	76	606	170	776	73
19	Ulcinj	7,679	1.1	41	42	1,071	52	5,556	958	6,514	85
21	Žabljak	43,015	1.5	52	38	22,870	6,309	6,738	7,061	13,799	32
	total	**1,596,526**	**1.5**	**63**	**16,858**	**576,616**	**110,988**	**654,176**	**237,889**	**892,065**	**56**

A4 : Analysis of biomass potentials according to NGI data (Scenario 2) (Action …, 2013, source Jurij Beguš)

No	Municipal-ity	Harvesting according to Sc1(m³)	Increment/ Standing volume(%)	Increment/ harvesting (%)	F and L logs (m³)	Round-wood (m³)	Other as-sort. (m³)	Fuel wood (m³)	Residue (m³)	Biomass (FW+res) (m³)	Biomass / harvest-ing(%)
1	Andrijevica	139,028	2.0	105	1,951	48,853	3,752	63,464	21,007	84,471	61
2	Bar	8,982	0.9	36	12	853	154	6,560	1,403	7,963	89
3	Berane	179,380	2.1	83	1,894	86,997	12,602	51,581	26,307	77,888	43
4	Bijelo Polje	178,292	1.7	65	1,863	63,165	14,434	73,869	24,961	98,830	55
5	Budva	1,684	0.9	29	0	65		1,402	217	1,619	96
6	Cetinje	10,762	1.2	40	12	1,065	24	8,085	1,576	9,661	90
7	Danilovgrad	24,892	1.6	70	79	6,609	2,114	11,769	4,321	16,090	65
8	Herceg Novi	9,930	1.8	68	71	3,063	535	4,782	1,479	6,261	63
9	Kolašin	254,424	2.3	132	4,405	70,574	2,069	138,206	39,170	177,376	70
10	Kotor	17,798	1.9	82	296	5,329	294	9,572	2,308	11,879	67
11	Mojkovac	65,081	2.0	79	544	21,147	2,647	30,675	10,070	40,744	63
12	Nikšić	159,384	1.6	67	1,272	41,671	8,096	84,762	23,582	108,344	68
13	Plav	57,575	1.5	55	130	24,274	5,765	17,710	9,696	27,406	48
14	Pljevlja	444,009	2.2	85	1,548	240,203	48,800	85,244	68,214	153,458	35
15	Plužine	109,229	1.9	86	1,286	34,868	4,263	52,599	16,214	68,813	63
16	Podgorica	128,749	2.0	96	4,136	38,268	2,077	66,768	17,501	84,268	65
17	Rožaje	149,667	2.0	70	689	78,464	19,589	27,508	23,417	50,924	34
20	Šavnik	39,019	1.8	73	201	7,720	468	25,118	5,511	30,629	78
18	Tivat	1,370	1.6	53		418	153	571	228	798	58
19	Ulcinj	7,879	1.2	42	48	1,245	100	5,484	1,001	6,486	82
21	Žabljak	70,399	2.5	86	48	39,078	9,693	9,810	11,771	21,581	31
	total	**2,057,530**	**2.0**	**82**	**20,485**	**813,928**	**137,628**	**775,538**	**309,951**	**1,085,489**	**53**

6. REFERENCES

Glavonjić B., Krajnc N., Stijovic A., Zvizdojević J., Peković D., Savićević M., Raičević B., Ristović D., Pavlović M., Šišević R.: Statistical Office (Monstat) in cooperation with FODEMO project: Consumption of Wood Fuels in Montenegro in 2011 – New Energy Balances for Wood Fuels, Podgorica 2013.

Dees M., Anđelić M., Fetić A., Jokanović B., Tepavčević V.,Borota D., Vasiljević A.,Winreich A., Hahn N., Marković D., Terzić D.: The First National Forest Inventory of Montenegro, Ministry of Agriculture and Rural Development, Podgorica 2013

Glavonjić B., Stijović A., Types, Characteristic and Wood Fuel Consumption in Montenegro, FODEMO project, Podgorica, 2013

Andjelić M., Dees M., Pantić D., Borota D., Šljukić B., Čurović M., 2012. Status of forest resources of Montenegro. Agriculture and Forestry Vol 57(11): issue 3: p. 39-52.

Biomass Potential for Montenegro- Ministry of Economy (2011)

2013 Annual Forest Management programme, Forest Administration, Pljevlja 2013

Harmel M., Krajnc N., Beguš J., Glavonjić B., Stijović A,: Proposal of the Action Plan for Wood Biomass utilisation in Montenegro, FODEMO, 2013

Bouriaud, L., Čurović, M.: Report on NAP implementation Progress (Training on systems/techniques for fighting illegal activities in forestry), FODEMO/ÖsterreichischeBundesforsteÖBf AG, Podgorica 2012.

Glavonjić B.: Possibilities, Challenges and Current Progress in Wood Biomass Market Development in Montenegro, FODEMO 2010

Glavonjić B. Current status of timber residue utilisation for energy generation in Montenegro and commercial options, Regional Conference "Sustainable Energy management in Public Buildings – From Policy to local action"Budva,27-29. April 2010

Nikčević, V.: Bio-energy Potential of Montenegro - Biomass Energy Potentials (2010)

Nuhodžić, M., Ferlin F.: Experiences in establishing an association of private forests owners of Montenegro and their influence on forest policy and legislation development in Montenegro. IUFRO RG conference »Forestry of small estates «, Bled/Slovenija, jun 7 – 9. Jun 2010.

An Assessment of Potentials for Renewable Energy Sources in the Republic of Montenegro (CETMA) 2007

The initial national communication of Montenegro on climate changes to the UN Framework Convention on Climate Changes (UNFCCC) 2010

Stritih J., Harmel M., Glavonjić B.: Strategy with forest and forestry development plan – National Forestry Strategy, FODEMO/ministry of Agriculture and Rural Development, Podgorica 2013

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