

WISDOM CROATIA

Spatial woodfuel production and consumption analysis
applying the Woodfuels Integrated Supply/Demand
Overview Mapping (WISDOM) methodology



REGIONALNA ENERGETSKA AGENCIJA
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Spatial woodfuel production and consumption analysis applying the Woodfuels Integrated Supply/Demand Overview Mapping (WISDOM) methodology

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TCP/CRO/3101 (A) Development of a sustainable charcoal industry in Croatia

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FOREWORD

Forests cover a large area in Croatia and are the principal resource of the country's well-established wood and wood processing industry. Both the forests and the wood processing industry provide a solid base for the development of woody biomass utilization as a complementary business activity, and have the added value of being an environmentally friendly and locally available source of renewable energy. Like the Scandinavian countries, Croatia boasts considerable forest coverage, equal to 0.51 hectares per capita, thus ranking as a country with significant wood energy potential.

To promote the use of this potential, the Forestry Department of FAO is broadening and disseminating knowledge and information on wood energy aspects, as well as actively collaborating with member countries in the development and implementation of tools supporting wood energy planning and policy formulation. One such tool is the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM), a spatially- explicit method for assessing woodfuel sustainability and supporting wood energy planning through the integration and analysis of existing consumption and production-related information.

Within the framework of the project «Development of a sustainable charcoal industry», TCP/CRO/3101, implemented by the Government of Croatia and supported by FAO, the WISDOM methodology was applied in order to acquire the knowledge base necessary to formulate national wood energy strategies that would also correspond with the criteria for Croatia's entry into the European Union.

Using the WISDOM geodatabase, and integrating it with specific aspects of local relevance, the Croatian Forestry Administration or any other interested party can instantly provide a comprehensive and detailed report, complete with tables and thematic maps. The aspects covered in this report include forestry data on wood assortments; their distribution and physical accessibility; productivity in non-forest areas; and analysis of wood consumption for heating in households, charcoal and pellets production and in district heating plants.

The knowledge generated by this part of the project has greatly enhanced the capacity of Croatian institutions to deal with wood energy issues and, ultimately, to contribute to the formulation of policies and to the planning of field activities and implementation projects.

We trust you will find this report interesting and informative.



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This project was launched in July 2006 within FAO Technical Cooperation Programme with the objective to assess the current status of the charcoal production in Croatia, in order to develop a programme for the revitalisation of this industry.

Apart from recommendations and best solutions for the technological modernisation, the programme provided guidelines for the production improvement and amplification with a holistic approach.

The Ministry of Agriculture, Forestry and Water management was responsible for the project execution on behalf of the Government of the Republic of Croatia.

EXECUTIVE SUMMARY

Thirty-six percent of Croatia is covered by forests and the country boasts a well established wood industry. There is, therefore, a considerable potential for use of woody biomass as an environmentally friendly and locally available source of renewable energy.

In order to find viable solutions for a development of charcoal industry in Croatia but also for an overall development of national bioenergy sector, the Government of Croatia, supported by FAO, implemented the project Sustainable Development of Charcoal Industry in Croatia TCP/CRO/3101.

The content of the project was wide and captured all areas important for the promotion of charcoal production and moreover development of sustainable utilization of biomass energy:

- Wood energy maps and information system,
- Analysis of domestic and international charcoal markets,
- Overview and economic evaluation of existing charcoal production technologies,
- Identification of legal/institutional aspects and gaps for charcoal and biomass energy,
- An action plan for the modernization of charcoal industry,
- Capacity building and education.

This report covers the first component of the project, which includes the creation of Croatia Wood Energy Information System.

Gathering and analyzing data about wood biomass potentials and present use in Croatia was based on the application of the Woodfuel Integrated Supply/Demand Overview Mapping – WISDOM. This is a spatially-explicit method for supporting strategic wood energy planning and policy formulation, through the integration and analysis of existing woodfuels demand and supply related information and indicators.

The use of WISDOM involves the following steps:

- Definition of the spatial unit of analysis.
- Development of the DEMAND module.
- Development of the SUPPLY module.
- Development of the INTEGRATION module and definition of priority areas.

The main objective and scope of using the WISDOM methodology in Croatia was to integrate available data about wood biomass potentials and present use of biomass, as the basis for the preparation of Croatian wood energy information system. This system should represent a practical tool for policy makers and should contribute to the biomass energy sector development.

The present report outlines the main results in terms of data included in the DEMAND and SUPPLY module and their visual representation, as well as the analysis available through the INTEGRATION module. Finally, conclusions and recommendations for further improvement and inclusion of additional datasets are provided.

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1 INTRODUCTION

1.1 BACKGROUND

Thirty-six percent of Croatia is covered by forests and the country boasts a well established wood industry. There is, therefore, a considerable potential for use of woody biomass as an environmentally friendly and locally available source of renewable energy. In fact, Croatia ranks as a country with a significant share of timber-land on the total government-owned land with 44 percent. In 1995, the wood energy potential was estimated in 33.8 PJ/a. Like the Scandinavian countries, Croatia is among the European countries with a considerable forest coverage equal to 0.51 hectares per capita.

In 2003, the Croatian National Forestry Strategy (accepted by the Parliament) recognized the priority role to be played by forests and forestry for the mitigation of climate change through the introduction of advanced forest management practices for the sustainable production of wood-based fuels including charcoal. In addition the Government has estimated that approximately 1.3 million m³ of woody biomass is available annually for energy purposes, half of which is derived from wood processing industry, [1].

Over the past years, and especially in 2006, there is a rather fast raise of interest in almost every type of biomass provoking harsh competition for the available quantities, both domestic and abroad. Export of wood waste to Hungary and Austria is boosting due to their better purchasing power. The competition on biomass market will further increase after Croatia adopted ordinances related to utilisation of renewable energy sources, especially those defining tariffs and subsidies for cogenerations and electricity production. In the respect to the wood processing industry in Croatia, many plants have a pending plan for installation of cogeneration plants primarily for their own purposes with possibility of selling the excess electricity to the grid. Finally, wood pellet industry in Croatia is developing rather quickly during the last few years and several wood processing companies announced their plans to start pellets production during 2008 with a total capacity of more than 100 000 tonnes. In comparison, data for 2005 show only one pellet production company with total capacity of 10 000 tonnes per year.

In order to find viable solutions for a development of charcoal industry in Croatia but also for a overall development of national bioenergy sector, the Government of Croatia, supported by FAO, implemented the project Sustainable Development of Charcoal Industry in Croatia TCP/CRO/3101. The project was implemented over the period 2006-2008. The Wood Energy Programme of FAO Forest Products and Economic Division (FOPP) was the Lead Technical Unit involved in the provision of technical assistance and supervision.

The content of the project was wide and it captured all areas important for the promotion of charcoal production and moreover development of sustainable utilization of biomass energy:

- Wood energy maps and information system,
- Analysis of domestic and international charcoal markets,
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This report covers the first component of the project, which include the creation of Croatia Wood Energy Information System.

In order to respond to the need for spatial and intersectoral data the activities followed the methodological approach named Woodfuels Integrated Supply/Demand Overview Mapping (WISDOM), which was developed by FAO Wood Energy Programme in collaboration with the National Autonomous University of Mexico. The WISDOM methodology constituted the basis for the development of this report and the analysis conducted may be considered as the Croatian application of this methodology.

1.2 OBJECTIVES

The scope and objective of this action was to assist the Government of Croatia in strengthening wood energy planning and policy formulation and in developing an adequate spatial and statistical information base. More specifically, the objectives were to contribute to the creation of the Croatia Wood Energy Information System (CROWEIS) and to develop a series of thematic wood energy maps including processed wood fuels like charcoal, pellets and others following the WISDOM methodology.

In other words, the objectives require an understanding of the true potential of wood energy as an economically and environmentally sound renewable energy source important for the Republic of Croatia. Key questions to be answered include the quantities and location of the present production and consumption of wood biomass in Croatia, the sustainable production potentials, and the locations where it is suitable to develop utilization of wood biomass for charcoal or pellets production, for heat and electricity generation etc.

The objectives of this activity are the following:

- to integrate the various and disperse information relevant for wood energy planning in Croatia into a spatially explicit dataset;
- to provide needed information concerning woodfuel consumption by different users on one side and locations and potentials of woody biomass supply sources including forests, non-forest land and wood processing industries on the other side;
- to identify areas most suitable for the development and implementation of wood energy projects including charcoal production plants;
- to prepare the Croatian Wood Energy Information System (CROWEIS) providing data on fuelwood, charcoal, pellets, briquettes production, consumption and trade.

1.3 FOREST MANAGEMENT IN CROATIA

Forests and forest land cover approximately 2.4 million hectares of Croatia, which is about 42.4% of total land area (excluding the Adriatic Sea). In terms of phytogeographic diversity there are two forest types: Euro-Siberian type, prevailing in the northern part of country, and Mediterranean type, spread in the karst region. Croatian forests are characterised with high species and community richness, with about 60 different forest communities (National Forestry Policy and Strategy, 2003). In the lowlands communities are mainly composed of deciduous tree species, while at the higher elevations mixed deciduous-coniferous or coniferous associations prevail. The Euro-Siberian forests predominate with 57%, as well as deciduous species which make 85% of all tree species. It has to be emphasised that 95% of Croatian forests are natural forest, which means that the species composition of the forests is almost the same as that in the virgin forests of this region. Table 1.1 shows the main tree species and their percentage in forest formation.

Table 1.1 Main tree species and their percentage in Croatian forests formation

Deciduous species		Coniferous species	
Beech (<i>Fagus sylvatica</i>)	36%	Abies and spruce (<i>Abies sp. and Picea sp.</i>)	10%
Pedunculate oak (<i>Quercus robur</i>)	12%	Pine tree (<i>Pinus sp.</i>)	2%
Sessile oak (<i>Quercus petraea</i>)	10%	Other coniferous species	1%
Hornbeam (<i>Carpinus betulus</i>)	9%		
Narrowleaf Ash (<i>Fraxinus angustifolia</i>)	3%		
Other hard broadleaved species	11%		
Soft broadleaved species	6%		

The State owns 78% of all forested land, while the rest 22% or 581 770 hectares are in the private ownership (National Forestry Master Plan, 2006). The Ministry of Agriculture, Forestry and Water Management is the administrative body responsible for the implementation of national forestry policy, while the state-owned company Hrvatske šume d.o.o. (Croatian forests Ltd) has a mandate to manage the state-owned forests according to the principals declared in the official documents that have to be approved by the Ministry and Government. Legal persons, other than Hrvatske šume d.o.o., manage a minor area of state-owned forests. A part of the State-owned forests are situated within protected areas, such as national parks, nature parks, protected landscapes and park-forests, which are administrated by the Ministry of Environmental Protection, Physical Planning and Construction. Forests in the national parks are managed by the national parks' management board according to the management plans of the parks. In nature parks, which have lower level of nature protection, Hrvatske šume d.o.o. manage the forests, but with the implementation of nature protection measures defined by the nature parks' management plans.

The Law on Forests (O.B. 140/05, 82/06, 129/08) lays down the criteria for forest stewardship, minimal level of education for people employed in forest management as well as obligation for Hrvatske šume d.o.o. to define long-term and short term management plans. Privately owned forests should comply with those long-term management plans, but this is not always the case. The reason could be found in the fact that private forest-holdings are highly

fragmented: there are 599 056 forest owners with an average forest-holding of 0.98 hectares. Continuing, privately owned forests are often linked with the lack of professional knowledge in forest management and forest stewardship tradition, insufficient number of forestry associations, through which the forest-owners would exchange knowledge and experience, and coordinate forestry interventions. Finally considerable part of private forests is degraded and requires high investments for rehabilitation.

During the last decade, in the period from 1996 to 2006, the total forestland in Croatia increased for 203 076 hectares, and in the same period the ownership structure changed in favour of private ownership. The total area of state-owned forests, managed by Hrvatske šume d.o.o. and other legal persons, and privately owned forests in 1996 and 2006 are compared in Figure 1.1.

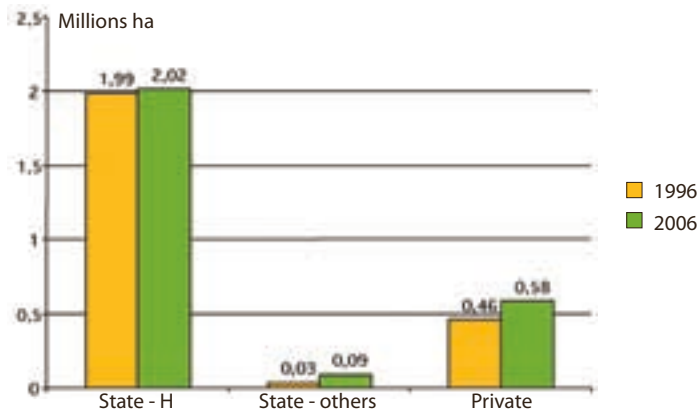


Figure 1.1 Ratio of state owned and private forests in Croatia in 1996 and 2006, [2] [3]

Forests in the ownership of the Republic of Croatia are divided into management units. Each unit has its own management master plan based on the principles of sustainable management, according to which forests are treated as renewable natural resource with distinct overall utilities, with postulate that forest rehabilitation has to be prompted, completed and enhanced where it is necessary. There are sixteen management units which are directed from the central office of Hrvatske šume d.o.o. The geographical location and name of each unit is presented in Figure 1.2.



Map Label	Name of management unit	Map Label	Name of management unit	Map Label	Name of management unit	Map Label	Name of management unit
A	Vinkovci	E	Bjelovar	I	Karlovac	M	Gospić
B	Osijek	F	Koprivnica	J	Ogulin	N	Buzet
C	Našice	G	Zagreb	K	Delnice	O	Split
D	Požega	H	Sisak	L	Senj	P	Nova Gradiška

Figure 1.2 The geographical location of forest management units of Hrvatske šume d.o.o.

As already indicated Hrvatske šume d.o.o. manage 78% or 2 018 987 ha of all forests in Croatia. There are two main management practices applied by Hrvatske šume d.o.o.: regular cut and selection cut management (Hrvatske šume, 2007). Regular cut management practice is commonly applied in low-land forests where *Quercus* species predominate. Trees in the canopy of these forests are commonly in the same development stage (i.e. of the same age and growth), and canopies are divided into development classes in the forestry unit management documents. Harvesting of regulated forest implies felling of canopies of higher development classes (mature and optimum forest development phase), thus providing space for further development of juvenile trees in the same area. Upon the felling, the harvested areas often look like area where clear-cut has been applied, but as juvenile trees and seedlings are not harvested this practice ensures the afforestation of the area. It is also important to emphasize that harvesting in this type of forests usually takes place on relatively small areas, and that on the level of management unit the net wood is constant or even increases over time.

The second management practice, selection management, is practiced in the mountainous forests of Croatia, where mixed beech (*Fagus* sp.) and coniferous forest communities dominate. In these forests canopies are composed of trees which are in different development stages, thus differing significantly in stem thickness as well as stem high. Based on the stem thickness trees within the canopies are alinedated into diameter classes. As a result of forest characteristics, as described above, individual trees in mature and/or optimal development phase are selected and designated for harvesting on a several-years bases. The forests managed by selection management practice give an impression of steady canopy composition, because felling of mature trees provide space for further development of juvenile trees, while providing approximately the same amount of harvested wood as when regulated management is applied.

The application of the described management practices through a long-term periods results in relatively high harvested wood production and forest increment at the same time. One of the reasons is continual and well-planned reforestation, which is conducted through natural reforestation and man-induced forestation via plantation of seedling. Hrvatske šume d.o.o. produce about 15 million seedlings annually. In 1996, Croatian wood-stock amounted 278 323 621 m³ (140 m³/ha), annual increment 8 123 496 m³ (4.1 m³/ha) and annual falling 4 934 199 m³ (2.5 m³/ha). In 2006 the wood-stock increased to 397 963 000 m³, annual increment to 9 643 117 m³; while the planned annual cut for the period 2006-2015 amounts 6 564 400 m³.

2 WORKING METHODS

Gathering and analyzing data about wood biomass potentials and present use in Croatia was based on the application of the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) [4].

WISDOM is a spatially-explicit method for supporting strategic wood energy planning and policy formulation, through the integration and analysis of existing woodfuels demand and supply related information and indicators. The main idea of the WISDOM methodology is to combine existing data and to provide new relative/qualitative values such as risk zoning or criticality ranking. WISDOM serves as an assessing and strategic planning tool to identify priority places for action.

The use of WISDOM involves the following steps:

- Definition of the spatial unit of analysis.
- Development of the DEMAND module.
- Development of the SUPPLY module.
- Development of the INTEGRATION module and definition of priority areas.

The application of the WISDOM methodology include the review, harmonization and integration, at the lowest possible administrative level, of all available information related to supply and demand of fuelwood. Very important is also visualization (maps) of current fuelwood consumption levels and supply sources and identification of priority areas for bioenergy development.

Till 2007 the WISDOM methodology has been implemented in case studies in three countries: in Mexico and Slovenia, it was conducted within the framework of FAO's Technical Cooperation Programme while in Senegal it was carried out as a Wood Energy Programme desk study.

Case studies proved that WISDOM methodology is flexible and adaptable to specific needs and to different development of bioenergy sectors within the countries. In all three case studies the main idea was to consolidate fragmented knowledge and to present particular woodfuel production/consumption patterns. It is interesting to note that the priorities identified in the three cases are very different. For example, in Mexico the critical aspect is the sustainability of and access to fuelwood supply sources in specific users' contexts (fuelwood "hot spots"); in Senegal, the main issue is the trend in charcoal consumption in rural villages; whilst in Slovenia the identification of biomass resources available for energy purposes and the socioeconomic constraints that limit the access to such resources are the most relevant aspects. In each case, the analysis was based on the integration into WISDOM of information already existing in the countries [5]. The study done in Slovenia during 2005 was one of the important basis for the study in Croatia considering that the natural and socio-economical conditions in both countries are similar. Also development of bioenergy sector in both countries has a lot in common.

2.1 WISDOM METHODOLOGY

The main objective and scope of using the WISDOM methodology in Croatia was to integrate available data about wood biomass potentials and present use of biomass, as the basis for the preparation of Croatian wood energy information system. This system should represent a practical tool for policy makers and is should contribute to the biomass energy sector development. To achieve this ambitious goals with limited resources and limited time as much as possible existing data should be used.

According to WISDOM methodology the work should be divided in to five main steps:

1. Definition of the spatial unit of analysis;
2. Development of the DEMAND module;
3. Development of the SUPPLY module;
4. Development of the INTEGRATION module;
5. Selection of the PRIORITY areas.

This five steps are shown in Figure 2.1. To follow this idea a list of variables to be included in the analysis was prepared. The variables can be grouped also in the following four categories:

- **Administrative elements:** code and name of Municipality and Region, share of rural population, area;
- **Demand-related variables:** population variables (number of dwellings heated with wood); surface of dwellings using wood for heating; estimated household fuelwood consumption for house heating and cooking; data on

existing biomass systems such as district heating systems, combined heat and power plants, charcoal producers and pellet producers;

- **Supply-related variables:** total and exploitable forest area; total wood stock and increment; area by forest phase development stage; annual allowable cut and its structure; area by land use classes; estimated productivity of non-forest land use classes, wood wastes from wood processing industry;
- **Integration variables:** Balance between consumption and supply scenarios.

All variables are listed in Annex I.

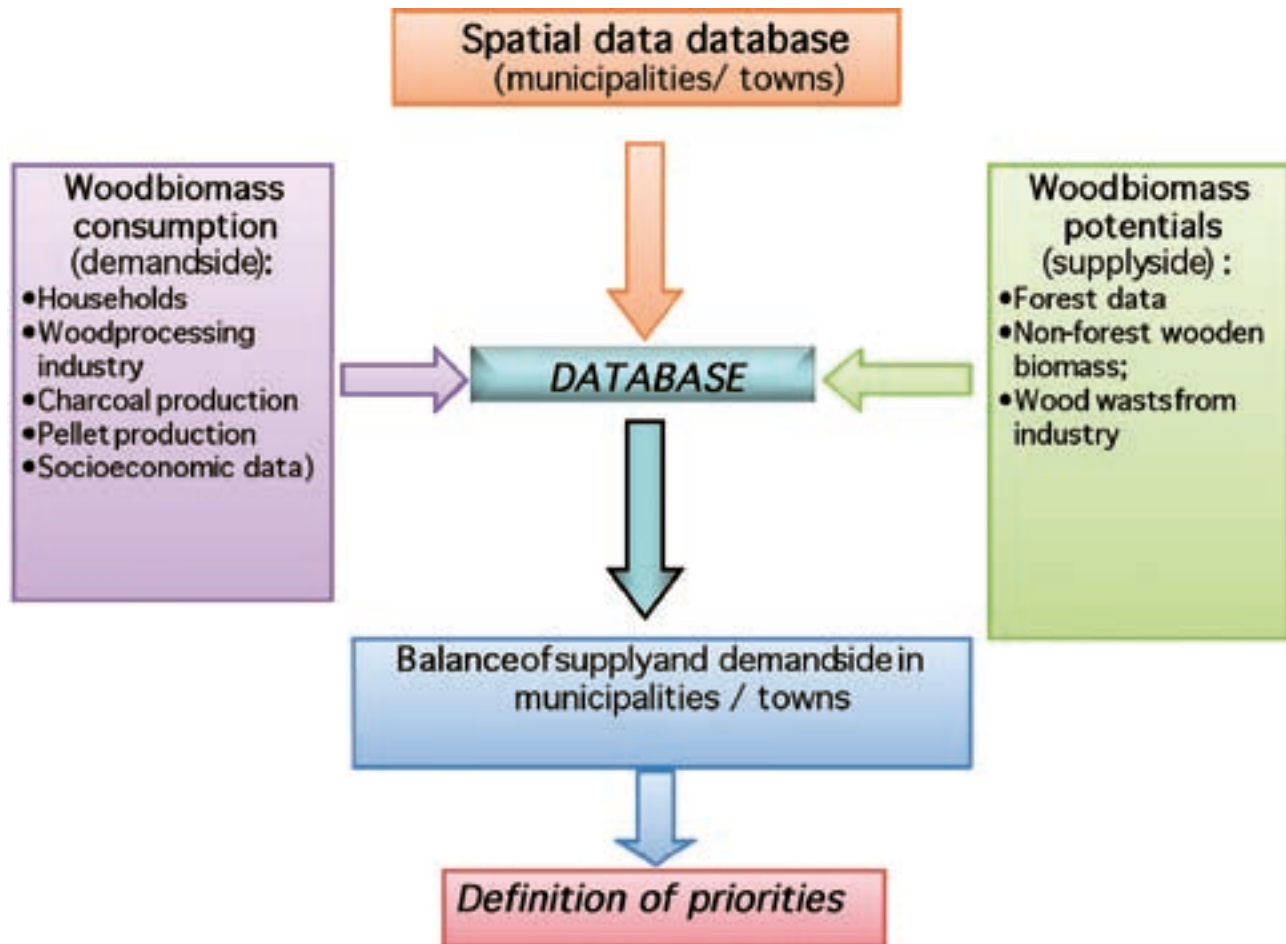


Figure 2.1 Main steps in WISDOM Croatia methodology development

2.2 SPATIAL BASE AND GEODATABASE STRUCTURE

The main spatial unit used within the data base is the level of Croatian municipalities, whereas the digital map of municipalities was used as the spatial base which are further structured in relation to existing counties. The municipalities layer consists of 550 units and this subdivision is compatible with the demographic, socio-economic and energy related data collected by the Croatian Central Bureau of Statistics, Figure 2.2.

The forestry part of the database contains data regarding potential sustainable supply of forest and its structure is entirely compatible with the data from the Central Bureau of Statistics hence a direct aggregation of forestry parameters at the municipality level was possible.

Database developed within the Forest Management Plan (2006-2015) was used as a source of forest data. This database was selected because it contains data about all forest in Croatia as of the end of 2005. The data regarding forest economic units representation in territorial structure units (municipalities/towns) was obtained by cross-referencing forest spatial data database with the data from graphical database registry of spatial units.



Figure 2.2 Municipalities and counties forming the structure of the data base

The Map of Biotopes in the Republic of Croatia (Ministry of Culture, 2004) was used to obtain data regarding non-forest land. All areas within the territorial units that were not encompassed by the forest spatial data database were separated. Cross-referencing the biotopes map with the spatial data registry determined areas for non-forest land categories on the municipality/town level.

Data regarding household energy demand were obtained from the Central Bureau of Statistics (2001 Census) and include the following municipality level figures:

- total number of inhabitants per municipality;
- number of inhabitants using fuelwood as exclusive or primary fuel for heating;
- number of occupied dwellings using fuelwood as exclusive or primary fuel for heating;
- total surface of occupied dwellings using fuelwood as exclusive or primary fuel for heating.

Based on the above mentioned figures the calculation of household fuelwood consumption was performed. Data on household fuelwood consumption are presented separately for house heating, water heating and cooking and total. A smaller part of the available data, namely related to existing biomass plants, charcoal and briquette producers and available quantities of wood residues from wood-processing industries is represented on a more detailed level of Croatian settlements, which consists of a total of 6736 units. However, this information was collected through extensive telephone interviews as well as 'on the field' surveys and within the framework of this study it was not possible to perform such a task for the remaining data.

The spatial and statistical data is structured in the form of a geodatabase (name CROWISDOM) which combines the spatial and statistical elements and allows a convenient handling in the ESRI ArcMap environment. Figure 2.3 shows a screen capture of ArcMap and ArcCatalog while viewing the file CROWISDOM. The thematic contents of the database, i.e. the attributes associated to the municipalities, resulted from the development of the Demand, Supply and Integration modules which is described later.

Municipalities / towns were used as main units for spatial database because the demographic and socio-economic data, which are collected by the Croatian Bureau of Statistics, exist on that level and the data about forests and the usage of land can be consolidated on the same level.

Another important cartographic layer is the spatial distribution of settlements. Dotted layer of settlement centroids is used to display distribution of wood-processing industry locations and biomass industry heating plants based on wood consumption as well as charcoal and wood pellets producers.

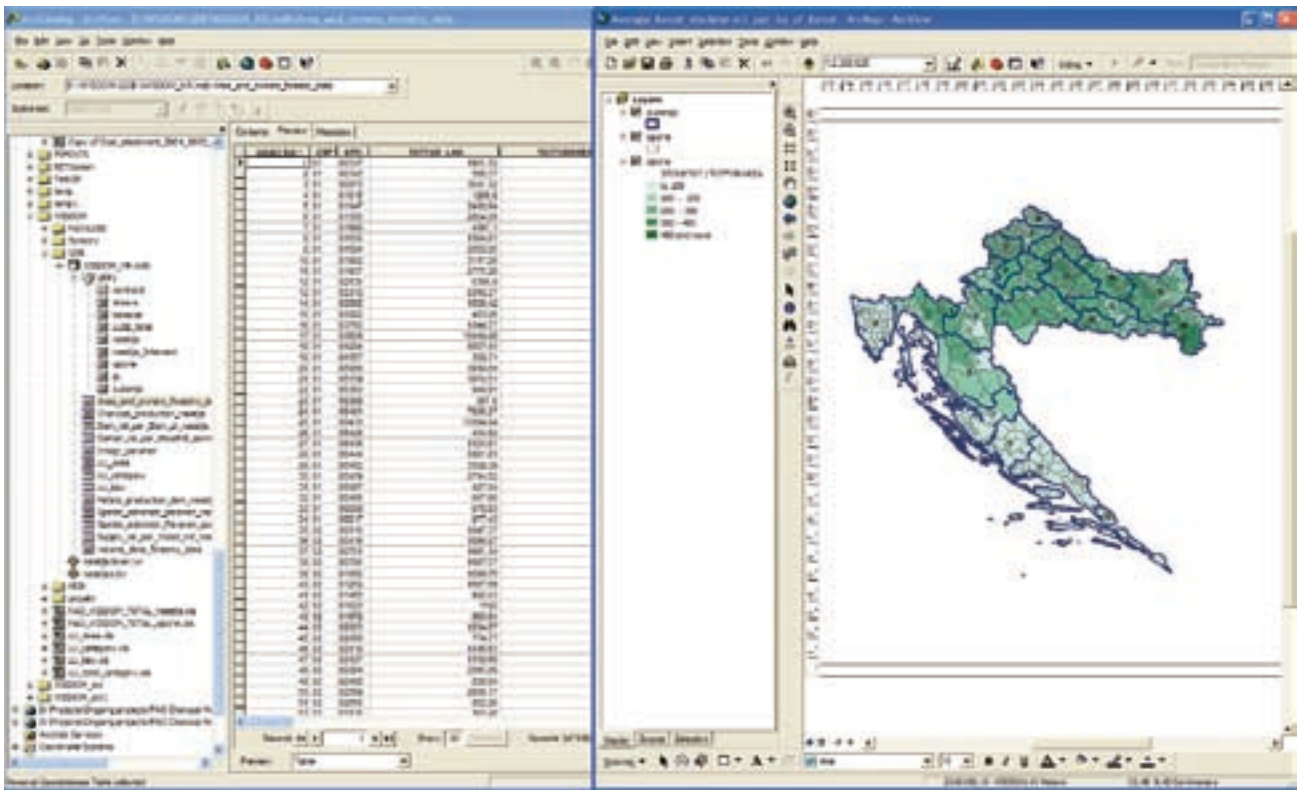


Figure 2.3 Screen capture of ArcMap and ArcCatalog while viewing the CROWISDOM geodatabase

3 WISDOM CROATIA - RESULTS AND FINDINGS

3.1 SUPPLY MODULE

3.1.1 Forests

Areas, ownership structure and conditions for forest and forest land use

Total area of the Republic of Croatia is 87.661 km², out of which 56.594 km² is mainland and 31.067 km² is sea. Total size of the forest-economic area, determined by the Forest Management Plan in 2006 amounts 26.887 km², which represents 47% of the countries mainland. Different forms of forest vegetation occupy 24.028 km², which is 42% of the mainland area. The forest property not covered with growth category has a size of 2.084 km², non-productive forest property not covered with growth (forest tracks, trails, etc). amounts 329 km² and infertile property 445 km², [6]

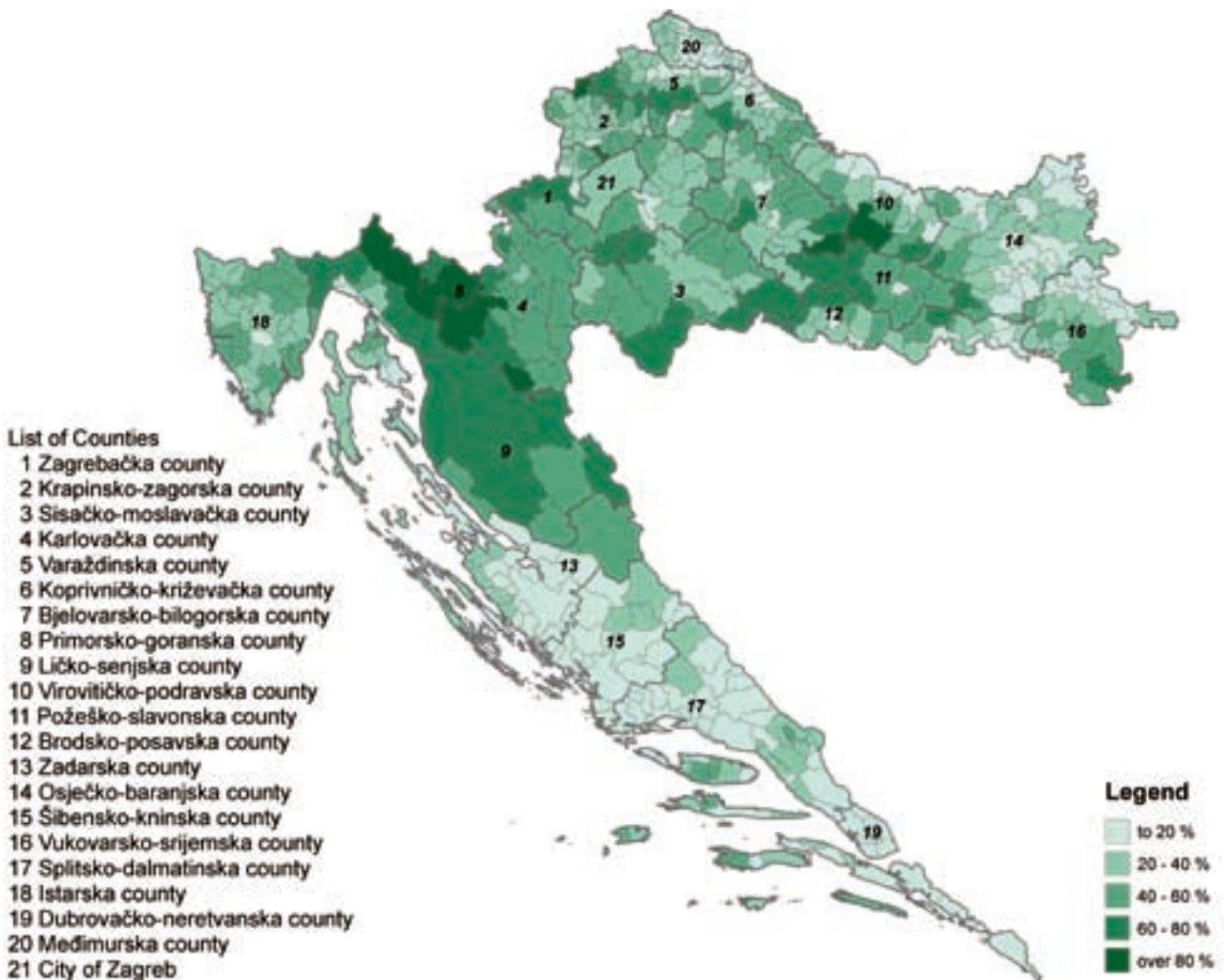


Figure 3.1 Share of woodlands in municipalities / towns

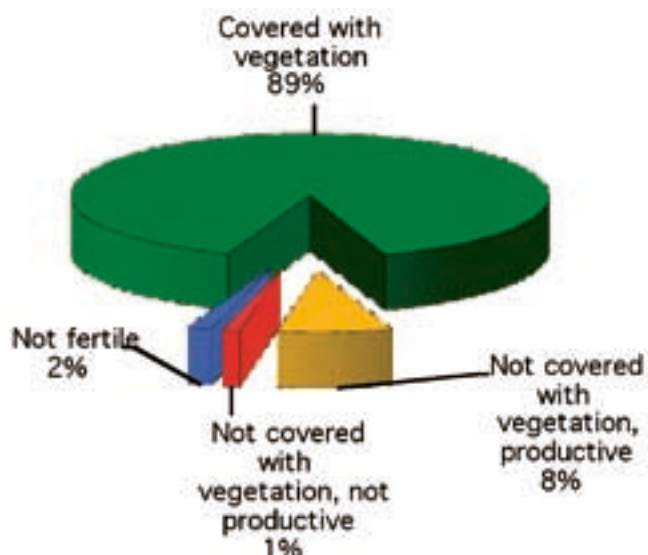


Figure 3.2 Share of different forest property categories in total forest management plan area, [6]

Republic of Croatia owns 21.069 km² of forest and forest property, which is 78% of the total area. Companies manage 20.190 km² of state-owned forests and forests lands, while state administration bodies and legal persons founded by the Republic of Croatia use 879 km².

Private forest owners manage 5.818 km² of forests and forest property, which is 22% of total forest and forest property size.

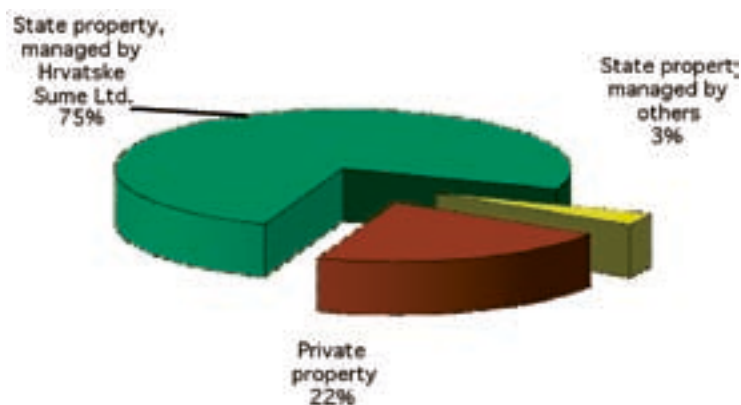


Figure 3.3 Ownership structure of the Forest management plan, [6]

According to Forest Law, forests according to their purpose can be categorised into the following: economic, conservation, and special purpose forests. Economic forests, along with preservation and improvement of their generally beneficial functions can be used for production of wooden products. Conservation forests can be used for protection of land, waters, settlements, objects and other property. Special purpose forests are:

- Forests and forests parts registered for forest seed production;
- Forests within protected area of natural values protected under nature conservation regulations;
- Forests intended for scientific research, school, defence and other purposes according to special regulations.

Economic forests and forest properties occupy 24.161 km², which is 90%, conservation forests occupy 1.545 km² (6%) and special purpose forest occupy 1.180 km², which is 4% of total forest area and property.

In nature parks there is 2.960 km² of forest and forest properties where there are 2.312 km² of economic forests, 526 km² of conservation forests and 122 km² of special purpose forests.

According to Forest management plans, forests and forests lands in nature parks, unless pre-classified into conservation forests or special purpose forests, are classified as economic forests. Pursuant to the Article 14 of the Forest Law, the forests within protected areas will be classified as special purpose forests, which will be carried out during forest management plan revision. Following the implementation of this regulation, the special purpose forests will have 13% share in total forest and forest property size.

According to the Forest Ordinance (O.B. 111/06) the constituents are classified by silvicultural form and type of origin into: high silvicultural form constituents (seedlings), low silvicultural form constituents (chucks), degraded constituents (coppice, maquis, garrigue, scrub), cultures and plantations.

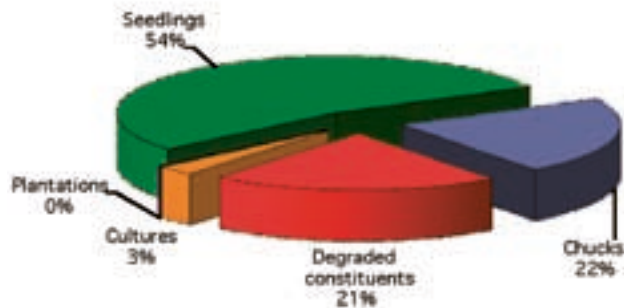


Figure 3.4 Different silvicultural share in total area of the forest management plan covered with growth, [6]

Degraded forest constituents consist of copsewood, maquis, garrigue, and scrubland. Management of these constituents consist mainly of implementation of protective measures preventing further degradation and stimulating succession toward higher silvicultural forms. There are no prescribed cuts or silvicultural works for these constituents so the energy wood potential is not shown for them.

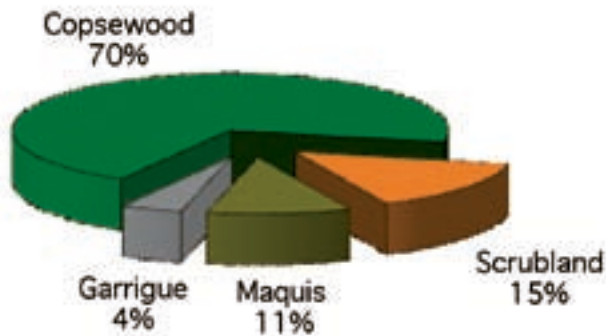


Figure 3.5 Different degradation status share in total area of degraded constituents on the level of the forest management plan size, [6]

According to conditions of use, main part of economic forests (71%) in Croatia fall into the most favourable class (slope less than 30% and average attraction distance less than 400 m).

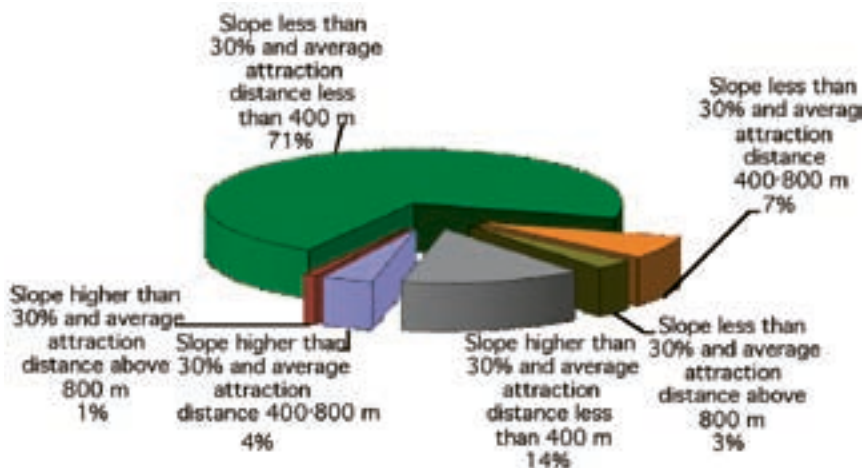


Figure 3.6 Different forest class share according to conditions of use in the Republic of Croatia, [6]

Growing stock, yield-growth and allowable cut

Total Croatian growing stock is 398 million m³, out of which 302 million m³ are state-owned forests managed by Hrvatske Šume, d.o.o., more than 78 million m³ are privately owned and 17 million m³ are state-owned but managed by other legal subjects, [6].

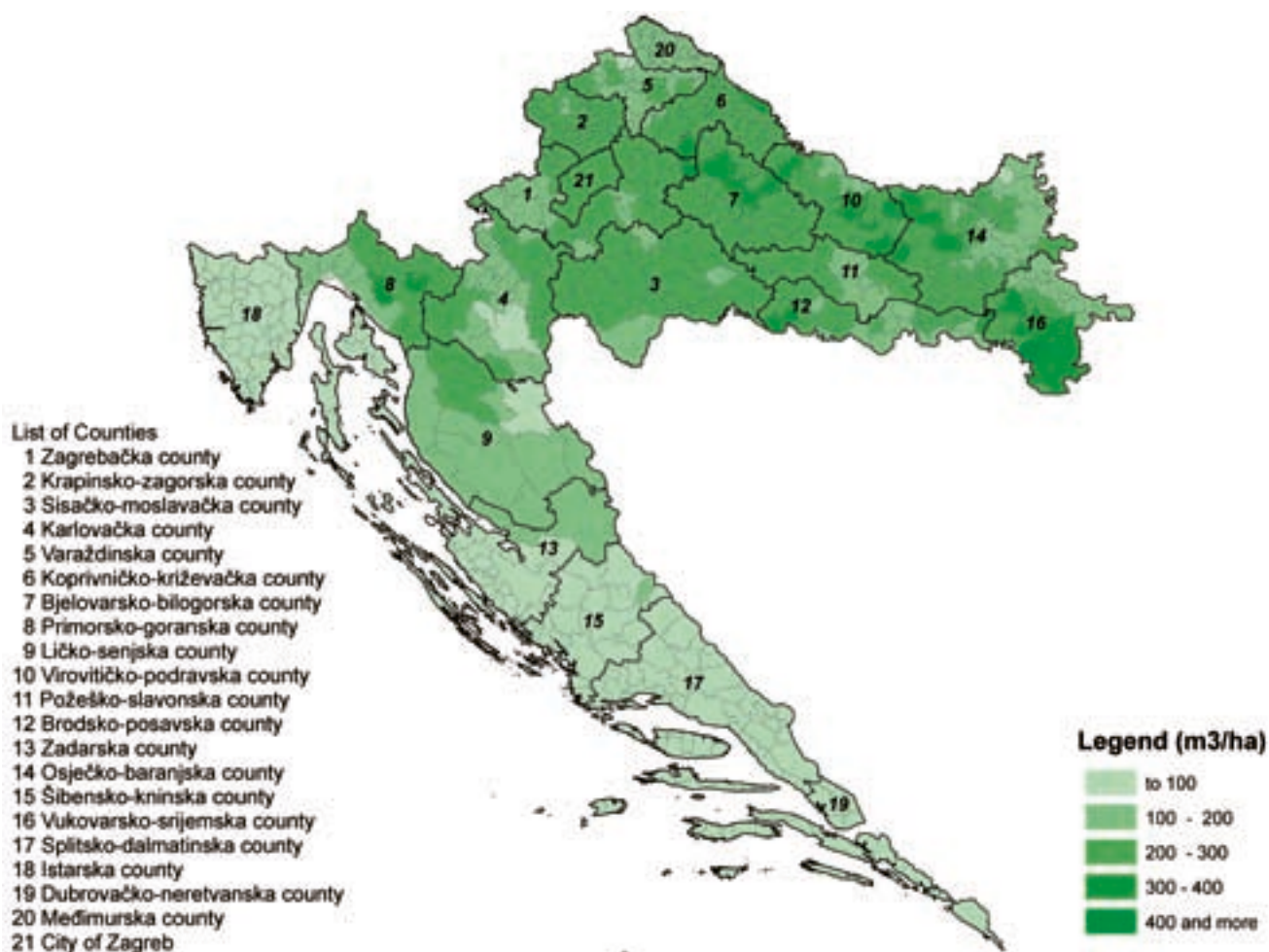


Figure 3.7 Average growing stock per hectare in municipalities / towns

Annual growth-yield of growing stock on the level of forest management area is 10.5 million m³, out of which 8 million m³ is in state-owned forest managed by Hrvatske Šume d.o.o., 2.1 million m³ is in privately-owned forests and approximately 0.4 million m³ in other state forests.

Annual growing stock growth-yield percentage for forests managed by Hrvatske Šume d.o.o., is 2.6%, for other state-owned forests is 2.4%, for privately owned forests 2.7% and total per area level is 2.6%.

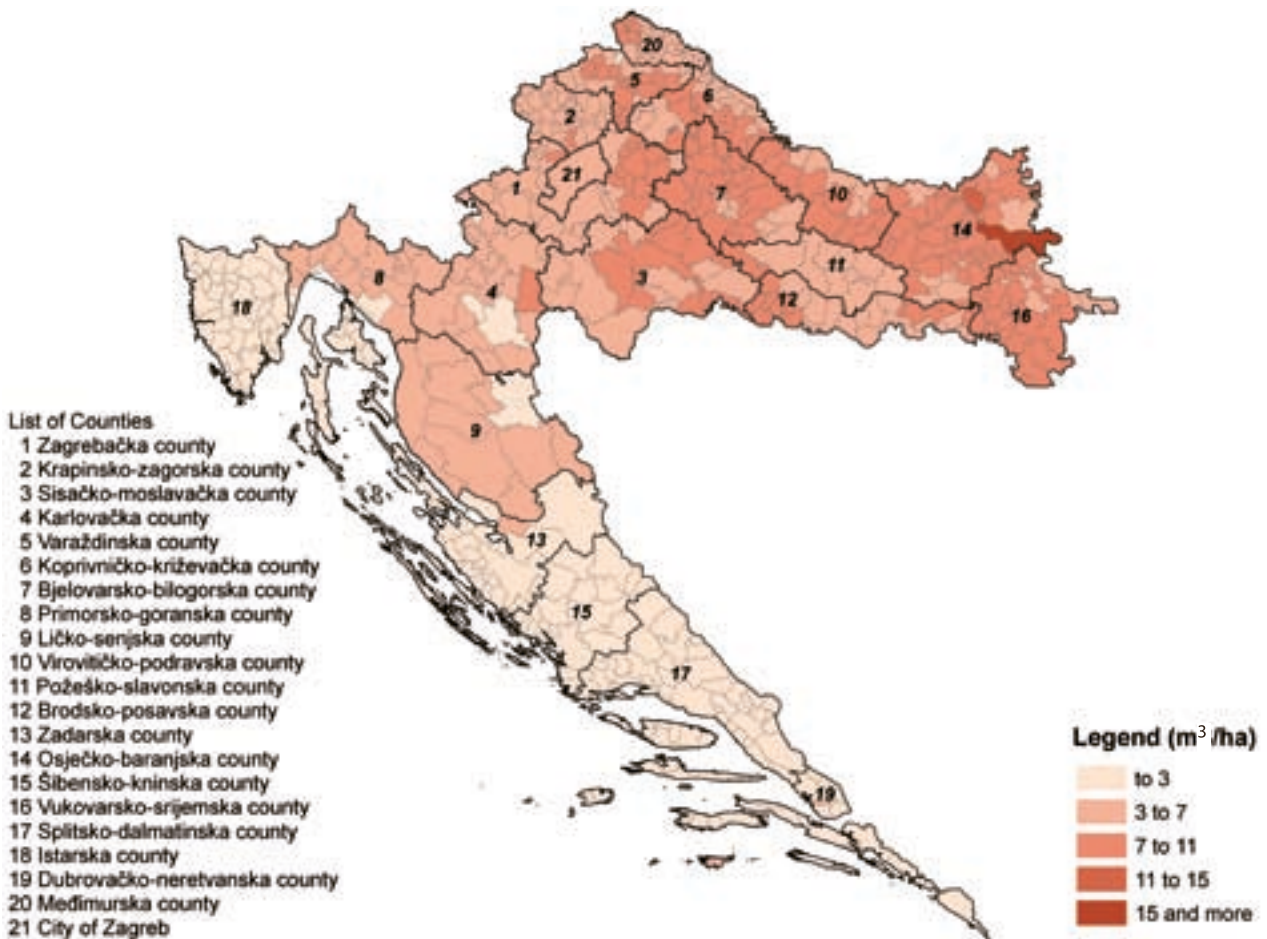


Figure 3.8 Average annual growth-yield per hectare in municipalities / towns

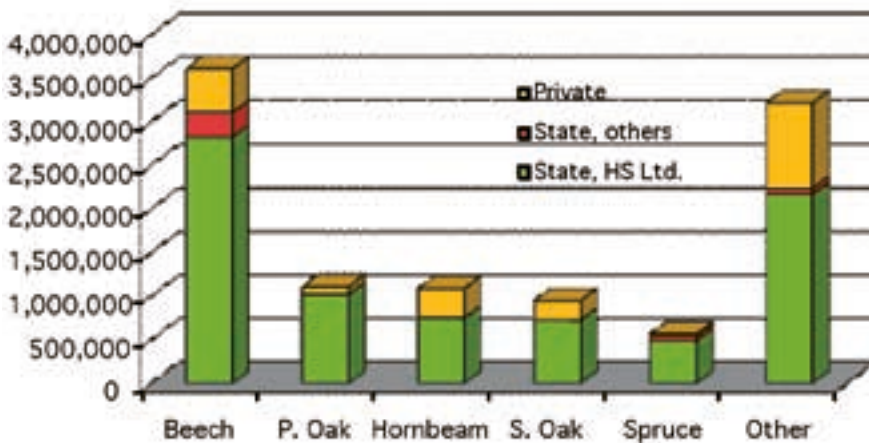


Figure 3.9 Annual growth-yield - main types of trees (m³), [6]

Overall ten year allowable cut on the forest management plan area is 65.6 million m³, out of which 57.9 million m³ are state forests managed by Hrvatske Šume d.o.o., 7 million m³ are private forest owners and the rest of 0.7 million m³ are other state forests.

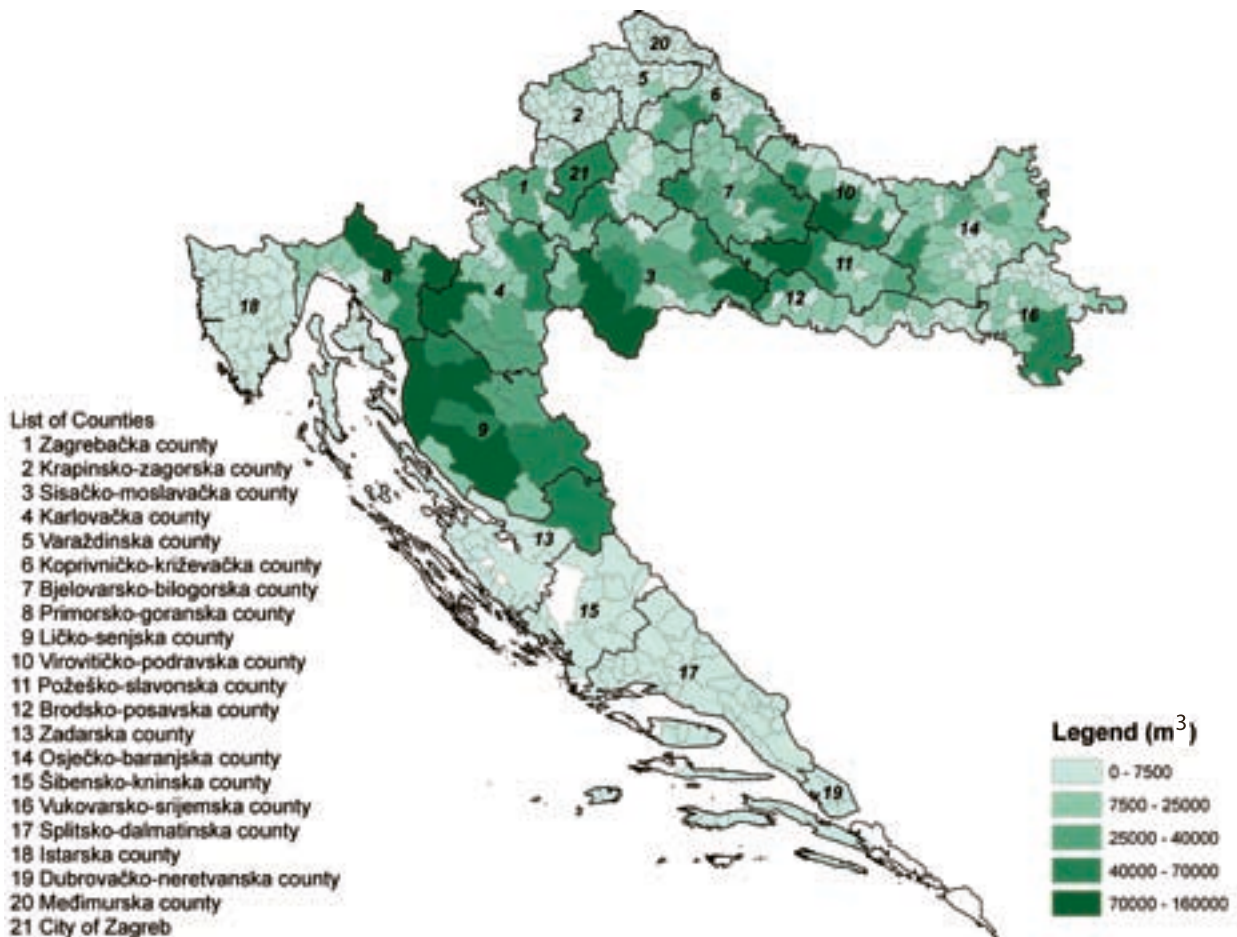


Figure 3.10 Average annual allowable cut per municipalities / towns for the period from 2006 to 2015

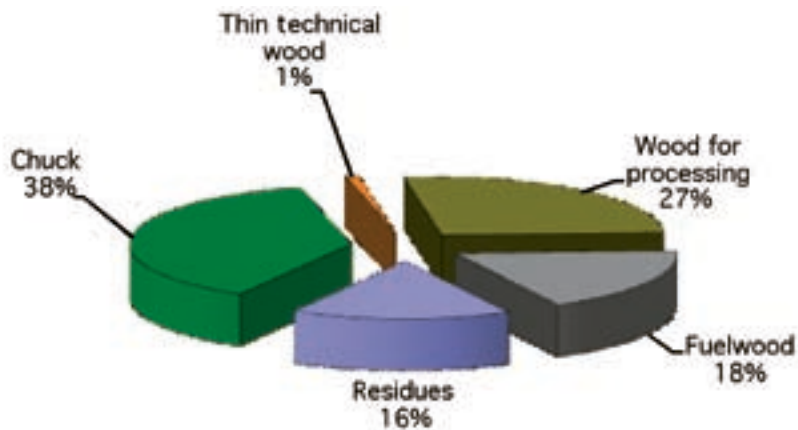


Figure 3.11 Structure of planned allowable cut per main groups of assortment for all forests in the Republic of Croatia, [6]

Changes in forest area, growing stocks and growth-yield

This study does not take into account changes in forest area, growing stock and growth-yield on the level of spatial units (municipalities / towns). Comparing the forest status data according to Forest Management Plan of 1996 and 2006 it is possible to notice positive shifts on the national level. Total area of forests and forests lands, according to 2006 status, has increased for 203.077 hectares compared to 1996. Increase of forest and forest land size is evident in all ownership categories, but it is the most significant in the class of privately owned forests (120.634 ha).

Observing the classes of forest purposes, economic, i.e. multi-purpose forest have increased on national level for 74.625 ha, which is the result of the privately owned economic forests increase for 117.190 ha and decrease of size of the economic forests managed by Hrvatske šume, d.o.o., for 40.004, and decrease of size of the state owned economic forests managed by other legal persons for 2.558 ha.

The size of forest land covered with growth has increased for 324.493 ha on the forest management plan area. The increase of forest property covered with growth size is evident in all ownership classes, as follows: state-owned forests managed by Hrvatske šume, d.o.o. - 155.016 ha; state-owned forests managed by other legal persons – 48.140 ha and privately-owned forests 121.337 ha. This increase is determined by inventories conducted over the last 10 years and inventories of space with the application of remote research methods conducted for the purpose of drafting of Forest Management Plan in 2006. These inventories classified significant part of forests on the area of Forest Administration Split, which were classified in productive land not covered with growth according to previous Management Plan, have now been classified as forest property covered with growth with different status of degradation.

Compared to 1966, growing stocks on national level have increased for 73.7 million m³. The largest increase is evident in privately-owned forests - 40.3 million m³, followed by state-owned forests managed by Hrvatske šume, d.o.o. – 24.1 million m³ and state-owned forests managed by other legal persons – 9.3 million m³.

Taking into account that significant changes in size took place in state owned forests used by other legal persons and privately owned forests the data per types of trees in those categories are not comparable.

In state-owned forests managed by Hrvatske šume, d.o.o. the largest relative increase of growing stocks is realised for spruce (22%), narrow-leaved ash (16%), beech and hornbeam (11%), sessile oak (6%), pedunculate oak (4%). Growing stock of fir has decreased for 1% during last 10 years.

Table 3.1 Comparison of growingstocks in 1996 and 2006 on national level, [6]

Type of tree	COMPARISON OF WOODEN STOCKS IN 1996 AND 2006											
	Republic of Croatia Hrvatske šume			Republic of Croatia others			Forest owners			Total		
	1996.	2006.	Difference	1996.	2006.	Difference	1996.	2006.	Difference	1996.	2006.	Difference
	000 m ³											
Pedunculate	43.307	45.034	1.727	229	238	9	823	3.368	2.546	44.359	48.640	4.281
Sessile oak	26.980	28.728	1.748	144	109	-35	5.113	9.573	4.459	32.237	38.410	6.172
Beech	101.992	113.191	11.199	4.638	11.238	6.600	11.046	18.916	7.870	117.676	143.345	25.669
Narrow leaved ash	10.089	11.793	1.704	43	75	32	108	894	787	10.239	12.762	2.523
Hornbeam	20.875	23.242	2.367	97	76	-21	3.778	13.022	9.245	24.750	36.340	11.590
Abies	28.133	27.840	-293	1.594	2.942	1.348	648	624	-23	30.374	31.406	1.032
Spruce	5.414	6.622	1.208	584	1.325	741	9	602	593	6.007	8.549	2.542
Other species	41.535	45.969	4.434	576	1.242	666	16.504	31.301	14.797	58.614	78.512	19.897
Total	278.324	302.417	24.094	7.905	17.245	9.340	38.028	78.301	40.273	324.256	397.963	73.707

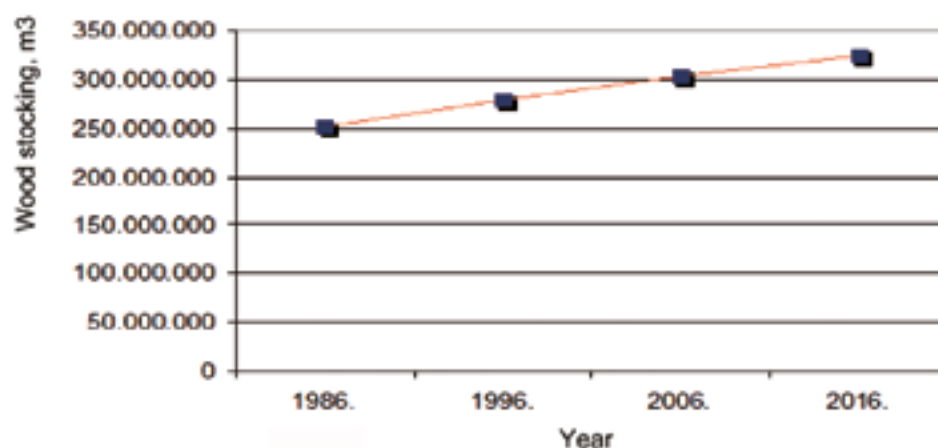


Figure 3.12 Growing stock movements in forests managed by Hrvatske šume d.o.o. in the period 1986-2016

On the national level the annual growth-yield of growing stock has increased for 883 thousand m³ which is the result of privately owned forests growth-yield of 792 thousand m³ and other state-owned forests for 254 m³, and decreased growth-yield in state-owned forest managed by Hrvatske šume d.o.o. for 163 m³.

The decrease of growth-yield in national forests managed by Hrvatske šume d.o.o. is a direct consequence of valuable forests transfer into other state-owned forests categories (expansion of national parks), degree of damage and deterioration of main tree types (fir, pedunculate oak, sessile oak).

Table 3.2 Comparison of annual growth-yield in 1996 and 2006, [6]

Type of tree	State owned managed by Hrvatske šume d.o.o.			State owned managed by other legal persons			Privately owned forests			Forest Management Plan area		
	Status 2006.	Status 1996.	Difference	Status 2006.	Status 1996.	Difference	Status 2006.	Status 1996.	Difference	Status 2006.	Status 1996.	Difference
	m ³											
Beech	2.823.438	2.825.709	-2.271	285.007	89.013	195.994	499.788	387.205	112.583	3.608.233	3.301.927	306.306
Pedunculate oak	1.016.081	1.004.199	11.882	4.505	3.821	684	85.567	32.341	53.226	1.106.153	1.040.361	65.792
Hornbeam	746.738	756.745	-10.007	2.605	2.481	124	337.826	163.319	174.507	1.087.169	922.545	164.624
Sessile oak	720.284	833.149	-112.865	2.505	3.239	-734	224.229	161.648	62.581	947.018	998.036	-51.018
Fir	490.645	539.108	-48.463	55.675	33.822	21.853	18.744	15.411	3.333	565.064	588.341	-23.277
Other species	2.163.100	2.164.586	-1.486	71.213	35.366	35.847	978.288	591.955	386.333	3.212.601	2.791.907	420.694
Total	7.960.286	8.123.496	-163.210	421.510	167.742	253.768	2.144.442	1.351.879	792.563	10.526.238	9.643.117	883.121

3.1.2 Non-forest land

According to the methodology given in the previous chapter, 23 categories of non-forest lands and their sizes were displayed (Table 3.4). Total area of all categories which can be used as energy wood, to a certain extent, amounts 205.065 ha. Analysis of the non-forest lands categories in counties (municipalities / towns) has showed that the largest share of those properties is in Šibenik-Knin County. Share of non-forest lands in municipalities is given for this county (Figure 3.13). Taking into account that analysis of growing stocks and growth-yield categories, i.e. usage of properties has not been conducted yet, the results presented in this study can only include total, rough estimate of growing stocks, annual growth-yield and energy wood production according to given categories.

According to the results of previous studies, including the WISDOM Study Slovenia (FAO, 2006) average growing stocks of biomass for non-forest lands amounts 15.5 m³/ha, and the annual growth 0.53 m³/ha. Based on these data it is estimated that the total growing stocks of biomass for the non-forest lands in Croatia amounts 3.2 million m³, and annual growth-yield amounts 108 thousand m³. Possible production of energy wood is estimated to 75 thousand m³ (with the use of 70% of the annual growth-yield).

Table 3.3 Overview of non-forests land sizes in Croatia, per categories

LUSE_CODE	LUSE_NAME	Size, ha
1122	Built areas with infields	6.537
2211	Vineyards	18.448
2221	Orchards	6.937
2222	Orchards/olive groves	15.061
2231	Olive groves	2.377
2232	Olive groves/orchards	613
2421	Public non-productive cultivated green areas	14.574
2422	Mosaics of cultivated areas with individual houses	46.254
2432	Agricultural properties with significant share of natural vegetation and prevailing grasslands	5.382
2433	Agricultural properties with significant share of natural vegetation and single trees and bush	4.338
2441	Agricultural and forests areas	3.126
3112	Broadleaved species plantations	199
3113	Groups of trees / small trees	1.115
3121	Conifer plantations	3.672
3211	Natural grasslands mostly without trees and bush	152
3212	Natural grasslands with trees and bush	1.659
3222	Sub-mountain mugo pine	11
3231	Stone pastures / scrublands	3.056
3240	Scrublands /olive groves	1.512
3241	Scrublands	34.888
3242	Scrublands / natural grasslands	29.768
3243	Hedges and bush-like vegetation	5.355
3245	Bush-like vegetation	29
Total		205.065

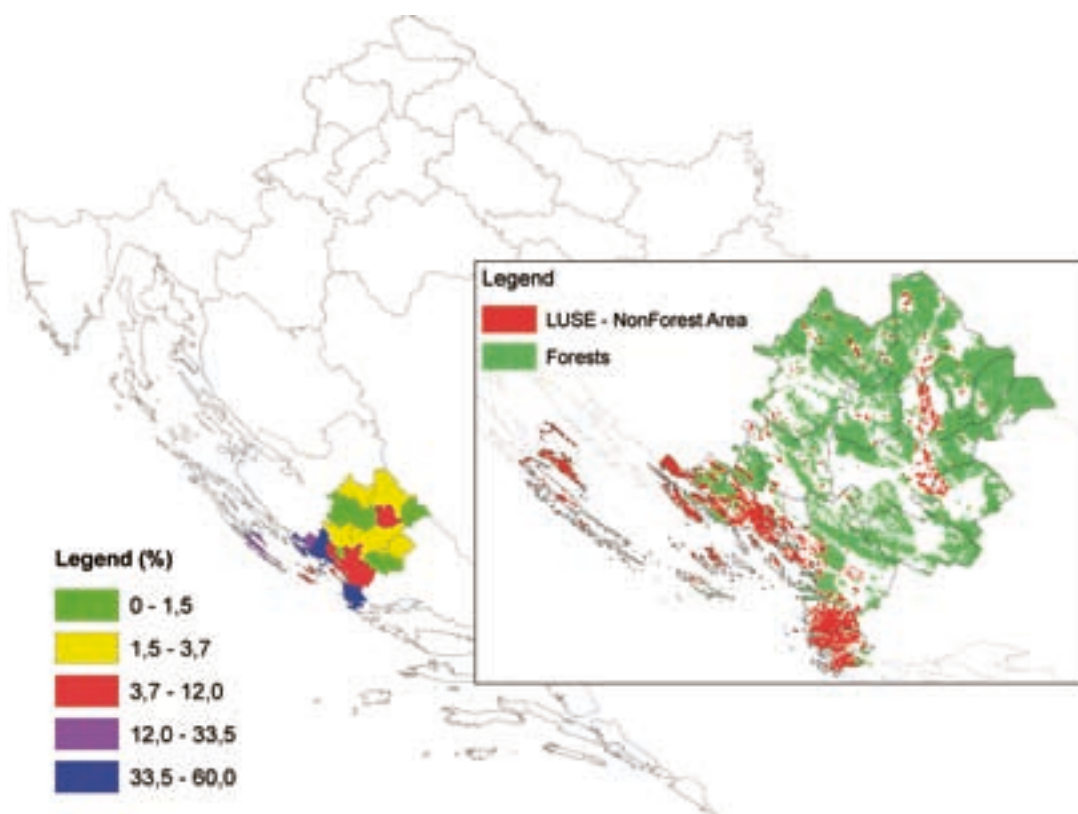


Figure 3.13 Spatial share of non-forest lands for Šibenik-Knin county municipality / town level

3.1.3 Wood residues

The basis for the estimation of wood residues was the database obtained from the Croatian Ministry of Agriculture, Forestry and Water Management regarding the quantities of timber supplied to wood processing companies. The database includes all registered companies working within the wood processing sector in Croatia and contains data on supplied quantities of timber for four main species of forest: oak, ash, beech and fir.

In order to estimate the available quantities of wood residues which remain after the wood processing it was necessary to assume the efficiency of the processing, for which data from relevant literature have been used, [7]. Specifically, the available data include the percentage of the average log yield with classic sawmilling technology in Croatian sawmills for the four main wood species mentioned above. Some impartial data regarding the efficiency of wood processing in companies other than sawmills was also available, however the database of companies within the wood processing sector does not include a specification regarding the type of company. Hence a conservative assumption was made in the form that for all companies within the database the percentage of average yield corresponds to the sawmilling one. The total quantities of residues have been estimated at 413.400 m³/y giving an equivalent of 287.400 t/y, while the Figure 3.14 below shows the distribution of this quantity at the settlement level.

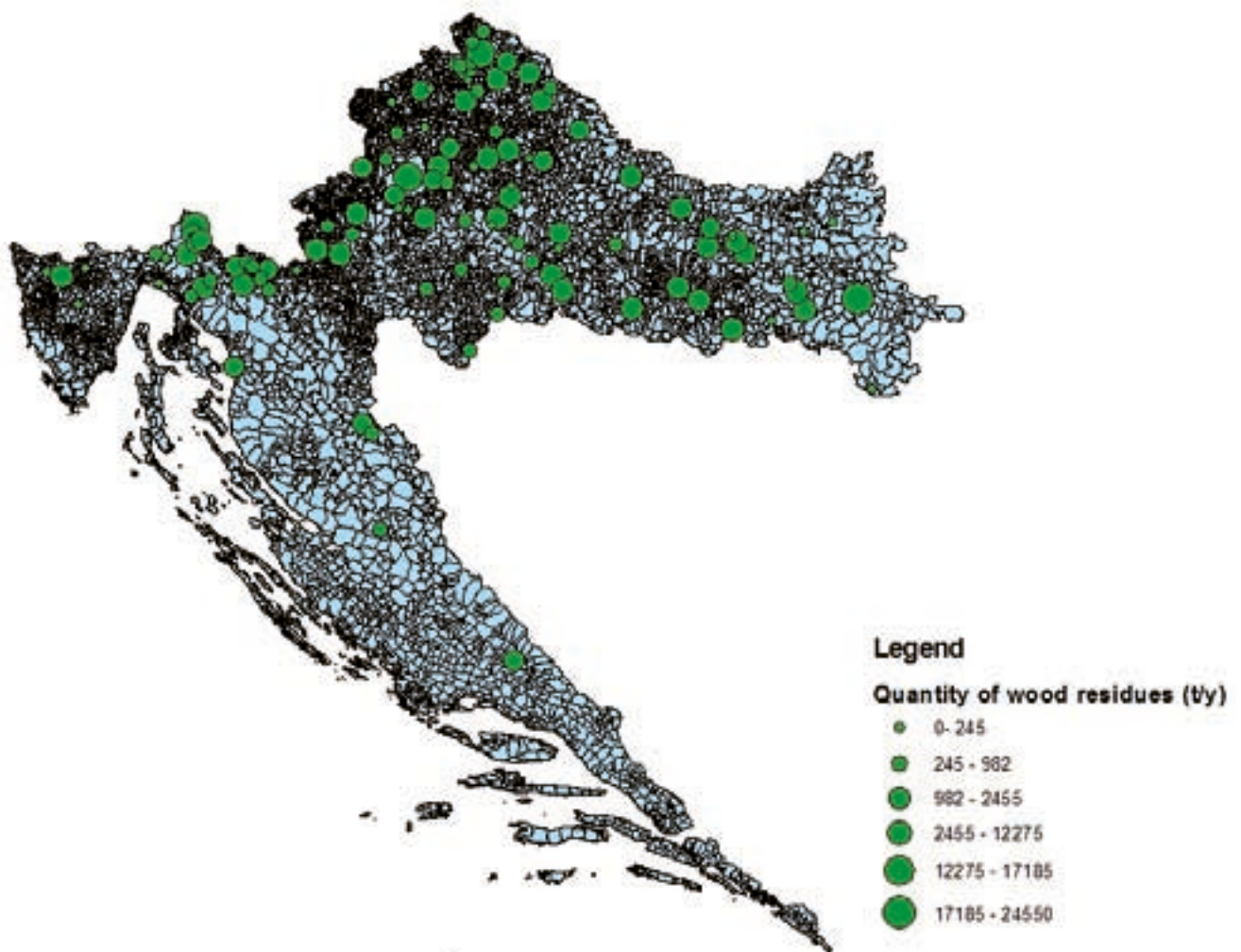


Figure 3.14 Distribution of the quantity of wood residues at the settlement level

3.2 DEMAND MODULE

3.2.1 Household consumption

Currently the majority of fuelwood in Croatia is consumed within the household sector primarily for space heating. According to data for 2006 fuelwood contributes with approximately 4% to the total primary energy supply, [7]. However, apart from the estimated total consumption on the national level, reliable statistics on fuelwood consumption at municipality levels were not available.

In order to fill this information gap, consumption estimates for the municipalities level have been produced. The main data source used was the information available from the Central Bureau of Statistics which includes the number and surface of occupied dwellings that use wood as exclusive or primary fuel for space heating.

In addition, an estimation had to be performed for the following variables:

- Energy requirements for house heating (MJ/m²);
- Additional energy requirements for cooking and water heating (MJ/m²);
- Energy conversion factors, average wood energy contents and conversion efficiency.

Figure 3.15 shows the estimation of the saturation of fuelwood use for space heating on the municipalities level, based on census data.

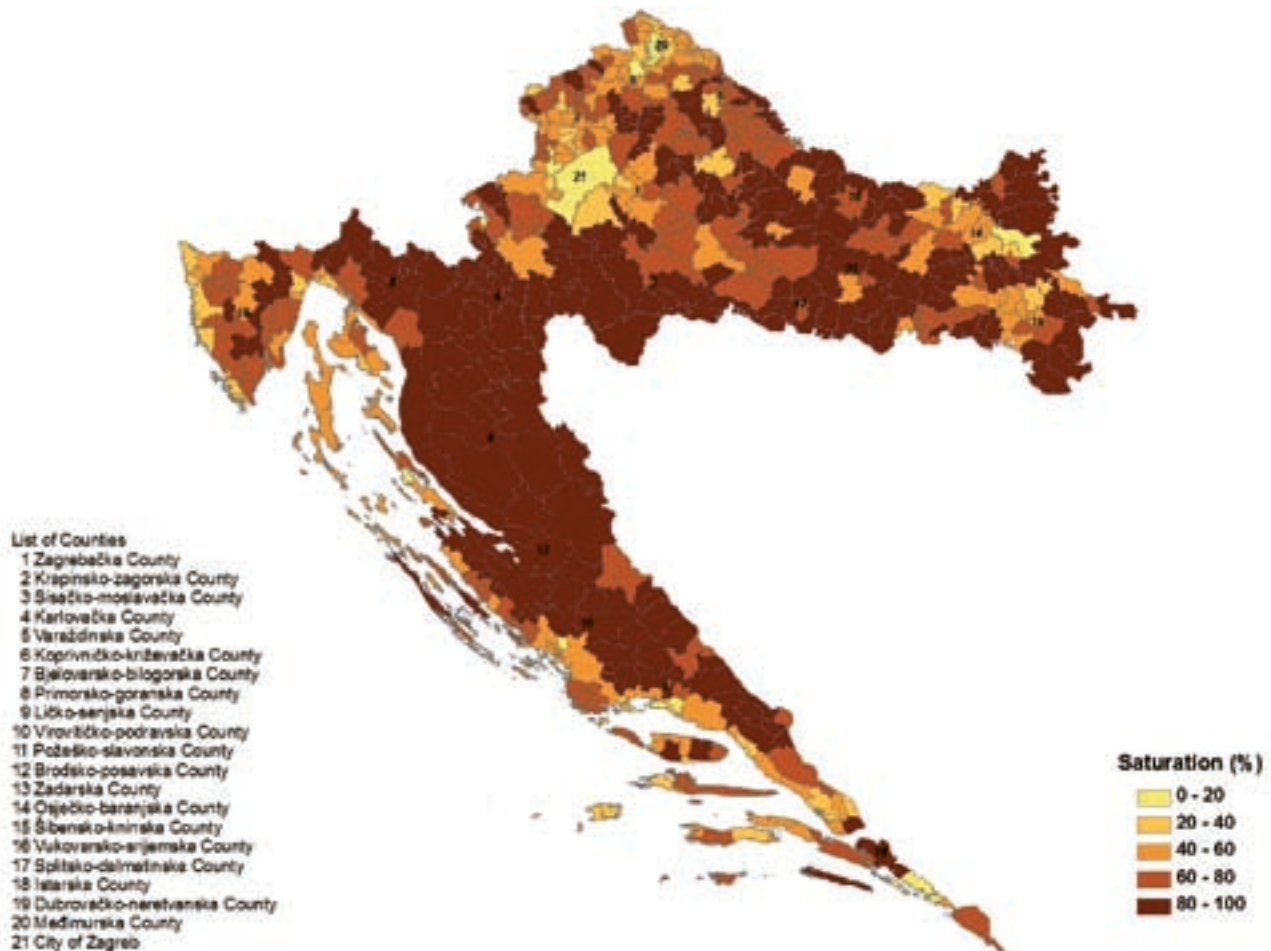


Figure 3.15 Saturation of fuelwood users (fraction of the dwelling using primarily or exclusively fuelwood for space heating)

In order to estimate the energy requirements for house heating Croatia was divided into four climatic regions. For each region a different energy requirement multiplier in the form of final energy per total dwelling area was used. In order to obtain the energy consumption the total dwelling area is multiplied by the energy requirement, which can afterwards be converted into tonnes or cubic meters of consumed fuelwood. The main results are summarized in the Table 3.5 below.

Table 3.4 Estimated energy and wood fuel requirements for space heating, water heating and cooking in Croatian households

	kWh/m ²	MJ/m ²	m ³ wood/m ²	twood/m ²
Energy requirements per m ²	115	415	0.061	0.044
Estimated energy/wood consumption by dwellings using wood as exclusive or primary fuel (referring to the actual heated fraction)				
	GWh	TJ	m ³ wood	twood
Total Croatia Estimated heated surface: 47,953,000 m ²	5,533	19,917	2,935,072	2,117,101
	kWh/dw	MJ/dw	m ³ wood/dw	twood/dw
by dwelling 659,419 dwellings	8,390	30,203	4.45	3.21
	kWh/inh	MJ/inh	m ³ wood/inh	twood/inh
by inhabitant 2,097,177 inhabitants	2,638	9,498	1.40	1.01
Assumed wood energy efficiency = 65% = 1885 kWh/m ³				

The spatial distribution of fuelwood consumption per inhabitant for space heating, water heating and cooking in Croatian households is shown in Figure 3.16. The subdivision into the four climatic regions is rather clearly visible on the figure by the abrupt changes in fuelwood consumption between neighboring counties, especially for the north-western and north-eastern Croatia. In order to further refine the estimates on household consumption it would be necessary to include data on climatic variations and length of heating seasons at the county level. However, these data are not available at the moment.

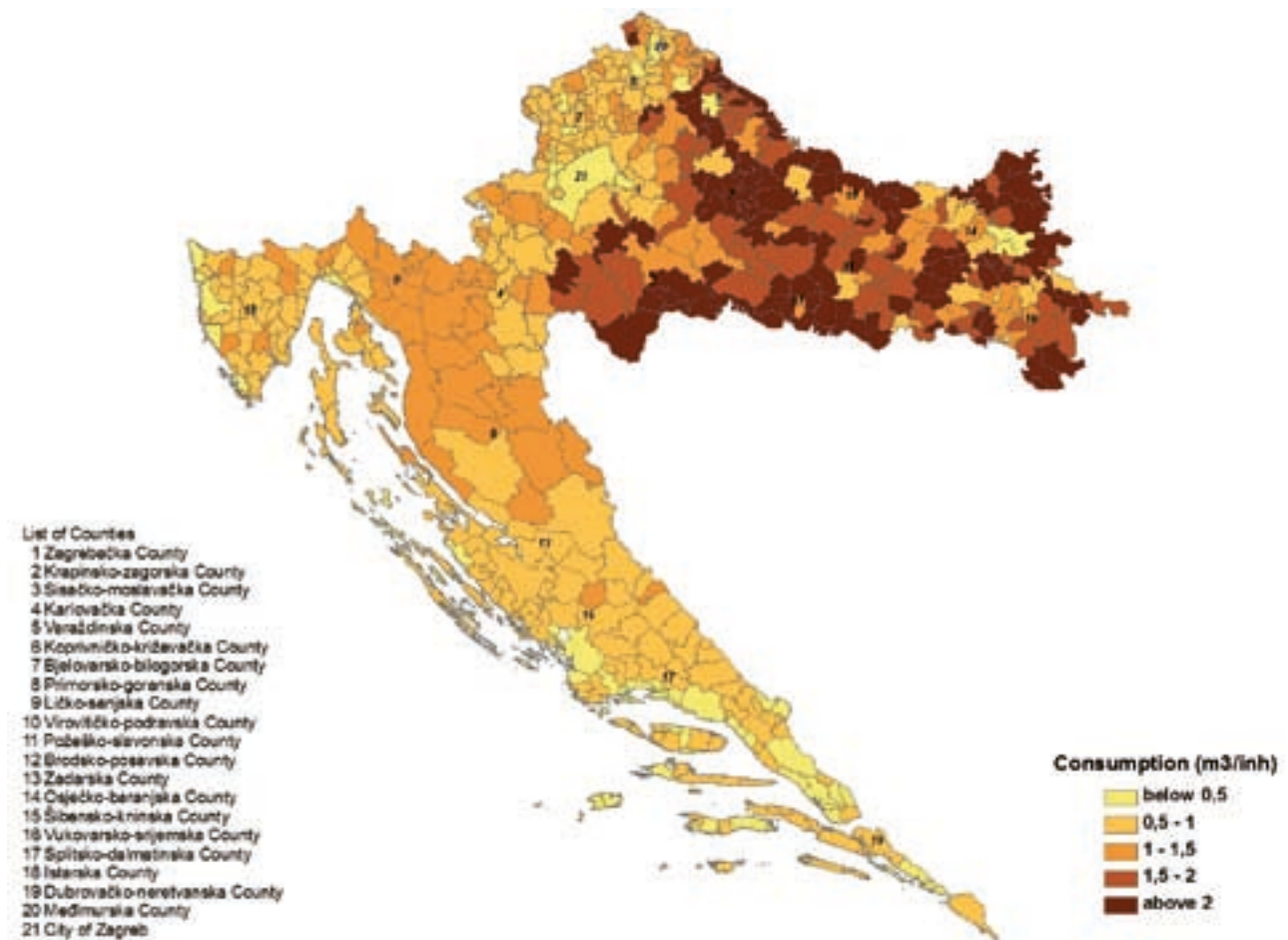


Figure 3.16 Fuelwood consumption per inhabitant by Croatian households

3.2.2 Industrial consumption

Prior to the start of the work on this study the information on industrial wood energy consumption was available only in aggregated form at the national level and hence it was of very little use. Consequently, considerable efforts were made in order to obtain relevant information in the form which can be useful. Based on the already mentioned database from the Croatian Ministry of Agriculture, Forestry and Water Management, which includes all registered companies working within the wood processing sector in Croatia, three rounds of telephone surveys were performed. The information gathered is structured at the level of settlements and includes the installed boiler capacity and yearly operating hours, which enables to make an estimation of the wood consumption.

After the first round of surveying data about 64 biomass heating plants was collected, which was considered to be considerably less than the actual number of plants in operation. In order to obtain more reliable data a second and third round of surveying was performed leading to the collection of data about 108 biomass heating plants. The total installed capacity of these heating plants amounts to 375.7 MW, whereas the estimated total wood consumption amounts to 1.227.938 m³/year (710.975 t/year).

Figure 3.17 shows the distribution of industrial biomass heating plants in Croatia with five different categories regarding installed capacity.

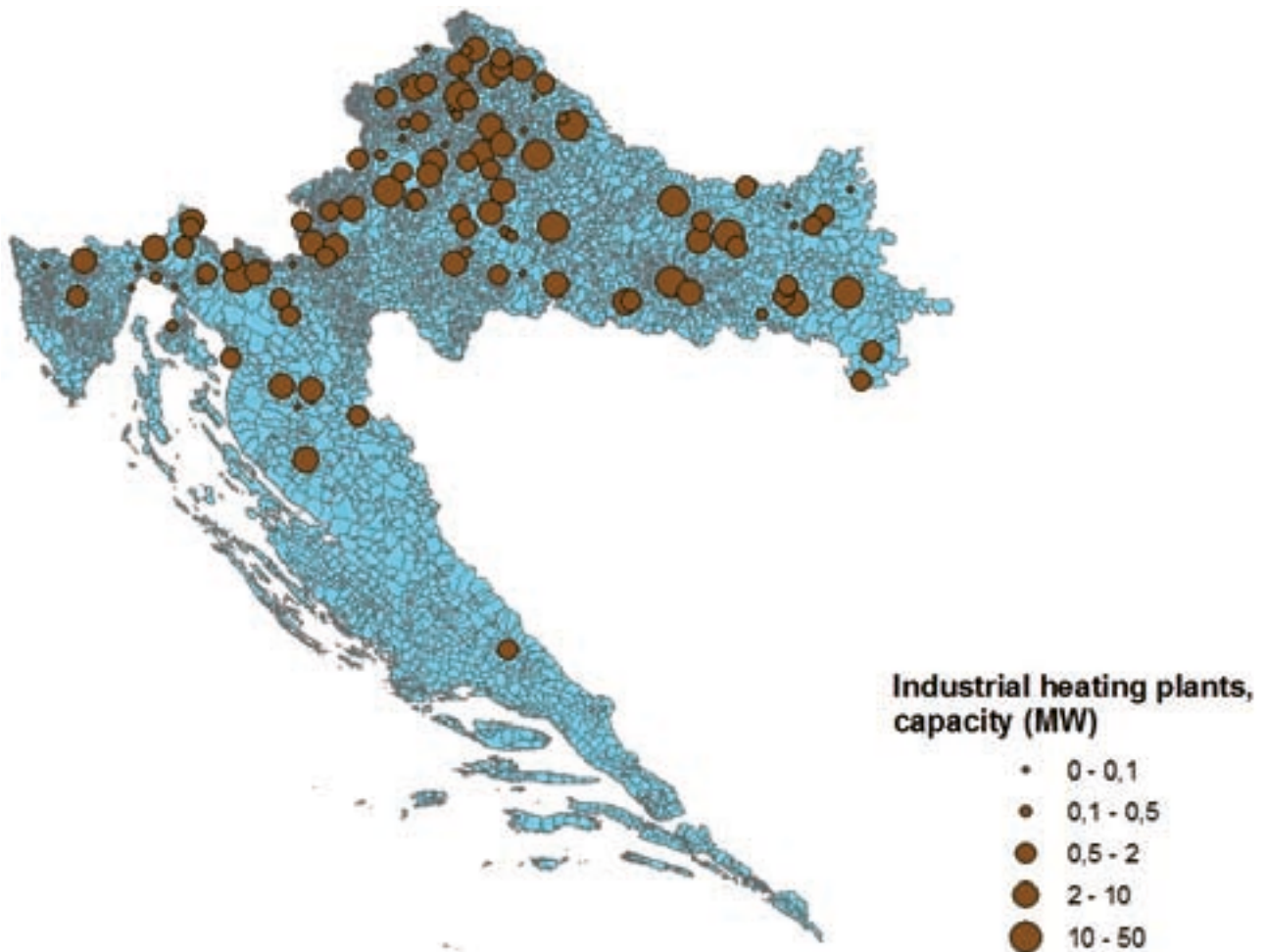


Figure 3.17 Distribution of industrial biomass heating plants in Croatia

3.2.3 Briquettes, pellets and charcoal production

Prior to the start of the work on this study there was relatively little reliable information regarding existing and planned briquettes, pellets and charcoal production. Furthermore, the information was available only in aggregated form at the national level. In order to obtain reliable information in the useful form telephone interviews as well as on-the-field surveys were undertaken. Regarding pellets and briquettes producers, the data collected include plants in operation and near completion (within a year). The total production capacity for pellets amounts to 106.800 t/year and for briquettes 30.800 t/year. However, considering that pellets are still a relative novelty in Croatia and most of the pellets producers started operation within the last year or are planning to start in 2008, only a small part of pellets production capacity is utilised. Briquettes production has a longer tradition in Croatia and in 2006 approximately 20.000 tonnes of briquettes were produced.

Regarding charcoal production, official records recognize only one major charcoal producer located in Belišće, eastern Croatia, which uses retort technology for production. Other sources of information show that there are eight more medium and small charcoal producers in Croatia. They use traditional earth kilns and improved clay kilns production methods, which result in lower conversion efficiency as well as pollution due to the emission of unburnt gasses. A large number of very small private and non-registered producers (approximately 400), located in the area of Zagorje, Kalnik and Našice, produce charcoal in traditional charcoal pits utilising mud for insulation.

3.3 INTEGRATION MODULE

3.3.1 Forest production vs. Households consumption

The analysis of the demand and supply balance between forest production and fuelwood consumption was conducted on municipality / town level. It was conducted based on the data on different assortment groups potential which can be used as energy wood and have other purposes (heating, heating and cooking, heating of water).

The key parameters in the analysis included the following:

- gross allowable cut in management plans vs. gross actual cut for different wood assortments and species groups commonly used as fuelwood;
- gross allowable cut in management plans vs. gross actual cut for different wood assortments and species groups which can be potentially used as fuelwood;
- household fuelwood consumption for heating and total (heating and cooking).

The main results obtained within the integration module are presented on the following figures.

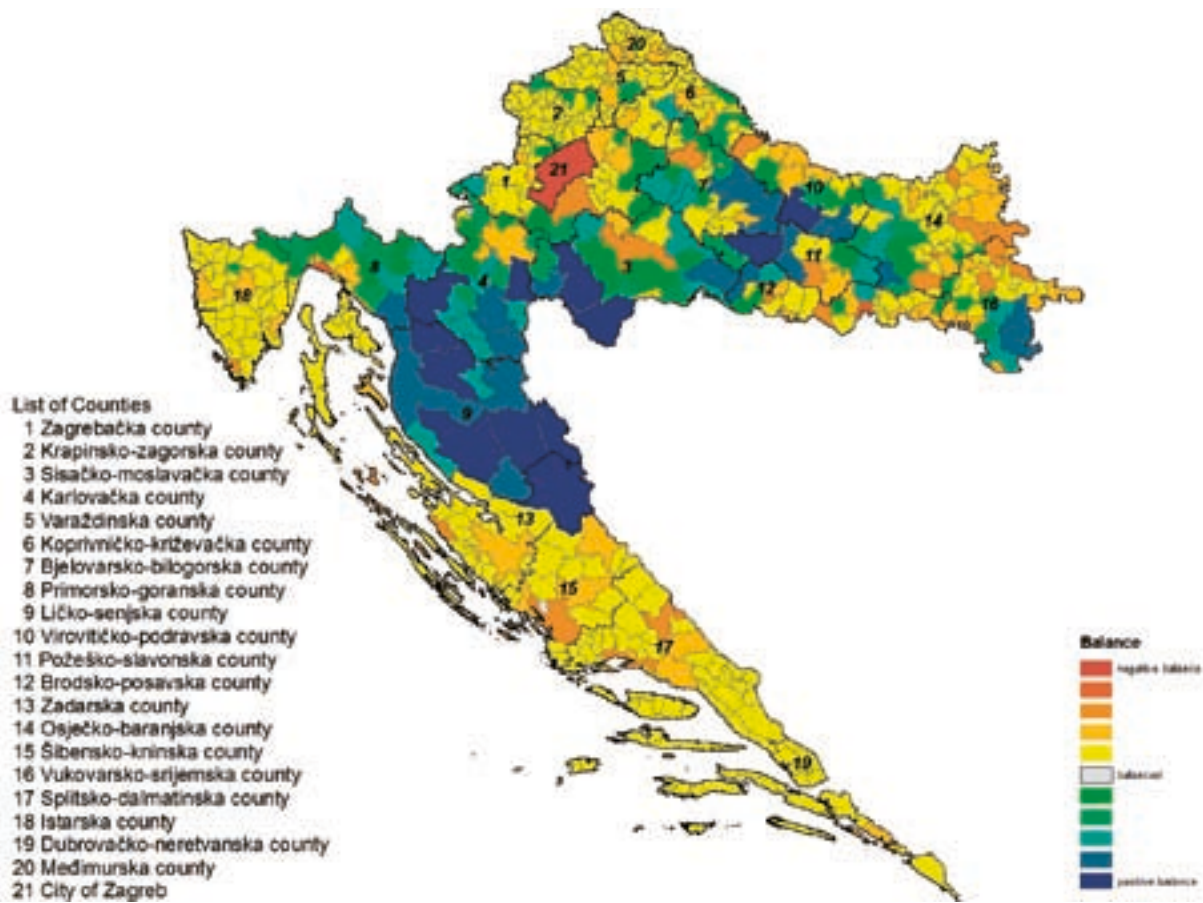


Figure 3.18 Balance of gross allowable volume of preferred non-timber assortments and fuelwood consumption for heating in households

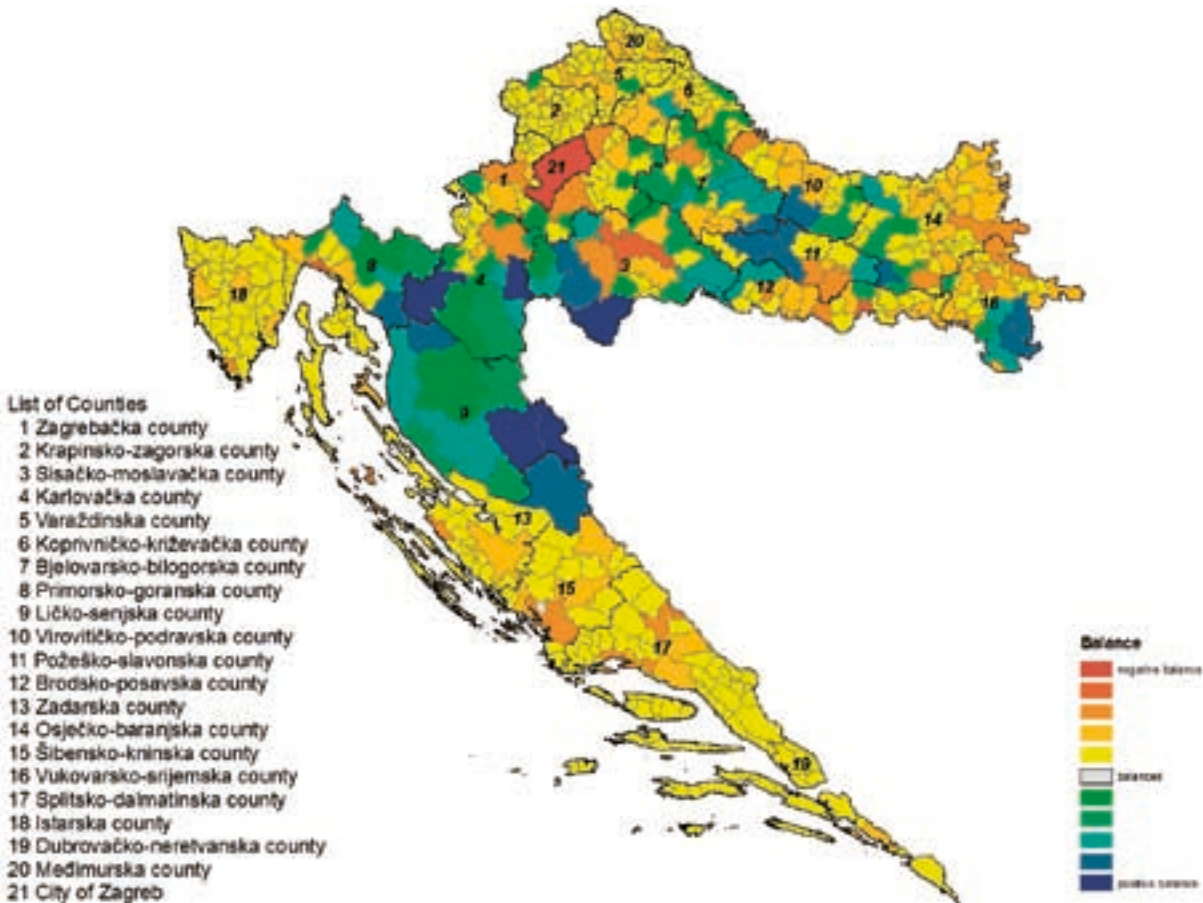


Figure 3.19 Balance of gross actual cut of preferred non-timber assortments and fuelwood consumption for heating in households

3.3.2 Wood residues vs. Pellets production

The analysis of the existing and planned pellet production capacities and the available quantities of wood residues from wood processing industries at the settlement level was performed, the main results are shown in Figure 3.19. The main conclusion which can be drawn from the data presented is that most of the wood residues quantities are located in north-western Croatia, while at the same time in that area there is only one pellet production factory in existence (total capacity of this factory is 10.000 t/y). This indicates the possibility for the establishment of more pellet production capacities in the area, however in order to support this conclusion a more detailed investigation would need to be performed.

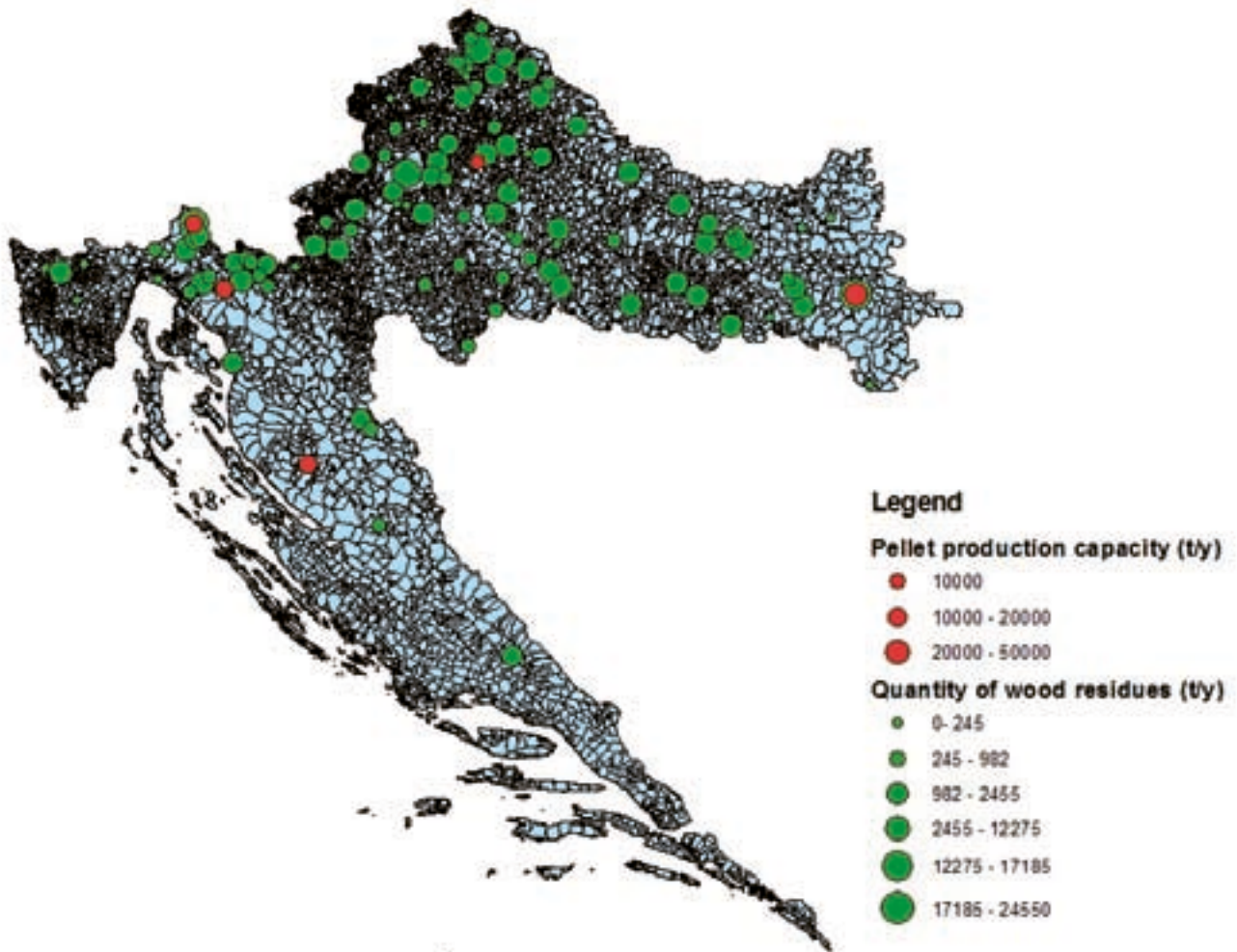


Figure 3.20 Distribution of existing and planned pellets production capacity and quantity of wood residues in Croatia

3.3.3 Total biomass vs. Charcoal production

Figure 3.20 shows the distribution of total biomass availability (sum of wood residues and annual allowable cut of all timber and non-timber assortments) and the locations and capacities of the existing charcoal and charcoal briquettes producers at the municipality level. The total biomass availability was normalized (divided) by the municipality area, and hence is expressed as tonnes per hectare and year. The data regarding the annual allowable cut was available at the municipality level, while the data regarding the quantities of wood residues and the locations and capacities of charcoal and charcoal briquettes producers was available at the settlement level. Consequently, it was necessary to aggregate the data in order to allow its unified presentation on one figure.

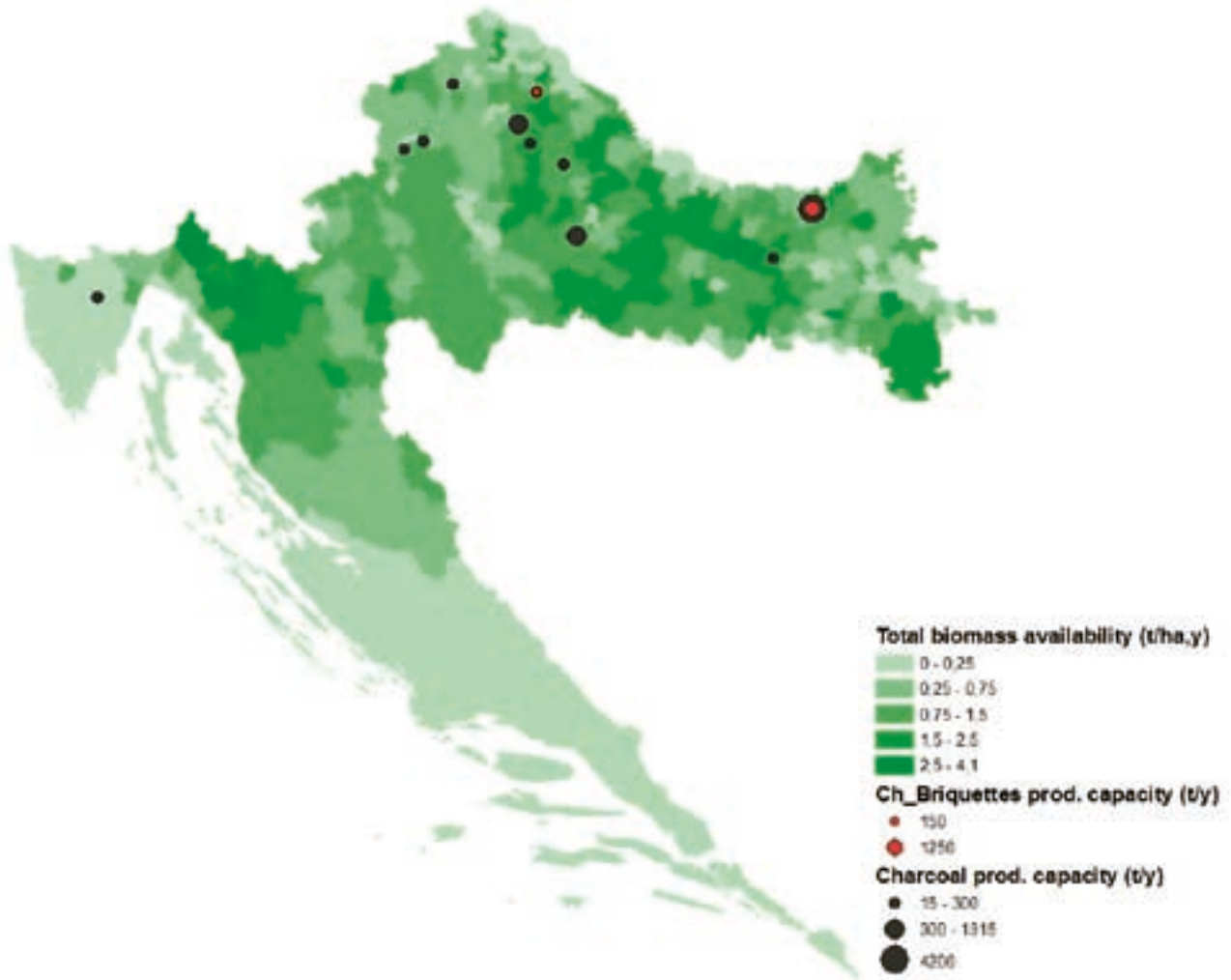


Figure 3.21 Distribution of total biomass availability normalized by municipality area, charcoal producers and charcoal briquettes producers in Croatia

4 CONCLUSIONS AND FURTHER DEVELOPMENT OF WISDOM CROATIA

The WISDOM methodology in Croatia has been implemented within the framework of the FAO TCP/CRO/3101 project Sustainable Development of Charcoal Industry in Croatia. The main part of the implementation was the development of an extensive database incorporating both the supply and demand side of woodfuels in Croatia.

The database is divided into two main modules, namely supply and demand. In order to maintain long-term effectiveness of WISDOM and Croatia WEIS as planning tools, it is recommended that data collection be continued and further developed. The following text provides an overview of the data categories within the two modules and recommendations for data updating.

- **Supply module**, containing the following data categories
 - **Forest biomass availability**, for both state owned and private forests. The data included in this section need to be periodically revised at least once in every ten years, or if necessary after every major change. The first revision and update should be conducted in 2010, and will be based on the comparison of data within the WISDOM database and actual data on gross cut of all timber and non-timber assortments. Special care should be given to data on private forests, as currently only estimates on allowable and actual cuts are available. The Forest Extension Service (founded in 2006 by the Croatian Government) is currently in the process of procuring these data, however due to the very extensive on the field measurements required to obtain the data this process will be completed by 2015;
 - **Non-forest land**. Until recently no data at all existed on non-forest land potential regarding woodfuel supply and for the purposes of this project a rough estimation was performed on wood stocking, annual increment and woodfuel production for different categories. Since no systematic and detailed research on these parameters has been conducted, it is recommended to follow up activities in that direction in order to update the data on non-forest woodfuel supply in two phases:
 - Interpretation/delineation on digital orthophoto (1:5000), which would allow a better differentiation between vegetation cover types within the existing classes based on the Croatia habitats map, [9].
 - On the field measurements on a random sample (included all categories), in order to calculate the average wood stocking and increment, annual wood production for energy for different categories of non-forest land.
 - **Wood residues**. This part of the data was obtained through the estimation based on quantities of timber supplied to companies within the wood processing industry in the year 2006. The data will need to be periodically updated and the first revision is planned in 2009.
- **Demand module**, containing the following data categories
 - **Household fuelwood consumption**. This part of the data is based on the population census from 2001, while the next census will be performed in 2010. This will allow the update with new information especially for parts of Croatia where the gas network was developed (and consequently fuelwood consumption decreased considerably), but also the analysis of the time series for the household sector.
 - **Industrial consumption**, including industrial biomass heating plants as well as pellets, briquettes and charcoal production. The information was obtained through on the field work as well as telephone surveys of wood-processing companies. This information will need to be periodically updated and in most cases more detailed information on wood consumption (ex. type and source) is needed.

The **Integration module** is developed by joining the supply and demand modules and allows for a comprehensive overview of woodfuel balance. The WISDOM analysis has already proved its usefulness in supporting local and national planning in countries where it has been developed.

In Croatia, specific applications in the period after establishing the WISDOM Croatia database include the following:

- analysis of net available biomass (supply minus demand) for charcoal production in Belisce;
- analysis of net available biomass for several biomass district heating systems in various Croatian municipalities and towns (Pokupsko, Slunj, Velika Gorica, Rakovica);
- analysis of biomass supply and demand on county level and inclusion of this information in regional energy strategies for different Croatian counties (Zagreb County, Krapina-zagorje County, Karlovac County and others).

Using the WISDOM geodatabase and integrating it with specific aspects of local relevance, the Croatian Forestry Service or any other subject could provide, without delay, a comprehensive and detailed report enriched by many tables and

thematic maps. The aspect covered in this report included forestry data on wood assortments; their distribution and physical accessibility; productivity in non-forest areas; and analysis of wood consumption for heating in households, charcoal and pellets production and in district heating plants

The knowledge generated by this project has greatly enhanced the capacity of Croatian institutions to deal with wood energy issues and, ultimately, to contribute to the formulation of policies and to the planning of field activities and implementation projects.

Further development options which are being considered for the extension of the WISDOM database in Croatia include the following:

- inclusion of data for other types of biomass (ex. liquid biofuels, agricultural biomass) and availability of land for their production;
- inclusion of data focusing on economic and social aspects of biomass production and utilisation (ex. creation of new employment);
- inclusion of data regarding environmental impact of biomass production and consumption;
- inclusion of data on potential of other types of renewable energy sources (ex. solar and wind energy).

The inclusion of the above mentioned parameters would enable a more comprehensive analysis of the overall energy sector on local/regional as well as national levels.

Most of the problems and opportunities that the wood energy sector presents in Croatia are common to the countries of East and Central Europe. Actions oriented to the development of this sector are clearly needed in these countries and the lessons learned in Croatia represent a useful and potentially replicable experience.

This will represent a significant policy shift with regards to the old view in which biomass was viewed as a non-commercial rural source, or poor man's fuel.

REFERENCES

- [1] DOMAC, J. et al. 2001. BIOEN – National energy programme on biomass and waste, Report on new findings and applications. Energy institute Hrvoje Pozar, Zagreb.
- [2] National Forestry Policy and Strategy of the Republic of Croatia (O.B. 120/03), 2003.
- [3] National Forestry Master Plan of the Republic of Croatia, 2006.
- [4] Masera, O.R., R. Drigo, M. A. Trossero, 2003. Woodfuels Integrated Supply/Demand Overview Mapping – WISDOM. FAO.
- [5] DRIGO, R., KRAJNC, N., VESELIČ, Ž., TROSSERO, M. Area-based woodfuel flow analysis using the WISDOM Approach : a case study for Slovenia. In: Second world biomass conference : biomass for energy, industry and climate protection : proceedings of the World Conference held in Rome, Italy 10 -14 May 2004. Florence: ETA; Munich: WIP, 2004, p. 666-669.
- [6] General Management Plan of Forestry in the Republic of Croatia 2006-2015, Croatian forests Ltd., Zagreb, 2006.
- [7] BREŽNJAK, M., Sawmilling technology (in Croatian) part I, Faculty of Forestry of the University of Zagreb, Zagreb, 1997
- [8] Energy in Croatia 2006, Annual Energy Report published by the Ministry of Economy, Labour and Entrepreneurship, Zagreb, January 2008
- [9] Ministry of Culture (2004): Habitats map of the Republic of Croatia (available only in Croatian - Karta staništa Republike Hrvatske). Developed by OIKON Ltd., Institute for implemented ecology.

ANNEX: LIST OF VARIABLES IN WISDOM CROATIA DATASET

Attribute table of geodatabase with national summary values associated with municipalities (550 records)

Spatial / administrative parameters

Field name	Indicator description	Unit	Total
ZUP_NAZIV	County name	-	-
OG_NAZIV	Municipality name	-	-
OG_MB	Municipality code number	-	-
TOT_Area	Municipality area	ha	5.659.440

Demand related parameters

Field name	Indicator description	Unit	Total
TOT_POP	Total population of municipality	-	4.437.460
URB_POP	Fraction of urban population	-	-
RUR_POP	Fraction of rural population	-	-
INH_PRWF	Number of inhabitants using fuelwood as exclusive or primary fuel for heating	-	2.097.177
SATURATION	INH_PRWF/TOT_POP (fraction of population using wood for heating)	-	
OCCU_DW_PRWF	Number of occupied dwellings using fuelwood as exclusive or primary fuel for heating	-	659.419
OCCU_M2_PRWF	Total surface (m2) of dwellings using fuelwood as exclusive or primary fuel for heating	m ²	47.953.000
NETM3_CONS_H	Net volume of wood needed for house heating	m ³	2.625.562
NETM3_CONS_C	Net volume of wood needed for water heating and cooking	m ³	784.229
NETM3_CON_HC	Net volume of wood needed for house heating plus water heating and cooking	m ³	3.409.821

Supply related parameters

1 – Area and ownership (forestry data)

Field name	Indicator description	Unit	Total
TOTFOR_LAN	Total forest and forest land area	ha	2.658.328
TOTFORAREA	Total forest area	ha	1.873.375
EXPLAREA	Exploitable forest area	ha	7.708.612
OW2_FRACT	Fraction of forest ownership2: PRIVATE	-	-
OW3_FRACT	Fraction of forest ownership 3: Other	-	-
OW5_FRACT	Fraction of forest ownership 5: STATE	-	-
OW236_FRAC	Fraction of NON-State forest ownership (2 and 3)	-	-
OW2	Area of forest ownership 2: PRIVATE	ha	518.557
OW3	Area of forest ownership 3: Other	ha	428
OW5	Area of forest ownership 5: STATE	ha	1.189.628
DR_1_AR	Area of exploitable forests of first age category	ha	102.662

DR_2_AR	Area of exploitable forests of second age category	ha	147.656
DR_T_AR	Area of exploitable forests of third and above age category with reproducing forest	ha	716.511
REG_F	Average yearly area of single age forests in process of renewing	ha	7.622
DR_S_AR	Area of exploitable forest with selection cut	ha	245.733
COPPICE_AR	Area of exploitable coppice-wood	ha	469.051
OWL_AR	Area of other wooded land	ha	440.964
CL1	Accessibility class 1 (slope < 30%, dist. < 400 m) % of EXPLAREA	-	-
CL2	Accessibility class 2 (slope < 30%, dist. < 400-800 m) % of EXPLAREA	-	-
CL3	Accessibility class 3 (slope < 30%, dist. > 800 m) % of EXPLAREA	-	-
CL4	Accessibility class 1 (slope > 30%, dist. < 400 m) % of EXPLAREA	-	-
CL5	Accessibility class 2 (slope > 30%, dist. < 400-800 m) % of EXPLAREA	-	-
CL6	Accessibility class 3 (slope > 30%, dist. > 800 m) % of EXPLAREA	-	-

2 – Area (land use data)

Field name	Indicator description	Unit	Total
LU_1122	Built areas with infields	ha	6.537
LU_2211	Vineyards	ha	18.448
LU_2221	Orchards	ha	6.937
LU_2222	Orchards/olive groves	ha	15.061
LU_2231	Olive groves	ha	2.377
LU_2232	Olive groves/orchards	ha	613
LU_2421	Public non-productive cultivated green areas	ha	14.574
LU_2422	Mosaics of cultivated areas with individual houses	ha	46.254
LU_2432	Agricultural properties with significant share of natural vegetation and prevailing grasslands	ha	5.383
LU_2433	Agricultural properties with significant share of natural vegetation and single trees and bush	ha	4.338
LU_2441	Agricultural and forests areas	ha	3.126
LU_3112	Broadleaved species plantations	ha	199
LU_3113	Groups of trees / small trees	ha	1.115
LU_3121	Conifer plantations	ha	3.672
LU_3211	Natural grasslands mostly without trees and bush	ha	152
LU_3212	Natural grasslands with trees and bush	ha	1.659
LU_3222	Sub-mountain mugo pine	ha	11
LU_3231	Stone pastures / scrublands	ha	3.056
LU_3240	Scrublands /olive groves	ha	1.512
LU_3241	Scrublands	ha	34.888
LU_3242	Scrublands / natural grasslands	ha	29.768
LU_3243	Hedges and bush-like vegetation	ha	5.355
LU_3245	Bush-like vegetation	ha	29

3 – Volume data

Field name	Indicator description	Unit	Total
STOCKTOT	Total economic growing stock for trees above 10 cm diameter on the height of 1.30 m	m ³	360.323.843

INCRTOT	Annual growth-yield of total economic growing stock for trees above 10 cm diameter on the height of 1.30 m	m ³	9.582.441
TOT_WOOD_G	Average annual allowable cut (planned wooden stocks for cutting, according to forest management plan) for all wooden assortments (timber + thin timbers + processing wood + firewood, no residue).	m ³	5.518.026
PREF_FW_G	Average annual allowable cut of processing wood + firewood for trees mostly used as firewood (according to Annex 1, BCD group)	m ³	2.495.489
TOT_O_FW_G	Average allowable cut of processing wood + firewood for all trees, including all conifer species	m ³	2.939.194
CONIF_O	Average allowable cut of processing wood + firewood for all conifer species	m ³	232.900
HARDBR_O	Average allowable cut of processing wood + firewood of selected hard broadleaved species, that are mostly demanded by wooden industry (species according to Annex 1, including: pedunculate oak and narrow-leaved ash)	m ³	384.713
FWSPECIES	Annual allowable cut of firewood for all hard broadleaved species	m ³	1.135.902
SOFTBR_O	Average allowable cut of processing wood + firewood for all trees for all soft broadleaved species	m ³	219.795
CUT_WOOD_G	Realised allowable cut in 2006 for all wooden assortments (timber + thin timbers + processing wood + fire wood, no residue).	m ³	4.067.764
CUT_P_FW_G	Realise annual allowable cut in 2006 of processing wood + firewood for trees mostly used as firewood (according to Annex 1, BCD group)	m ³	1.671.875
CUT_T_FW_G	Realised allowable cut of processing wood + firewood for all trees, including all conifer species	m ³	2.023.922
CUT_CONI_O	Realised allowable cut of processing wood + firewood for all conifer species	m ³	229.237
CUT_H_BR_O	Realised allowable cut of processing wood + firewood of selected hard broadleaved species, that are mostly demanded by wooden industry (species according to Annex 1, including: pedunculate oak and narrow-leaved ash)	m ³	371.157
CUT_FWSSP	Realised allowable cut of firewood for all hard broadleaved species	m ³	783.417
CUT_S_BR_O	Realised allowable cut of processing wood + firewood for all soft broadleaved species	m ³	129.962

4 – Wood industries

Field name	Indicator description	Unit	Total
TOTM3_WASTE	Quantities of wood waste from wood processing industry	m ³	413.338

Integration parameters

Production/consumption balances

Field name	Indicator description	Unit	Total
BGFWSP_H	Average annual allowable cut of firewood for all hard broadleaved species minus net volume of wood used for household heating	m ³	-1.489.660
BGP_FW_H	Average annual allowable cut of processing wood + firewood for trees mostly used as firewood (according to Annex 1, BCD group) minus net volume of wood used for household heating	m ³	-130.073
BGO_FW_H	Average allowable cut of processing wood + firewood for all trees, including all conifer species minus net volume of wood used for household heating	m ³	313.632
BCUTFWSPH	Realised annual allowable cut in 2006 of firewood for all hard broadleaved species minus net volume of wood used for household heating	m ³	-1.842.145
BCUTP_FWH	Realised annual allowable cut of processing wood + firewood for trees mostly used as firewood (according to Annex 1, BCD group) minus net volume of wood used for household heating	m ³	-953.687
BCUTO_FWH	Realised allowable cut in 2006 of processing wood + firewood for all trees, including all conifer species minus net volume of wood used for household heating	m ³	601.640
BGFWSP_HC	Average annual allowable cut of firewood for all hard broadleaved species minus net volume of wood used for household heating, water heating and cooking	m ³	-2.273.919
BGP_FW_HC	Average annual allowable cut of processing wood + firewood for trees mostly used as firewood (according to Annex 1, BCD group) minus net volume of wood used for household heating, water heating and cooking	m ³	-914.332
BGO_FW_HC	Average allowable cut of processing wood + firewood for all trees, including all conifer species minus net volume of wood used for household heating, water heating and cooking	m ³	-470.627
BCUTFWSPHC	Realised annual allowable cut in 2006 of firewood for all hard broadleaved species minus net volume of wood used for household heating, water heating and cooking	m ³	-2.626.404
BCUTP_FWHC	Realised annual allowable cut in 2006 of processing wood + firewood for trees mostly used as firewood (according to Annex 1, BCD group) minus net volume of wood used for household heating, water heating and cooking	m ³	-1.737.946
BCUTO_FWHC	Realised allowable cut in 2006 of processing wood + firewood for all trees, including all conifer species minus net volume of wood used for household heating, water heating and cooking	m ³	-1.385.899
CUT_S_BR_O	Realised allowable cut of processing wood + firewood for all soft broadleaved species	m ³	129.962

Values associated to settlements point data

Spatial / administrative parameters

Field name	Indicator description	Unit	Total
ZUP_NAZIV	County name	-	-
OG_NAZIV	Municipality name	-	-
OG_MB	Municipality code number	-	-
NAS_NAZIV	Settlement name	-	-
NAS_MB	Settlement code number	-	-
AREA	Settlement area	ha	5.659.440

Demand related parameters

Biomass plants

Field name	Indicator description	Unit	Total
BmSys_Name	Name of company	-	-
Prod_Cat	Category (ranges from 1 to 3, depending on plant capacity)	-	-
w_cons_t	Wood consumption in tons (incomplete data)	t	710.976
w_cons_m3	Wood consumption in cubic meters (incomplete data)	m ³	1.227.938
Cap_h_MW	Plant capacity	MWth	375,64
Operation_time	Plant operation time in months	month	-
Syst_type	Type of system	-	-

Charcoal producers

Field name	Indicator description	Unit	Total
Ch_Produc_Name	Name of producer	-	-
Prod_Cat	Category (ranges from 1 to 3, depending on production capacity)	-	-
w_cons_t	Wood consumption in tons	t	38.120
Prod_cap_ch	Charcoal production capacity	t	6.810
Prod_cap_br	Charcoal briquettes production capacity	t	1.400
Syst_type	Type of production (kiln, retort, pit)	-	-
Ch_prod_exp	Exported charcoal production	%	-
Br_prod_exp	Exported charcoal briquettes production	%	-
Ch_prod_2006	Charcoal production in 2006	t	5.610
Br_prod_2006	Charcoal briquettes production in 2006	t	1.270

Wood pellets producers

Field name	Indicator description	Unit	Total
Pel_Produc_Name	Name of producer	-	-
Prod_Cat	Category (ranges from 1 to 3, depending on production capacity)	-	-
w_cons_t	Wood consumption in tons (incomplete data)	t	-
Prod_cap_pel	Pellets production capacity	t	106.800
Pel_prod_exp	Exported pellets production	%	-
Pel_prod_2006	Pellets production in 2006	t	35.000

