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FAO Slovenian wood biomass project

Supply and utilization of Bioenergy to promote Sustainable Forest Management

WISDOM Slovenia

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Annex 6 Final Report

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SLOVENIA FOREST SERVICE

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Summary

Slovenia is rich with forests, which cover almost 60% of its surface. There are a lot of trees and bushwood also on other non-forest categories of land, especially on abandoned farm lands which are getting overgrown with forest vegetation. Rich wood resources though, are rather badly exploited in Slovenia, yet cutting in forests, as the most important wood resource, does not even reach half of their increment.

The project "Supply and Utilization of Bioenergy to Promote Sustainable Forest Management", which was approved by FAO at the end of 2002 and signed by the Slovenian Authorities in early 2003, was designed to promote the production and utilization of wood biomass in Slovenia for energy purposes. The Project had several components, including "Slovenia Wood Energy information System" and "Slovenia Wood Energy Maps". Both components were based on the implementation of the Woodfuels Integrated Supply / Demand Overview Mapping (WISDOM) methodology, which was developed by the Wood Energy Programme of FAO in collaboration with the University of Mexico in a previous FAO project in that country. They represent the Slovenian application of this methodology and therefore this entire report is titled Slovenia WISDOM.

WISDOM – Woodfuels Integrated Supply / Demand Overview Mapping

WISDOM is a spatially-explicit method oriented to support strategic wood energy planning and policy formulation, through the integration and analysis of existing woodfuels demand and supply related information and indicators.

The Slovenia WISDOM analysis was based on 2696 Cadastral Communities (KO, from Katastrske Občine), which represent the basis of Slovenia territorial structure and a reference for both forestry and demographic statistics. Another cartographic layer was the distribution of some 6000 human settlements providing basic demographic data. The integration and elaboration, at KO level, of data from existing statistics (forestry, census, land use, etc.) and from the new survey on woody biomass outside forests, resulted in a rich data set of over 100 parameters related to woodfuel consumption and supply. In addition, point data allowed the distribution of wood industries, biomass plants, district heating systems and associated parameters.

The quantities and locations of the present production and consumption of wood biomass in Slovenia for energy purposes were estimated within this study. The study also shows, on the basis of quantities and locations of production potentials for wood biomass, areas where it is suitable to develop utilization of wood biomass for energy purposes as a priority.

WISDOM allows a holistic vision of the wood energy sector and the national-level aggregations of key parameters constituted the main entries of the Slovenia Wood Energy Information System (SWEIS). As a planning tool, the main value of WISDOM is in its spatial character. Its fine spatial and thematic resolution makes it a flexible tool for the representation of Slovenia's fuelwood production/consumption situation in different locations and, in synthesis, for the definition of priority areas under a wide variety of perspectives.

SWEIS – Slovenia Wood Energy Information System

SWEIS summarizes at national level the production, import, export and consumption of woodfuels over the period 1995 - 2002. SWEIS uses the national-level totals of selected parameters that were developed for WISDOM Slovenia as well as additional data from Statistical Office of Slovenia and other sources. It includes all data important for planning and designing the policy in the area of wood energy, and in the organizational sense, to provide regular gathering of these data.

Main findings and conclusions

Approximately 1.9 million m^3 of wood were used as an energy source in Slovenia in 2002, of which 1.3 by the household sector 0.6 by the industrial sector, including biomass energy systems. It appears that there are two fairly independent woodfuel circuits: one household circuit that use mainly fuelwood from forests and farmlands (and marginally charcoal) and one industrial circuit that use mainly residues from wood and pulp and paper industries..

The comparison of these consumption estimates with existing fuelwood production data from SFS Statistics lead to the conclusion that "Fuelwood" reported by the Statistical Office of Slovenia represents only a small fraction (some 20 %) of the volumes actually used as fuel.

The gross inadequacy of the "official" fuelwood production data shows in some way that the energy use is not adequately recognized and studied in the national context. Moreover, this situation misleads the analysis of forest role in the energy sector as well as the analysis of the share of wood fuels in the national energy mix.

The demand for woodfuels is concentrated on fuelwood (the production and use of charcoal being marginal) and on rural areas. Large part of fuelwood trade is informal as it is either collected by farmers in their own lands and forests or bought locally. Most demand comes from households for heating purposes. Other uses such as district heating and combined heat and power plants (CHP) are still marginal but may grow as viable energy policy alternatives.

Supply issues

It is justified to believe that the potential supply of woodfuels could more than double today's extracted volumes without limiting the timber industry or affecting the growing stock. On the contrary, fuelwood production especially through thinning operations would have a positive effect on forest health condition, on stands resistance to extreme weather conditions and on the quality of timber products.

The current allowable cut (4 million m^3/yr), which is the basis of the sustainable productivity assumed in this study, is very conservative, as it represents less than 60% of the estimated annual increment (over 7 million m^3/yr). Moreover, of the 4 million m^3 of the annual allowable cut only 2.4 were actually extracted on average during the period 1991-2001. Although in recent years the cut fraction has increased to some 2.8 million m^3, the biomass built-up in Slovenia forests represents a serious issue and a threat to the health of Slovenia forests and to the quality of its timbers.

Although it is known that a significant share of fuelwood for household use is collected by farmers in their own non-forest lands, no information had existed before this study on the wood stock and productivity of these areas. The survey of non-forest woody biomass, conducted in the framework of the project, produced the first objective estimation of wood stocking and annual increment outside forest areas in Slovenia. Survey results indicate that the standing volume in non-forest areas (including meadows, abandoned agriculture, agro-forestry, urban areas, orchards, etc.) amounts to some 11.5 million m^3, with an estimated annual increment of some 400 000 m^3. From this resource, approximately 300 000 m^3 are probably used as fuel every year[1].

The best available information on wood residues from forest industries and their use for energy is in the 1998 study by Slovenian Forestry Institute (SFI), which provides summary data with reference year 1995. For that year the total annual production of wood residues was estimated at 722 000 m^3. Because of decreasing of industrial wood production, as reported by the Slovenia Statistical Office [14], the annual production of wood residues at year 2002 was tentatively estimated at some 553 000 m^3.

Demand issues

At present, almost the entire consumption of fuelwood in Slovenia is absorbed by household uses and principally for heating, for which this fuel provides about one third of the national energy demand. In spite of its relevance, reliable statistics on fuelwood consumption do not exist.

To fill the critical information gap on fuelwood consumption by Slovenia households, new estimates were produced using data from the 2002 Census on dwellings, which allowed estimating the saturation of fuelwood use for space heating by cadastral communities, and previous studies on average energy requirements for space heating and cooking.

The information available on industrial wood energy consumption was fragmented and recent data largely incomplete. Such information was composed by data on 5 district heating systems, 5 combined heat and

[1] These values represent the first estimation ever done of non-forest woody biomass. However, since the variance of tree cover outside the forest is extremely high, the margin of error is very wide and they should be considered indicative only.

power plants (CHP) and on 55 industries that have wood-fed boilers of which 21 with some consumption details and 34 without details except their location.

The total consumption from available biomass systems data at year 2002 amounts to some 390.000 m3. This is incomplete since for many units the consumption is not yet known. In consideration of some other references we estimated the consumption of industrial biomass systems on the amount of some 500.000 m3.

Integration

Because of lack of information on wood industrial residues the integration of supply and demand parameters was limited to supply/demand balance analyses between household fuelwood consumption and forest/non forest production.

Several scenarios were created on the field of the fuelwood supply, considering current and potential forest (allowed/actually extracted wood assortments and species groups) and non-forest productivity.

As example of priority zoning, three aspects that are of particular relevance in future forestry planning of woodfuel production were combined. These are: (i) high surplus of non-timber assortments suitable for energy use,(ii) high fragmentation of forest properties and (iii) high proportion of forest stands at thinning stage. These areas are critical under forest management viewpoint: In these areas forest owner associations should be promoted in order to achieve an acceptable profit level for the owners and to undertake the needed sylvicultural treatments that are otherwise neglected. In these contexts, energy offers good opportunities, with benefit for the society and for the forest ecosystem.

Recommended follow-up

The information so far collected and processed covers the main aspects of wood energy in Slovenia, providing a coherent overview of this sector. However, some dataset are preliminary and/or incomplete and other aspects of the analysis need to be further developed. Therefore it is recommended to continue to collect relevant information and to further develop and deepen SWEIS and WISDOM with special attention to the following:

- fuelwood consumption time series for the household sector,
- climatic variables related to heating energy requirements in order to support a more reliable estimation of fuelwood consumptions;
- new and more complete data on the production of wood residues by forest industries and on their use;
- more complete data on woodfuel consumption and energy production by biomass plants.

It is also recommended to complement the study with:

- the analysis of trade and market aspects and other economic parameters as soon as these will be available and
- the analysis of accessibility factors that limit the full exploitation of the country's wood energy potential from a physical, legal and economic perspective.

As mentioned above, the official national statistics on woodfuels are incomplete and do not reflect the true role that wood energy plays in both forestry and energy sectors. This is a major limitation in the development of this sector. It is therefore strongly recommended that the Statistical Office of Slovenia define, in collaboration with forestry and energy authorities, a specific set of wood energy variables and that specific attention be given to the production and consumption of individual woodfuels in future statistical surveys of both forestry and energy sectors.

1 INTRODUCTION

1.1 Background

Slovenia is rich with forests, namely forests cover almost 60% of its surface. There are a lot of trees and bushwood also on other non-forest categories of land, especially on abandoned farm lands which are getting overgrown with forest vegetation. Rich wood resources though, are rather badly exploited in Slovenia, yet cutting in forests, as the most important wood resource, does not even reach half of their increment.

In state forests the quantity of cutting is approaching the quantities, allowed by forest management plans as forests are treated integrally. The quantity of cutting in private forests is much lower, considering reports from 1991 – 2000, only little more than half of the allowable cut (54%). For the mentioned period the study states a low share of cutting even for state forests, compared with the allowable cut (76%) but this is a consequence of denationalization, as in this period about one quarter of former community forests were returned to their original owners, while cut had been planned for the entire surface. As in some returned forests owners have already been cutting and the cut is included among cutting in private forests, we could undoubtedly say that cutting in former private forests hasn't reached even half of the allowable cut. There are several reasons for that. Forest owners are not organized, for small scale owners the income from wood from the forest is mostly unimportant, the production of small quantity of wood is expensive and it is difficult to reach a good price for it in the market. Forest owners are deciding to cut only in those forest stands, or even only that particular tree, where they can expect, in spite of the above stated unfavorable factors, a good economic result. Therefore, a lot of unused, especially wood of lower quality, remains in forests. The damage is double, the unused wood slowly rots in the forest and abandoning the thinning of forest stands we are abandoning the most important measure of forest stand tending and thus loosing the opportunity to raise forest stands with high quality trees.

The perception about the real current role of wood energy and about its potential for development remained fragmented and largely confused, keeping the planning and policy development of this sector in a sort of suspended limbo. The project "Supply and Utilization of Bioenergy to Promote Sustainable Forest Management", which was approved by FAO at end 2002 and signed by the Slovenian Authorities in early 2003, is an important contribution to the progress in this field and to promote a sustainable development of the wood energy sector in Slovenia.

The content of the above mentioned project is wide and it captures all areas important for the promotion of utilization of wood biomass in Slovenia for energy purposes. The entire project includes the following components:

- Wood energy maps,
- Wood energy information system,
- Socioeconomic aspects of wood energy,
- Analysis of woodfuel market,
- Extension on the field of wood energy,
- Dissemination of knowledge, strengthening of public awareness.

The present report covers the first two components of the Project, i.e. "Slovenia Wood Energy Maps" and "Slovenia Wood Energy information System". Both components were based on the application of the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology [7], which was developed by the FAO Wood Energy Programme in collaboration with the Autonomous University of Mexico in a previous FAO project. The analysis conducted may be considered the Slovenian application of this methodology and therefore this entire report is titled Slovenia WISDOM.

SWEIS – Slovenia Wood Energy Information System

The information system was made within this study. It includes all data, important for planning and designing the policy in the area of wood energy, and in the organizational sense, to provide regular gathering of these data.

SWEM – Slovenia Wood Energy Maps

The quantities and locations of the present production and consumption of wood biomass in Slovenia for energy purposes were estimated within this study. The study also shows, on the basis of quantities and locations of production potentials for wood biomass, areas where it is suitable to develop utilization of wood biomass for energy purposes as a priority.

1.2 Purpose of the study

As we have already mentioned in the introduction, we wanted to estimate, with this study, the quantities and locations of the present production and consumption of wood biomass in Slovenia and to show, on the basis of quantities and locations of production potentials for wood biomass, areas where it is suitable to develop utilization of wood biomass for energy purposes as a priority. Especially we have to stress that the analysis of wood biomass production tried, as much as possible, to capture, besides forests, also non-forest lands and wood residues from all forms of production which use wood as a raw material. Charcoal production was also treated as part of wood biomass production, as charcoal is mostly made of wood which would otherwise remain unutilized for energy purposes.

In short, the purpose of the study, mentioned in the introduction, was the following:

- to prepare the Slovenian Wood Energy Information System (SWEIS) providing statistical data from 1995 to 2002 at national and regional level for fuelwood, charcoal and black liquor production, consumption and trade (import, export) and users,
- to suggest the most suitable institutional arrangements for long-term implementation of SWEIS within SFS and the liaison with other partners involved in supplying and using the data collected,
- to integrate the rich but fragmented information relevant for wood energy planning available in Slovenia in a spatially explicit dataset and to fill critical information gaps,
- to understand the true potential of wood energy as an economically and environmentally sound alternative or complement to fossil fuels,
- to identify the zone of the country most, or least, suitable for the development and implementation of wood energy projects.

2 METHODOLOGY

2.1 General

Woodfuels Integrated Supply / Demand Overview Mapping (WISDOM)

WISDOM is a spatially-explicit method oriented to support strategic wood energy planning and policy formulation, through the integration and analysis of existing woodfuels demand and supply related information and indicators. Rather than absolute and quantitative data, WISDOM is meant to provide relative/qualitative values such as risk zoning or criticality ranking, highlighting, at the highest possible spatial detail, the areas deserving attention and, if needed, additional data collection. In other words, WISDOM serves as an assessing and strategic planning tool to identify priority places for action.

The use of WISDOM involves five main steps, AS SHOWN IN Figure 1:

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.

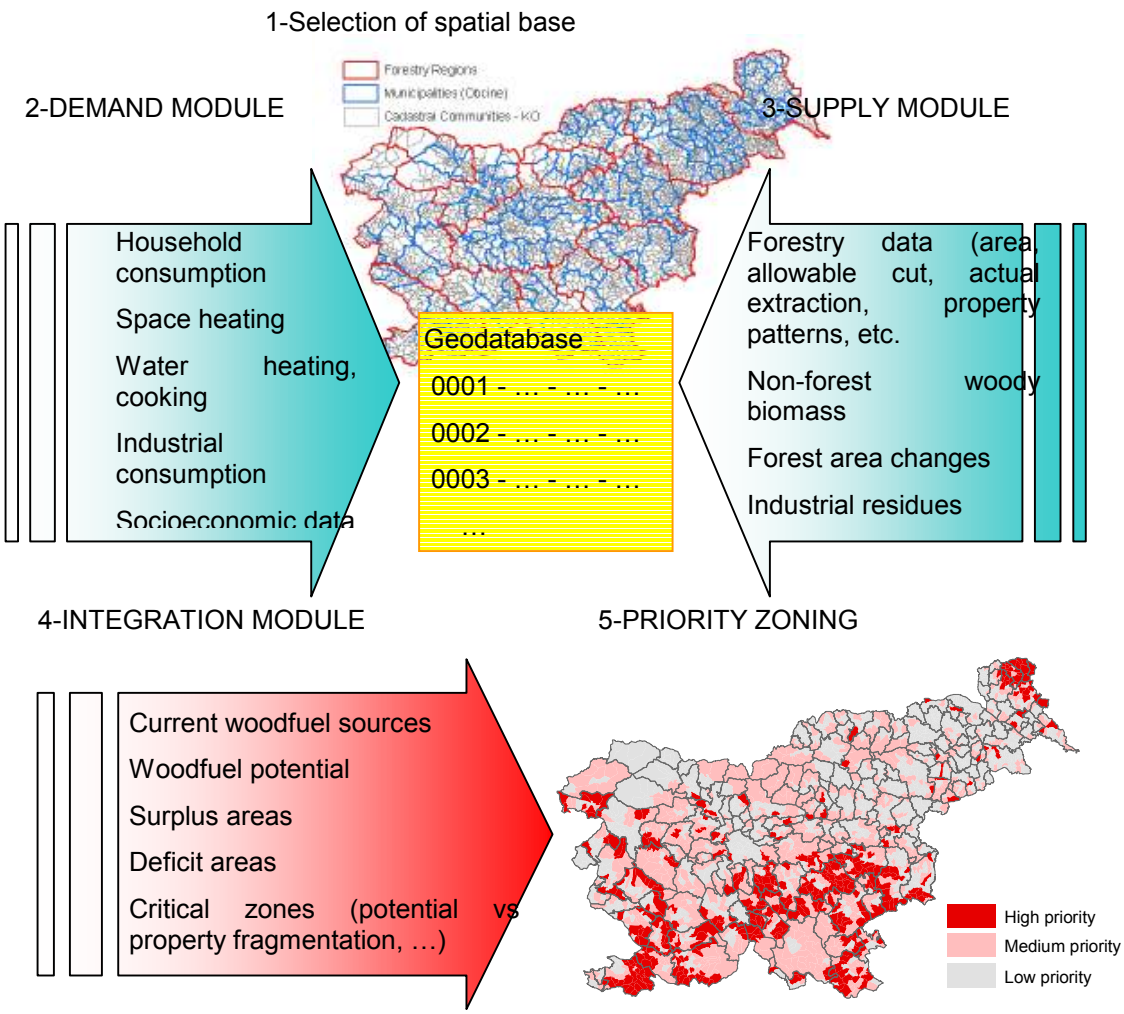

Figure 1: Diagram of the main steps in the development of WISDOM Slovenia.

WISDOM is a flexible and adaptable methodology the based on:

- the use of geo-referenced socio-demographic and natural resource databases integrated within a geographical information system;
- a minimum spatial unit of analysis at sub-national level;
- a modular, open, and adaptable framework which integrates information of relevance to wood energy from multiple sources;
- a coverage of woodfuel resources and demand from different energy users.

2.2 Administrative Spatial Units of Analysis

Minimum Administrative Spatial Unit of Analysis

The spatial base was developed on cadastral communities (KO), which represent the basis of Slovenia territorial structure. With 2696 units, the KO allow for a highly discreet spatial analysis and may be aggregated at municipality level and at any other reporting level. Additional layers are settlements (5997 points). Figure 2 shows the detailed KO structure and settlements distribution.

KO, as a spatial unit, is considered also by the Statistical Office of the Republic of Slovenia in censuses of population and farm economies. Therefore, a lot of data regarding dwellings, houses and population are available on the level of KO, which are important for the estimation of the quantity of spent wood biomass for energy purposes.

Others Administrative Units of Analysis

The administrative units of analysis of higher level are community (municipality), administrative unit and Slovenia.

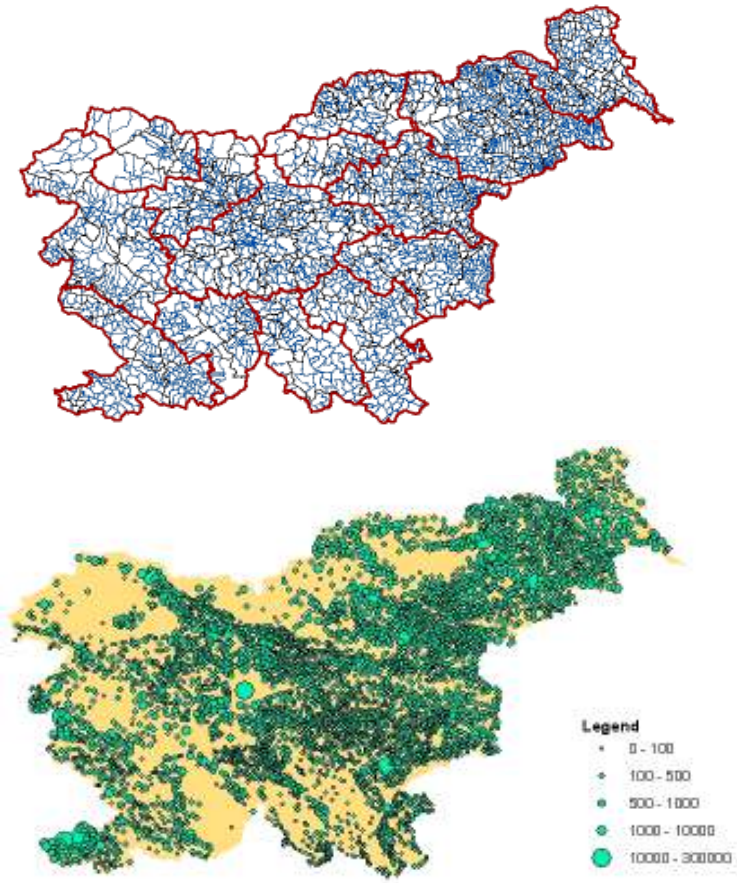

Figure 2. Top: Cadastral communities (2696) and forestry regions (14);
Below: Settlements (urban and rural) here shown by population size

2.3 Demand Module

2.3.1 Household Consumption

The consumption estimates were based on the following data and data sources:

Number of dwellings, surface and persons living therein, that use wood as exclusive or primary fuel for space heating.

Source: Statistical Office of Slovenia, 2002 census of population, households, dwellings and buildings.

Energy requirements for house heating (kWh/m2) by type of apartment, year of construction, level of insulation and maintenance.

Source: Estimation of potential emission reduction in Slovenia. Final report. Ministry of Environment and Spatial Planning. 2002.

Estimated additional energy requirements for cooking and water heating. The total energy requirement for heating and cooking was estimated by adding 30 % to the amount required for heating only.

Source: Study for energy plan and 2030 projection.

Energy conversion factors; average wood energy contents and conversion efficiency in Slovenia.

Source: Slovenian Forestry Institute, various references.

2.3.2 Industrial consumption

Available information on industrial wood energy consumption is fragmented and largely incomplete. To estimate industrial consumption to the best possible level the data from Slovenian Forestry Institute, Chamber of Commerce and Ministry of Environment and Spatial Planning was used.

2.4 Supply Module

2.4.1 Forests

Concerning forest areas, the basis of the module was the rich and regularly updated SFS database on forest compartments (over 65.000) and its new digital map, which provided information on stocking, annual increment, assortments production including fuelwood, actually cut quantities, ownership data, etc., all at the compartment/subcompartment level.

With the data from sub-compartments or compartments (where compartments are not divided into sub-compartments) we have calculated wanted quantities for higher levels – cadastral communities, municipalities, forest management regions and for the whole state.

The most important data we used for that purpose, were:

- forest area,
- wood stocking and increment – by tree species and classes of breast-high diameter,
- annual allowable cut,
- structure of forest developmental stages,
- skidding distance,
- incline of forest terrain,
- type and number of forest owners.

For the calculation of the expected wood assortment structures or the quantity of fuelwood which comes out of the annual cut we have used assortment tables, which show, for different tree species or group species, the relation between assortment structure and tree species and thickness of the tree, separately for more productive and less productive natural sites. Assortment tables were made years ago by SFS and State Fund for Agricultural and Forest Land on the basis of numerous data about relation between trees of different species and thickness and wood assortments, which had come out of their cut.

The quantity of fuelwood which comes out of annual cut or potential (allowable) cut was calculated in several versions, regarding tree species and wood assortments which are most commonly used as fuelwood, taking into account other tree species as well as other wood assortments.

2.4.2 Non Forest Areas

Concerning the non-forest fuelwood sources a specific survey was , carried out within a study, following a two-phase approach based on available ortophotos, the new Land Use Map (2002) and minimal field sampling.

The recent land use map, made by the Ministry of Agriculture (2002), represented the excellent background information about the structure of land use of non-forest area. It was directly in the non-forest biomass survey, where it constituted the basis for the stratification and for the distribution of sampling units. In total the map has over 650.000 polygons.

The analysis was composed of the following functions:

- determination of non-forest land types, with important quantities of trees and bushwood,
- determination of woody cover type,
- systematic selection of 227 land use units to determine shares of individual woody cover types according to different land use types,
- random selection of 29 land use units (from 227) for field measurement of wood stock of different woody cover types – in m^3/ha,
- field measurement of wood stock according to woody cover types,
- calculation of average wood stock on non-forest lands according to woody cover types - in m^3/ha,
- calculation of average wood stock on non-forest lands according to non-forest land use types - in m^3/ha,
- selection of adequate increment curves tree species groups and calculation of average increment according to individual woody cover types and individual non-forest land use types - in m^3/ha,
- calculation of absolute wood stock and increment for all spatial units on different levels (cadastral communities, communities, administrative units, Slovenia).

The analysis is described in Annex 6

2.4.3 Land use Change

In order to estimate further trends of wood biomass production potentials on non-forest lands as well as in forests, Slovenian Forestry Institute (author prof. dr. Milan Hočevar) has made a special study, based on ortophoto, dealing with changes of forest surfaces in Slovenia in the period from1975 to 2000.

With the same intention, data regarding lands in coalescence were analyzed, too. Their sources are the study made by Slovenian Forestry Institute within the project CORINE and just concluded study regarding land use, ordered by the Ministry of Agriculture, Forestry and Food.

2.4.4 Wood Residues in the Wood processing Industry

Data are very insufficient. The most useful information relates to the year 1998 when, with somewhat higher production in wood plants in the entire Slovenia, 700 t of wood residues were “produced”.

In order to acquire information about the quantities of wood residues in wood industry and the spatial distribution a questionnaire was made and sent to 65 wood industry plants. Only 21 answers were received, too little for precise analysis of relation between the size of wood processing plants, taking into account the number of employees, and the quantity of wood residues. Therefore these data were not used in this study.

2.5 Integration Module

Due to lack of more reliable data regarding “production” of wood residues and bigger plants for wood biomass utilization for energy purposes the integration module discussion is based only on lower spatial levels on the production of wood biomass in forests and on non-forest lands and on the data regarding wood biomass utilization for energy purposes in households.

2.6 Priority zoning

From the same reasons as stated in the chapter Integration module, priority zoning is preformed only on the basis of data regarding wood biomass production in forests and on non-forest lands and on the data regarding wood biomass utilization for energy purposes in households. Decision making regarding planning of wood biomass users for energy purposes has to be done with respect of available data about “production” of wood residues and locations of bigger users of wood biomass for energy purposes.

3 RESULTS

3.1 The Development of Slovenia WISDOM

The Slovenia WISDOM allows a first holistic and coherent vision of the main aspects of fuelwood demand and supply and their spatial relation. It provides, for each of the 2696 Cadastral Communities (KO) that compose the Country, all variables relevant to the wood energy sectors that could be so far assembled and/or estimated.

The spatial and statistical data is structured in form of geodatabase which combines the spatial and statistical elements and allows a convenient handling in both Microsoft Access (database features) and ESRI ArcMap environments. Figure 3 shows a screen grab of Access and ArcMap while viewing the file KOWISDOM. The attribute table of the file is viewed as both Access table (left) and shapefile and related table of attributes (right).

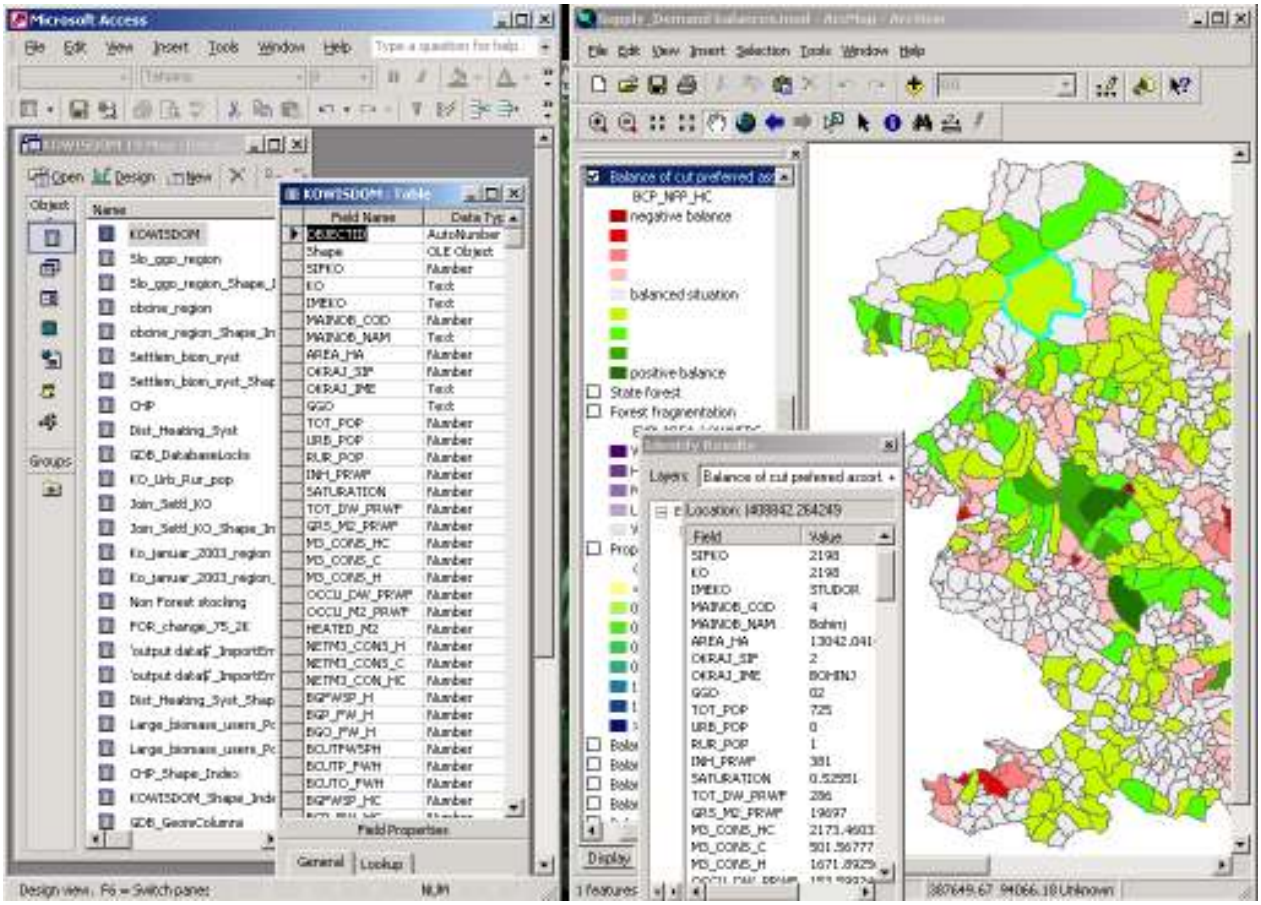

Figure 3: Screen grab of Access and ArcMap while viewing the KOWISDOM geodatabase

The WISDOM geodatabase contains many parameters. Annex 4 describe the attributes of the geodatabase which include over 110 parameters associated to the 2697 KOs and some 20 parameters associated to the 5997 point data. Annex 4 provides also the summary value at national level of all parameters associated to the map. Many of these national level results were used as input to the SWEIS.

The attributes may be grouped in the following four categories:

<u>Administrative elements:</u> code and name of Cadastral Community (KO), Municipality, Region, and other administrative units; settlement locations with relative population data and urban/rural classification.

Demand-related variables: population variables (total and fuelwood users, saturation, etc.); number and surface of dwellings using wood for heating; estimated household fuelwood consumption for house heating and cooking (original contribution of the current study); data (still rather incomplete) on existing biomass systems such as district heating systems, combined heat and power plants and other non specified.

Supply-related variables: total and exploitable forest area; type and number of forest owners; total wood stocking and increment; area by forest phase development stage; forest area by accessibility class; annual allowable cut as well as actual extraction for main wood assortments and species group; area by land use classes (21 classes); estimated stocking volumes, increment and productivity of non-forest land use classes (original contribution of the current study).

Integration variables: Balance between household fuelwood consumption and several supply scenarios determined by current and potential forest (allowed / actually extracted wood assortments and species groups) and non-forest productivity. Combination of surplus areas with ownership fragmentation and with forests at thinning stages. This allowed a delineation of priority areas for the implementation of field programmes oriented to solve the problem of undone thinnings through the promotion of owners associations and to increase woodfuel production.

This last group is so far limited to supply/demand balance analyses related to household consumption and forest/non forest productivity. Since the information on industrial woodfuels production and consumption is still partial, little use has so far been made so far in the WISDOM analysis.

On the other hand, this limitation doesn't seem to reduce the validity of the analysis done and the conclusions achieved for the household sector. In fact, there are two fairly independent woodfuel circuits: a "household" circuit that uses mainly fuelwood (and marginally charcoal) from forests and farmlands and an "industrial" circuit that uses mainly residues from wood industries and paper mills.

To bridge between these two circuits and to study the potential for industrial wood energy development, the analysis focused on the determination of (i) the total woodfuel potential according to current forest management plans, and (ii) the zones of the country where there is a significant biomass surplus (after having satisfied household needs) that could feed district heating systems, power generation systems or other industrial plants.

3.2 Demand module

3.2.1 Household Consumption

At present, almost the entire consumption of fuelwood in Slovenia is absorbed by household uses and principally for heating, for which this fuel provides about one third of the national energy demand. In spite of its relevance, reliable statistics on fuelwood consumption do not exist.

To fill this essential information gap, new consumption estimates were therefore produced using the following data sources:

Number of dwellings, surface and persons living therein, that use wood as exclusive or primary fuel for space heating; fraction of occupied dwelling. Source [13]

Energy requirements for house heating (kWh/m^2) by type of apartment, construction year, level of insulation and maintenance. The estimated energy requirement for heating only used, as main reference, the weighted average for single-family houses (see Annex 3). Source [9].

Estimated additional energy requirements for cooking and water heating. The total energy requirement for heating and cooking was estimated by adding 30 % to the amount required for heating only (see Annex 3). Source [8].

Fraction of apartments' surface actually heated. Source [12].

Energy conversion factors; average wood energy contents and conversion efficiency in Slovenia.

Census data on dwellings allowed estimate the saturation of fuelwood use for space heating by cadastral communities, as shown in Figure 4.

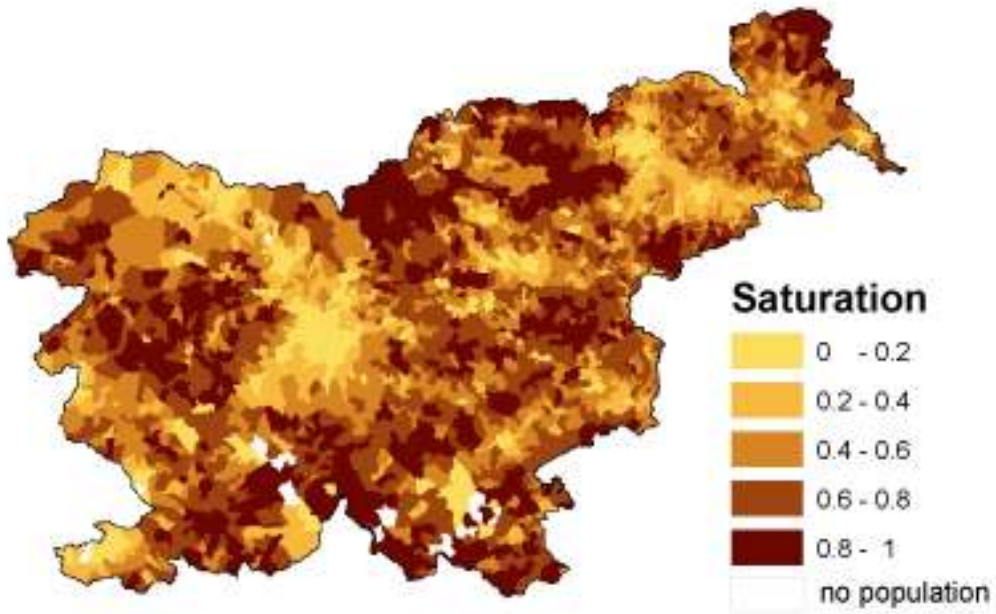

Figure 4: Saturation of fuelwood users (fraction of the dwelling using primarily or exclusively fuelwood for space heating)

The data sets described above allowed estimating the wood energy requirements summarized in Table 1.

The demand for fuelwood is concentrated on fuelwood (the production and use of charcoal being marginal) and on rural areas. Large part of fuelwood trade is informal as it is either collected by farmers in their own lands and forests or bought locally. Most demand comes from households for heating purposes. Other uses such as district heating and combined heat and power plants (CHP) are still marginal but may grow as viable energy policy alternatives.

The spatial distribution of household fuelwood consumption for space heating, water heating and cooking in Slovenia households is shown in Figure 5.

Table 1: Estimated wood energy requirements for space heating, water heating and cooking in Slovenian households

		kWh/m^2	CUM/m^2	tons/m^2
Energy requirements per m^2		208	0.11034	0.0800
Estimated energy/wood consumption by dwellings using wood as exclusive or primary fuel. The estimates refer to the actually heated fraction of occupied dwellings.				
		kWh	CUM	tons
Total Slovenia				
Estimated heated surface	11,618,290 m^2	2,416,604,390	1,282,017	929,462
		kWh/dw	CUM/dw	tons/dw
by dwelling	191,312 dwellings	12,632	6.7	4.86
		kWh/inh	CUM/inh	tons/inh
by inhabitant	594,934 inhabitants	4,062	2.2	1.56

Assumed wood energy efficiency = 65% = 1885 kWh/m^3 [12].

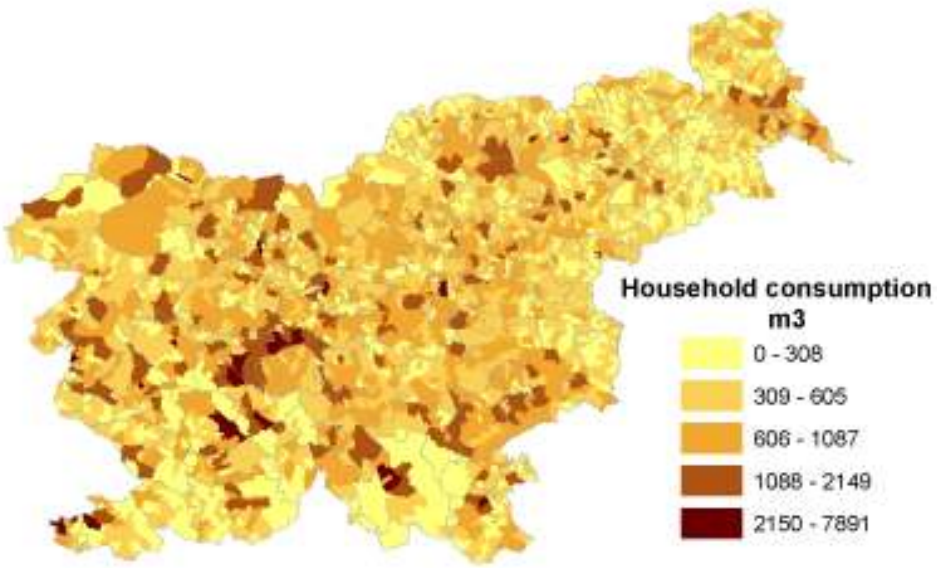

Figure 5: Fuelwood consumption by Slovenian households

Recommended further developments

The estimates of household consumption may be refined to reflect climatic variations using KO-level data on winter temperatures and length of heating seasons. Relevant parameters may be obtained from the Office of Spatial Planning of the Ministry of Environment, Social Planning and Energy, which produced Temperature Zone maps.

In addition to the above, the Demand module should include historical data to analyze recent trends and to allow some projection estimates. Unfortunately, this is not an easy task, since the previous censuses did not collect data on the types of fuel used for house heating.

More information, mainly qualitative, on fuelwood consumption will be generated through the analysis of "fuelwood user profile" that will be carried out by SFI using additional statistics from the census 2002 and from the census of agricultural holdings (2000) (see variables in Annex 2).

3.2.2 Industrial consumption

The information available on industrial wood energy consumption [10] [12] was fragmented and recent data [2] largely incomplete. Such information was composed by data on 5 district heating systems, 5 combined heat and power plants (CHP) and on 55 industries that have wood-fed boilers of which 21 with some consumption details and 34 without details except their location.

The total consumption from available biomass systems data at year 2002 amounts to some 390.000 m^3. This is incomplete since for many units the consumption is not yet known. SFI studies [10] estimated the total consumption in 1997 at 432 000 m^3.

In consideration of these references and to the fact that few systems were established after 1997, the estimate value entered in SWEIS was tentatively estimated at 500 000 m^3.

Figure 6 shows the distribution of the biomass systems and some detail about the available information.

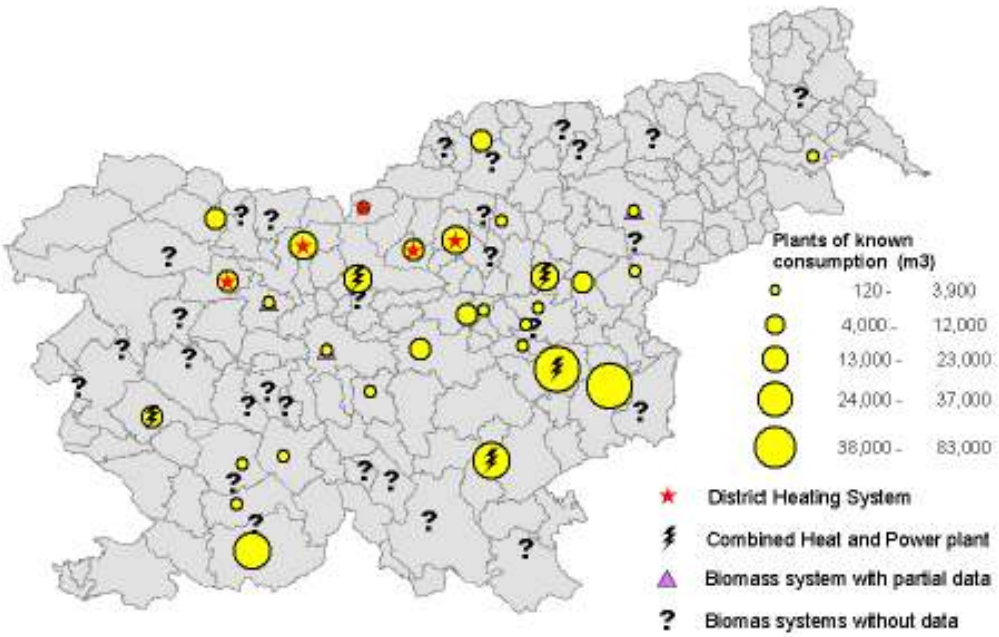

Figure 6: Distribution of biomass systems in Slovenia and available consumption data

3.3 Supply module

3.3.1 The data of Statistical Office of Slovenia

In spite of the importance of forest products for energy use and in spite of the excellent existing data on forest resources and outputs, the official statistics fail to provide realistic data on fuelwood production in Slovenia. When we compare the figures of the Statistical Office of Slovenia on fuelwood production shown in Table 2 to the estimated consumption shown in Table 1 it is evident that the formers cannot represent the true amount of fuelwood produced from Slovenia forests.

It is obvious that 280 000 m^3 of fuelwood (or 430 000 m^3, if we take the 5-years average) cannot satisfy the needs of some 600 000 people [13] that use wood for house heating, cooking and water heating, to consider only the household sector. Fuelwood production is definitely much higher than reported in official statistics but hidden under other categories.

Table 2: Production of row wood categories – by Statistical Office of Slovenia ('000 m^3)

	1990	1995	1998	1999	2000	2001	2002	5-yr average
TOTAL	1790	1751	2132	2068	2253	2257	2283	2199
Logs	979	918	1001	992	1120	1144	1164	1084
Pulpwood	281	519	451	434	396	410	414	421
Other_industrial_wood	335	88	142	137	205	408	425	263
Fuelwood	195	226	539	505	532	295	280	430

Source [14]

3.3.2 Forests

In order to develop the supply module with reliable and detailed data, the original forest compartment databases were used [11]. These databases are maintained by the SFS for the approximately 65.000 forest compartments that compose Slovenia forests. Compartment data relative to the period 1991-2001 were aggregated at KO level to form the databases described in Annex 5.

Some important characteristics of forests in individual Cadastral communities are shown in figures 7 - 9.

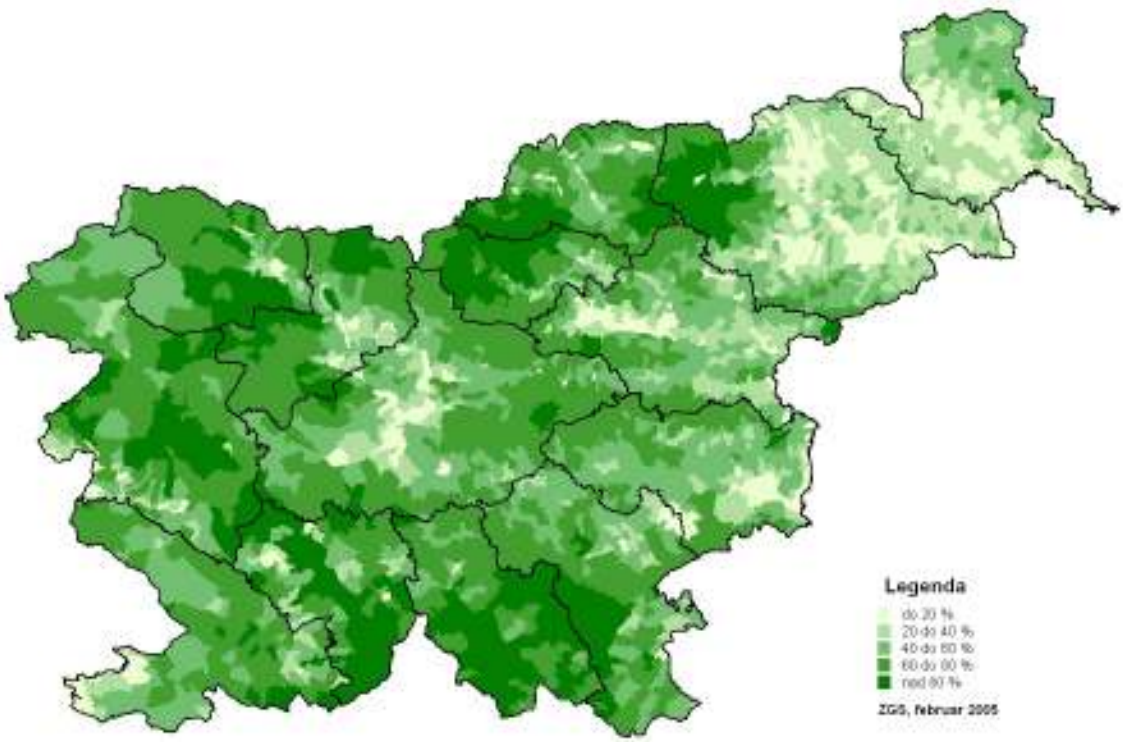

Figure 7: The share of surface covered by forest

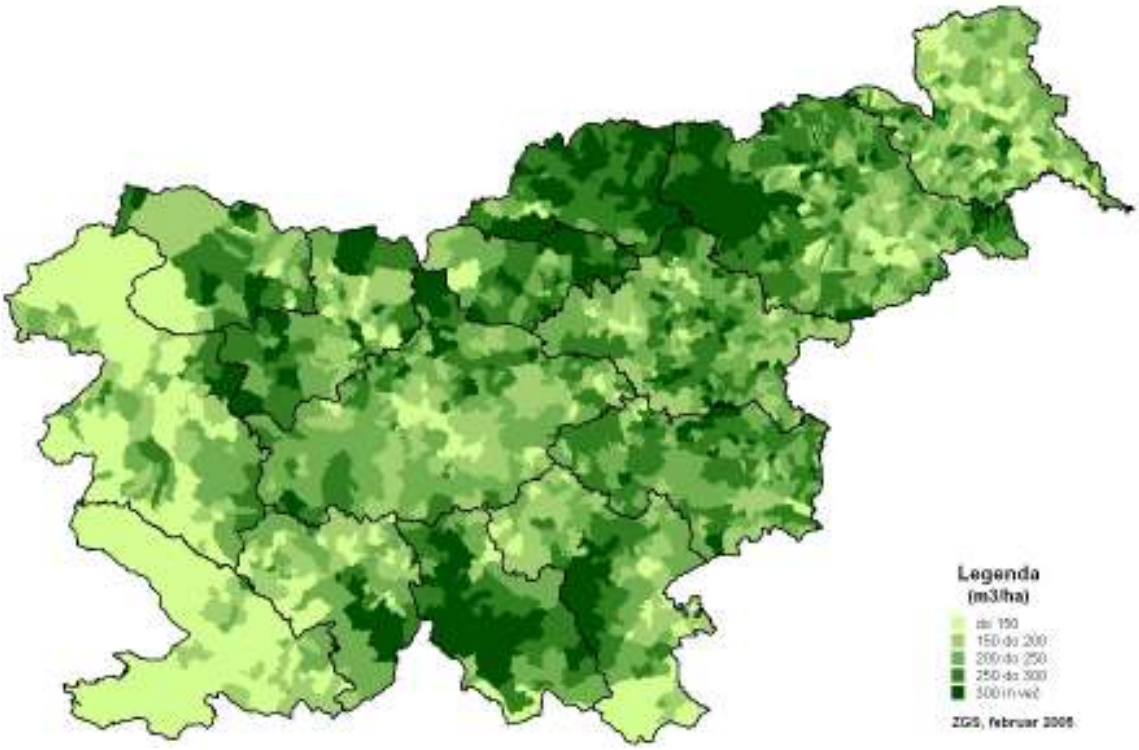

Figure 8: The average wood stock of forests - m3/ha

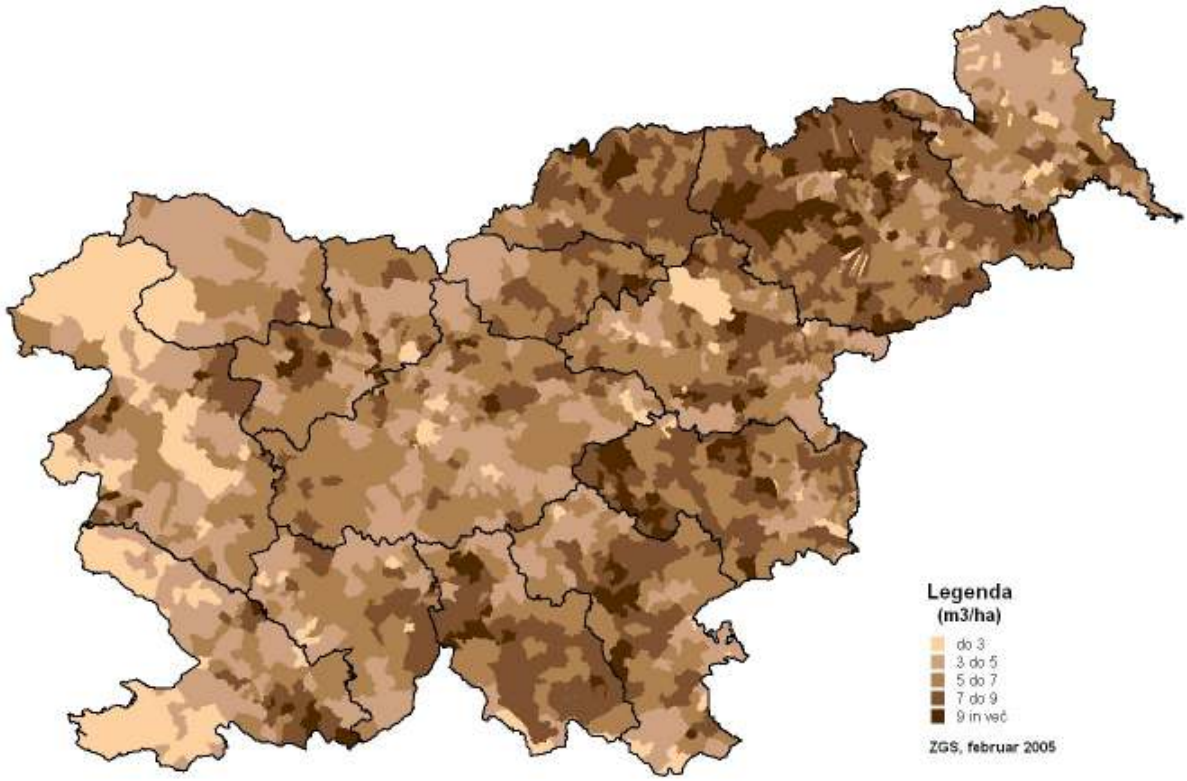

Figure 9: The average annual wood increment of forests - m^3/ha year

The database of SFS contains also data about allowable cut and present cut. Based on these data and assortment tables we estimated, for all analyzed levels, the amount of wood exploitable and actually extracted.

The assortments considered, were following:

Fuelwood assortments from species group ”Other hard broad leaved trees” (Carpinus, Ostrya, Fraxinus ornus, Robinia, Acer campestre, Sorbus, Quercus pubescens). This is the only assortment officially recognized as “fuelwood”.

Non-timber assortments commonly used as fuel (including Larch, Beech, Oak spp, Chestnut, and other quality broadleaves - group BCD in Annex 5).

Non-timber assortments of all species (all conifers included).

The first assortment class (the one specifically classified as “fuel”) represents only a small fraction of the volume actually used as fuel estimated in the Demand Module (17 % if we consider the allowable cut and 10 % if we consider the actual cut). However, practically all foresters that were interviewed recognized that other non-timber assortments are also primarily used as fuel [11].

The second assortment class, i.e. “Non-timber assortments commonly used as fuel” represents today’s main “forest” fuelwood supply for household use. It is likely that in addition to the amount reported there is a certain amount of “informal” and unrecorded forest extraction.

The third assortment class “Non-timber assortments of all species” represents the potential wood energy supply for household and industrial use in the near future, especially if the actual extraction will be increased to match the sustainable production capacity or at least the conservative levels defined by forest managements’ allowable cut. The distribution of this assortment class is shown in Figure 10.

The volumes were estimates as both allowable cut and actually extracted amounts. The ratio between actual extraction and the allowable cut depended mainly on ownership factors. Over the period 1991-2001 the ratio appeared to be, on average, 0.54 for forest owned by privates, rural communities and religious institutions and 0.76 for state forests [11]. Total values for all categories are given in Annex 4 and, in comparison with consumption levels, in Table 6.

Low value of 0,76 for state forests is to a large extent the consequence of denationalization, as in this period about one quarter of former community forests were returned to their original owners while the cut

had been planned for the entire surface. As in some returned forests owners have already been cutting and the cut is included among cutting in private forests, we could undoubtedly say that cutting in former private forests hasn't reached even half of the allowable cut.

Table 3: The most important data on the supply of fuelwood from the forests on the State level

Forests	
Total forest area	1.185.306 ha
Exploitable forest area	1.104.794 ha
Allowable cut by management plans	
Non timber assortments commonly used as fuel (group BCD)[1]	1.407.000 m^3
Non timber assortments of all species (all conifers included)	2.148.000 m^3
Volumes actually extracted (1991-2001)	
Non timber assortments commonly used as fuel (group BCD)	840.000 m^3
Non timber assortments of all species (all conifers included)	1.283.000 m^3

Notes: 1See Annex 5 for explanation.

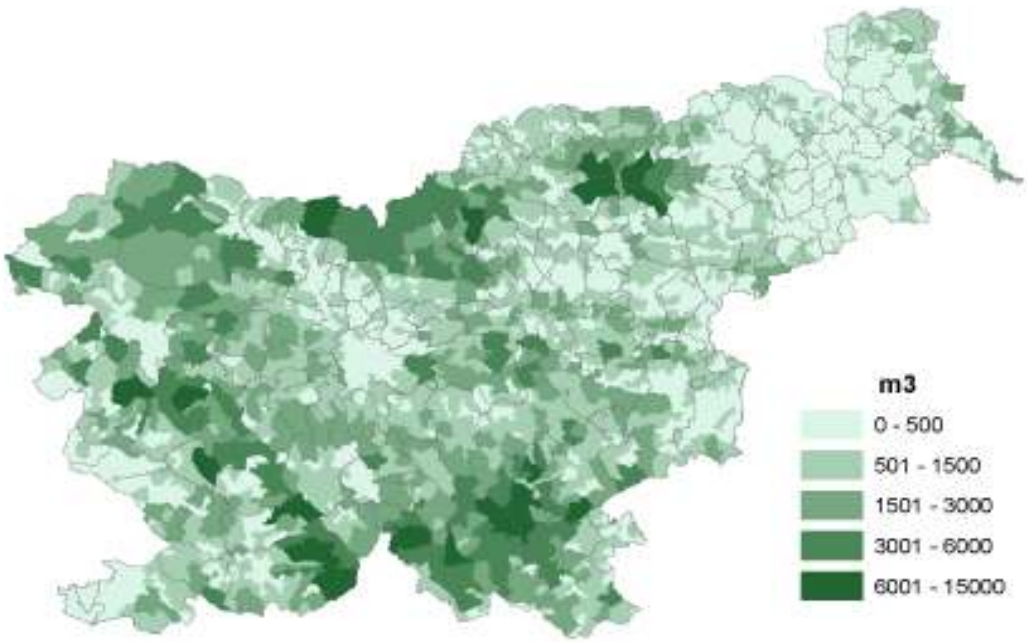

Figure 10: Cadastral community - level distribution of allowable cut of all non-timber assortments

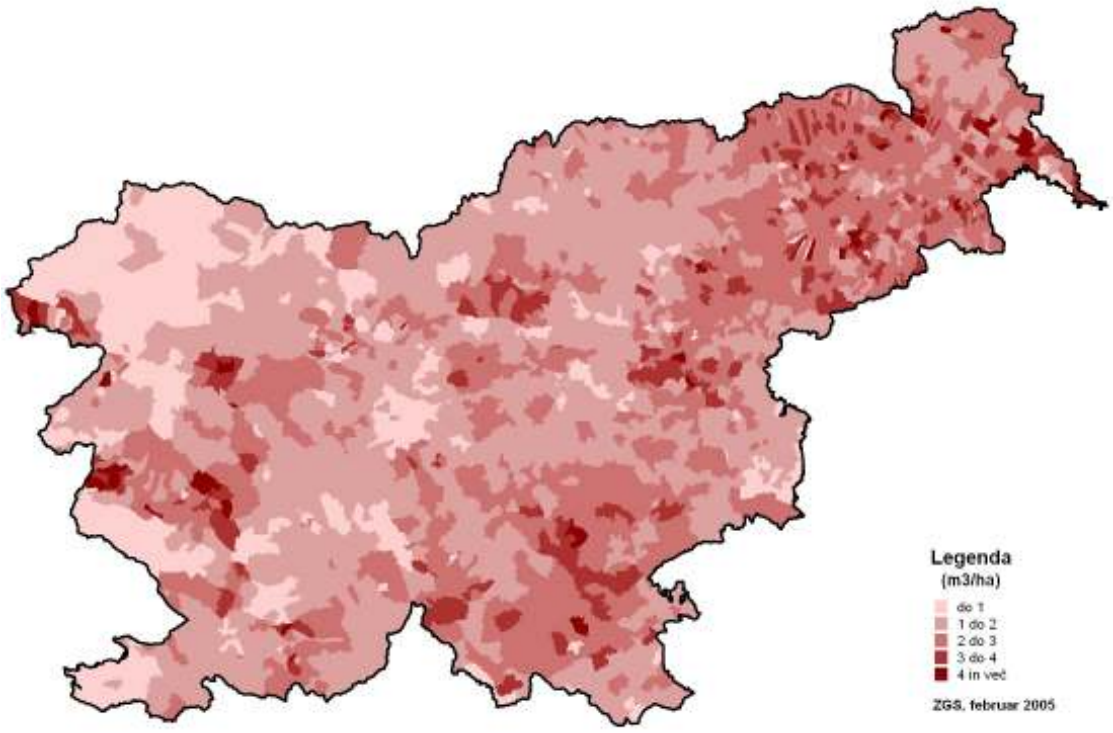

Figure 11: The average annual allowable cut of all non-timber assortments - m3/ha year

Among the many perspectives that this rich dataset provides, a particularly interesting one concerns forest ownership, which allows distinguishing forest area by levels of property fragmentation, as shown in Figure 12. Fragmentation of forest properties poses many problems for the implementation of forest policies, as many owners have marginal interest in their forest lots or simply do not know where they are. In fact, the efficiency of execution of allowable cuts seems inversely related to the fragmentation of forest ownership.

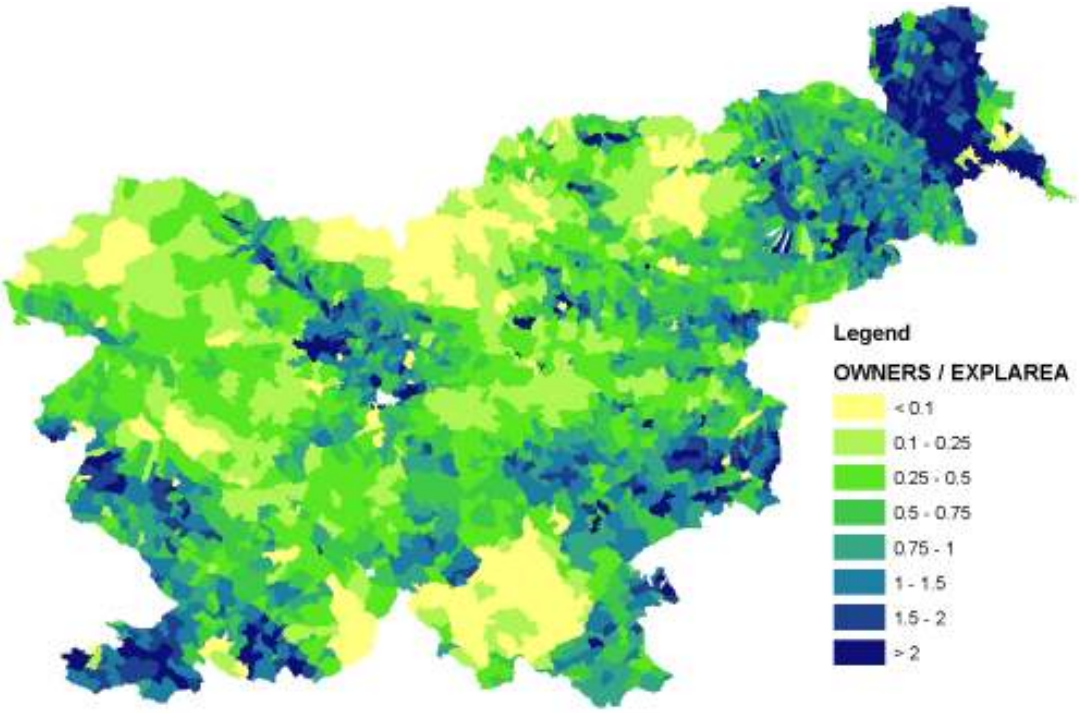

Figure 12: Forest ownership fragmentation. Number of forest owners per hectare of exploitable forest (co-owners are not considered)

3.3.3 Changes in forest area

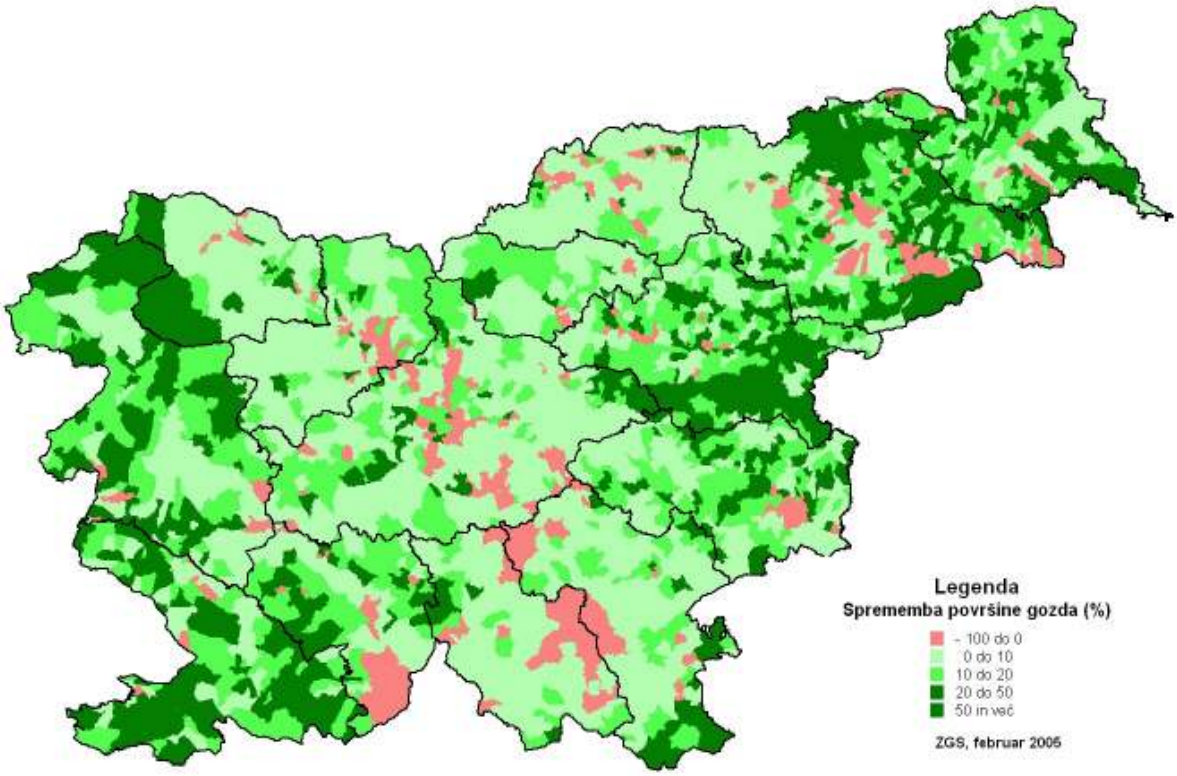

Figure 13: Forest area change over the period 1975-2000 - in % of surface 1975

The recent study on forest area change over the period 1975-2000 [4] estimated that Slovenia forests have grown with an average annual rate of 0.4 %. The area of forest has increased of over 116.000 ha in 25 years, passing from 1.085.000 to 1.201.000 ha. The spatial pattern of forest area change is shown in Figure 13. The increase of forest area is due mainly to abandoned marginal farmlands.

Other important aspect that strengthen the potential sustainable supply of fuelwood in the years to come are the steady growth in forest stocking, which grew from 207 million m^3 in 1990 to 286 million m^3 in 2003, and the similar growth of the mean annual increment, which increased from 5.3 million m^3 in 1990 to 7.3 million m^3 in 2003 [11] (Figure 14).

In fact, the current allowable cut, which is the basis of the sustainable productivity assumed in this study, is very conservative, as it represents less than 60 % of the estimated annual increment.

It is justified to believe that the potential supply of woodfuels could more than double today's extracted volumes without limiting the timber industry or affecting the growing stock. On the contrary, fuelwood production especially through thinning operations would have a positive effect on forest health condition, on stands resistance to extreme weather conditions and on the quality of timber products.

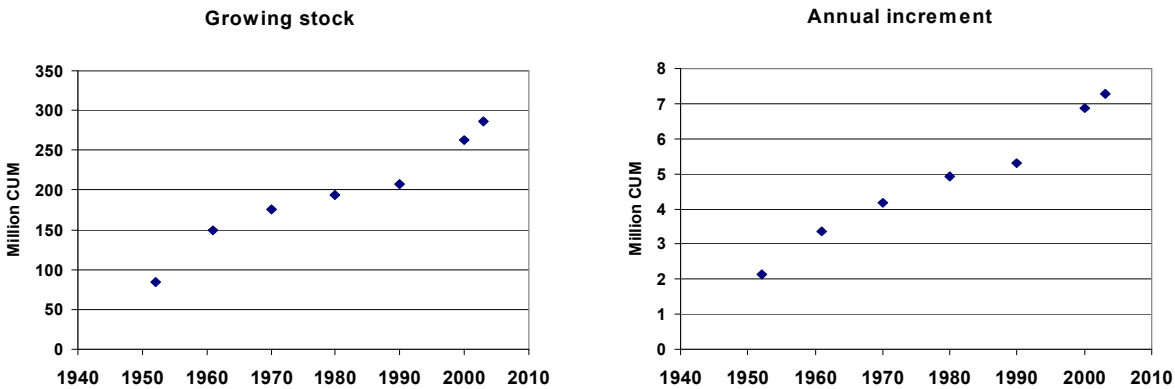

Figure 14: Change of growing stock and mean annual increment

3.3.4 Non-forest areas

Wood stock and productivity in non-forest classes

Slovenia landscape is rich in woody biomass both within and outside forest areas. In addition, dense natural vegetation builds up in marginal abandoned farmlands in a continuous process that produces a net increment of the country's woody biomass resources. However, although it is known that significant part of fuelwood for household use is collected by farmers in their own non-forest lands, no information existed on the wood stock and productivity of these areas and on the current and potential role of non-forest areas in the total fuelwood production and consumption in Slovenia.

This item represented a major information gap in the Supply Module. In order to acquire basic reference values, and therefore to fill such information gap, a survey of non-forest areas was carried out. It was based on available ortophotos, the new Land Use Map (2002) and minimal field sampling. Summary results are given in Table 4.

The results achieved give us the first objective estimation of wood stocking and annual increment outside forest areas in Slovenia.

Inevitably, due to the very heterogeneous character of non-forest landscapes, the variability is very high, as shown by the coefficients of variation close to 100 % for several classes (which means that the standard deviation and the mean have similar values). Preliminary statistical analysis indicate that the confidence interval, calculated through logarithmic transformation at 90 % confidence, ranges between 0.3 and 26 m^3/ha for stocking (mean 15.5) and between 0.12 and 3.21 for the increment (mean 0.53).

The productivity, in terms of fuelwood volume annually exploitable, has been estimated as 70% of the annual increment, which gives a national total of some 276 000 m^3/ha. The spatial distribution, by cadastral communities, of the estimated fuelwood productivity is shown in Figure 15.

Table 4: Summary results of non-forest woody biomass survey

Code	Land use classes	Total area (ha)	Mean Stocking		Mean Increment		Total stocking	Total increment
			m^3/ha	CV %	m^3/ha/yr	CV %		
1100	Fields and gardens	213,985	3.0	119.56	0.10	121.69	649,466	21,958
1221	Intensive orchard	5,049	33.1	78.84	1.12	79.53	167,004	5,675
1222	Extensive orchard	19,849	32.1	48.94	1.14	47.83	637,212	22,591
1310	Intensive meadow	159,652	8.5	82.43	0.28	85.27	1,358,629	44,579
1322	Extensive meadow	187,930	19.5	73.74	0.67	73.77	3,670,979	126,499
1410	Re-growth on old farmland	25,246	57.4	63.11	2.16	59.84	1,449,435	54,498
1500	Mixed use (agric / forestry)	18,953	94.6	48.82	3.30	46.58	1,792,963	62,624
3000	Urban and built up areas, roads	108,194	15.6	80.44	0.51	83.75	1,691,725	55,430
		738,858	**15.5**		**0.53**		**11,417,413**	**393,854**

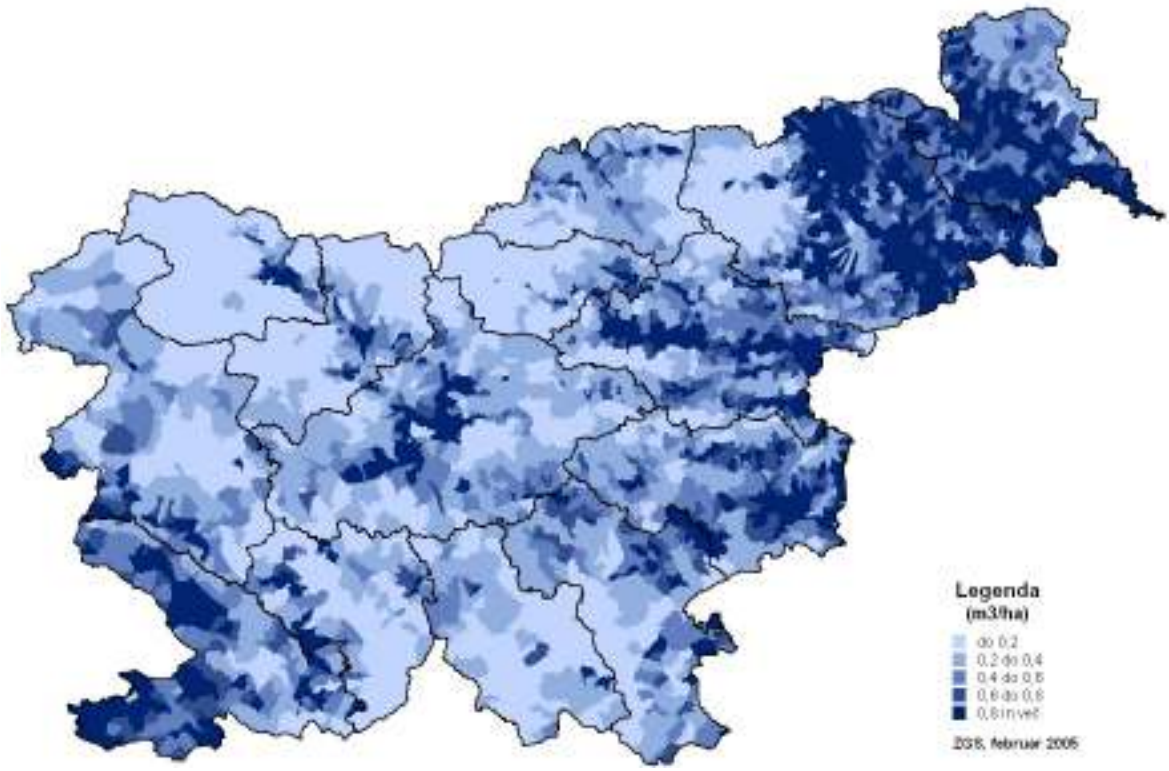

Figure 15: The average fuelwood productivity of non-forest land - m^3/ha year

3.3.5 Wood Residues in Wood processed Industry

The best available information on wood residues from forest industries and their use for energy is in the 1998 study by SFI [10], which provide summary data with reference year 1995. For that year the total annual production of wood residues was estimated at 722 000 m^3. The new data on wood industries that could be acquired in the frame of the project was limited to number of employees of primary wood industries (sawmills) and secondary wood industries (mainly furniture making) by settlements. This dataset is mapped in Figure 16.

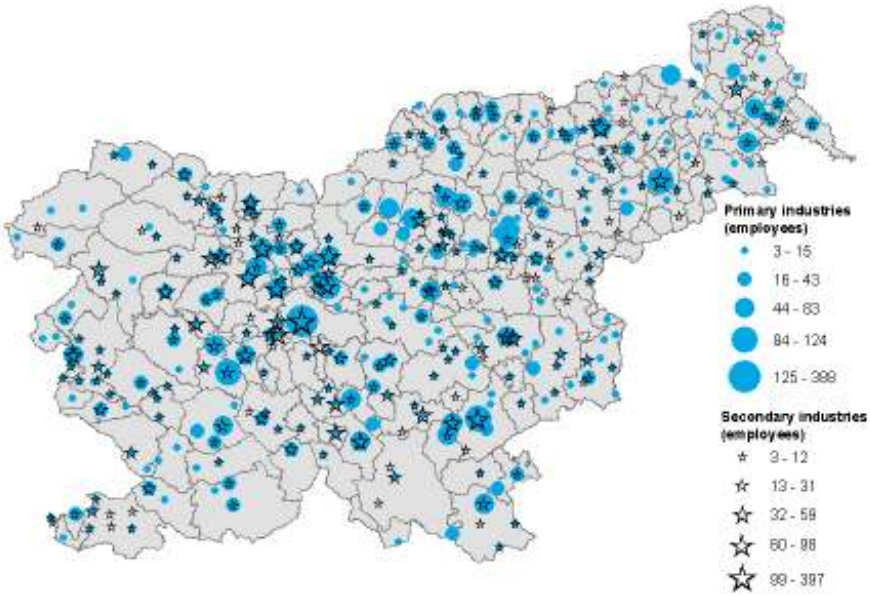

Figure 16: Distribution of primary and secondary wood processing industries

In the development of SWEIS the production of wood residues after 1995, reference date for [10], was estimated to decrease with direct correlation to the reduction trends of industrial wood products, as reported by the Slovenia Statistical Office [14]. Accordingly, the production at year 2002 was tentatively estimated at some 553 000 m^3.

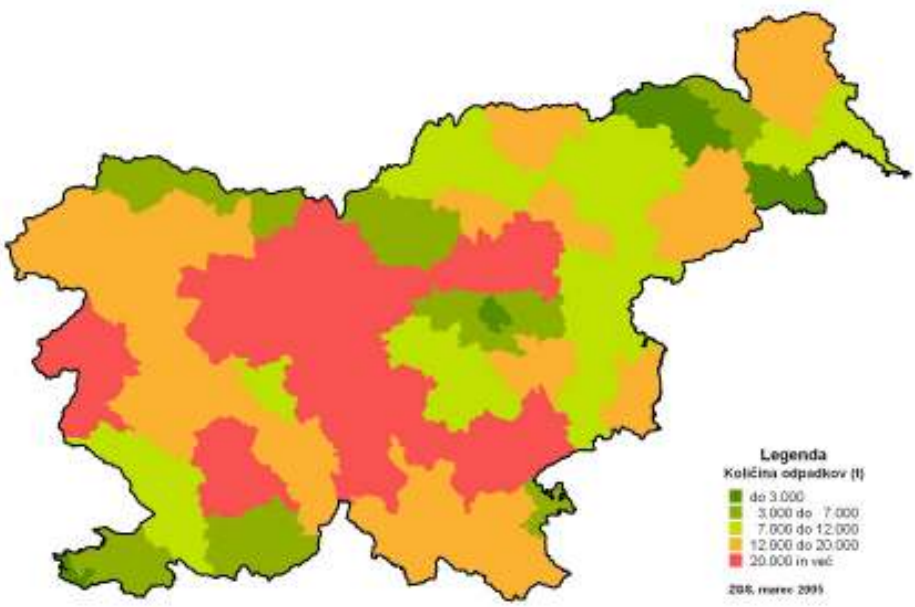

Figure 17: Quantities of Wood Residues in Wood processed Industry, according to new data collected by Slovenian Forestry Institute (2004) (The sum for Slovenia amounts 850.000 m^3.)

3.4 Integration module

Because of lack of information on wood industrial residues the integration of supply and demand parameters was limited to supply/demand balance analyses between household fuelwood consumption and forest/non forest production. Several scenarios were created on the field of the fuelwood supply, considering current and potential forest (allowed/actually extracted wood assortments and species groups) and non-forest productivity.

Table 5: The most important data on the apartments/houses and annual consumption of energy and fuelwood on the State level

Total population		1.963.341
Number of inhabitants using fuelwood as exclusive or primary fuel for heating		592.418
Number of dwellings using fuelwood as exclusive or primary fuel for heating		233.909
Total surface of dwellings using fuelwood as exclusive or primary fuel for heating	(m^2)	17.256.817
Total surface of occupied dwellings using fuelwood as exclusive or primary fuel for heating	(m^2)	14.107.542
Total heated surface of occupied dwellings using fuelwood as exclusive or primary fuel for heating	(m^2)	11.618.290
Net volume of wood needed for house heating (77 %) plus water heating and cooking (23 %) – heated surface and occupied dwellings)	(m^2)	1.282.017

Table 6: Fuelwood consumption/production balances between annual estimated household consumptions and annual fuelwood production from forests and other land uses (currently or potentially used as fuelwood). Values in '000 m^3.

Fuelwood Production				Household Fuelwood Consumption	
Forests			Non-forest land uses	1,280	
Allowable cut of all assortments (timber and non-timber)		3,927	394 [1]	Balance (production <minus> consumption)	
Allowable cut from management plans					
1 - Non-timber assortments commonly used as fuel (group BCD)[4]		1,407			404
2 - Non-timber assortments of all species (all conifers included)		2,148			1,144
Volumes actually extracted [3]	Avg 1991-2001	Recent cut rate	276 [2]	Avg 1991-2001	Recent cut rate
3 - Non-timber assortments commonly used as fuel (group BCD)[4]	840	~ 1,000		- 164	~ 0
4 - Non-timber assortments of all species (all conifers included)	1,283	~ 1,500		280	~ 500
Actual cut of all assortments (timber and non-timber) . Ten-years average 1991-2001	2,366	2,800			

[1] Estimated Mean Annual Increment of woody vegetation in non-forest land uses.

[2] Exploitable volume estimated as 70 % of Mean Annual Increment

[3] During the period 1991-2001 the actual cut was 54 % of allowable cut in private forests and 76 % in state forests). In recent years the cut amount reached approximately 2.8 million m^3 [11].

[4] See Annex 5 for explanation.

Shaded balances are shown in Figures 1 and 2 below.

Fuelwood consumption levels are based on elaboration of 2002 census data and specific studies on household energy requirements (see section on Demand Module below and Annexes 2 and 3). This estimation is an original contribution of the project as reliable statistics on fuelwood consumption did not exist.

Fuelwood production data are based on:

Forestry statistics maintained by the Slovenia Forestry Service. The data here presented summarize the very detailed and accurate data kept at forest compartment level (Annex 5). Fuelwood production was estimated as allowable cut according to the ten-year management plan 1991-2001 and also according to the amount of wood actually extracted during the same period. Two assortment categories were considered (all non-timber quality): today's preferred species groups and all species groups (see Annex 5). Since the consumption estimate refers to year 2002, an attempt was made to update the "extraction factor" according to recent years' data (where it seems to be significantly higher). Although the recording of forestry data is very accurate in the country one should consider that this is limited to "official data" and obviously missing illegal or simply unrecorded felling.

New estimates of fuelwood production in non-forest areas. This estimation was based on the results of the survey carried out by the project (see Section on Supply Module below and Annex 6).

Potential fuelwood production

In Slovenia there are two fairly independent woodfuel circuits [12]:

- a “household” circuit that uses mainly fuelwood (and marginally charcoal) from forests and farmlands, and
- an “industrial” circuit that uses mainly residues from wood industries and paper mills.

Table 6 refers to the first one, analyzing the relation between the forest/non forest productivity of fuelwood assortments and current household consumption. In this context, and concerning the potential fuelwood production capacity, the following conclusions may be drown:

Concerning the wood products actually extracted from the forests (points 3 and 4 in Table 6) there is an approximate zero balance between the household consumption and the production from forests (limited to the traditionally preferred wood assortments) and from other land uses. It shows also that at current extraction rates some half million m^3 of wood could be used for additional energy applications. These applications would be primarily industrial because this surplus wood is mainly coniferous and hence not suited for household consumption [11].

Concerning the entire allowable cut (points 1 and 2) there is a potential surplus that ranges between 0.4 and over 1.1 million m^3. These surpluses must be considered as very conservative because they refer to an allowable of 4 million m^3 while it is known that the annual increment of Slovenia forests is above 7 million m^3 [11]. This means that the true sustainable potential could easily be well above two million m^3 per year without affecting forest sustainability nor wood industries; on the contrary, a more intense exploitation for energy purposes, which would include the execution of thinning operations, would be highly beneficial for the health of the forests and for the quality of timber products.

However, the real problem is not with the exploitable biomass from Slovenia forests, which are increasingly overstocked, but rather with the low motivation of forest owners to implement management prescriptions. In this respect it is necessary to promote forest owners associations to combat property fragmentation and to raise forest owners’ economic interest by internalizing the multiple social, economic and environmental benefits deriving from an increased production of woodfuels.

Spatial patterns of fuelwood balance

Figure 18 shows current fuelwood consumption/production situation. The map reports the balance between the actually extracted wood from preferred fuelwood species (all non-timber assortments from hard broadleaved and Larch) plus the wood produced outside forests and the household consumption of fuelwood. The national summary value is shown in Table 6 (row 3, light grey). The negative value of this category, - 164 000 m^3, is due to the low cutting rate of the first half of the 90’s. Current extraction is more likely around 1 million m^3, thus balancing (together with the estimated non-forest fuelwood) the household demand.

Figure 19 shows the potential sustainable surplus of woody biomass on which the expansion of wood energy could be based. The map reports the balance between the total allowable cut of all non-timber assortments from all species plus the wood produced outside forests and the estimated household fuelwood consumption. The national summary value is shown in No 2 in Table 6 (darker grey). This estimation is very conservative since it is based on a total allowable cut (timber and non-timber assortments) of less than 4 million m^3, while it is known that Slovenia forests have an annual increment above 7 million m^3. Therefore, the real amount of wood available for energy use (here estimated at 1.144 million m^3) could be more than doubled without interfering with the timber and fiber industries and remaining within the limits of sustainable forest productivity.

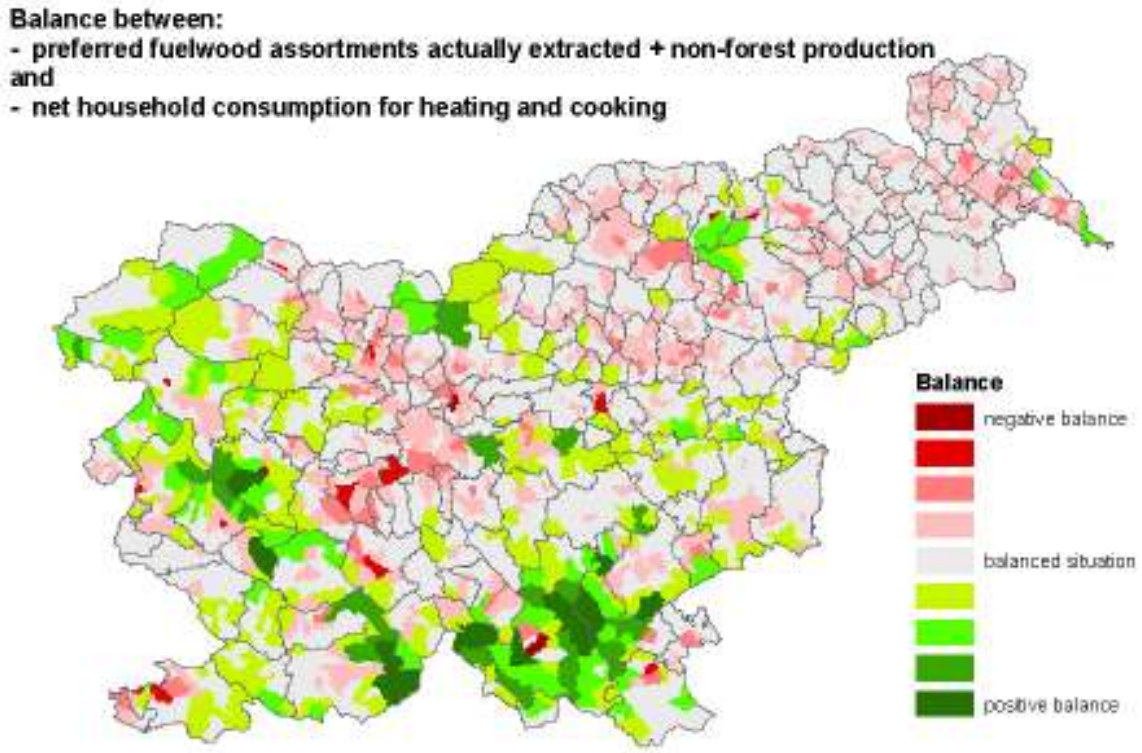

Figure 18: Spatial pattern of current fuelwood production/consumption situation

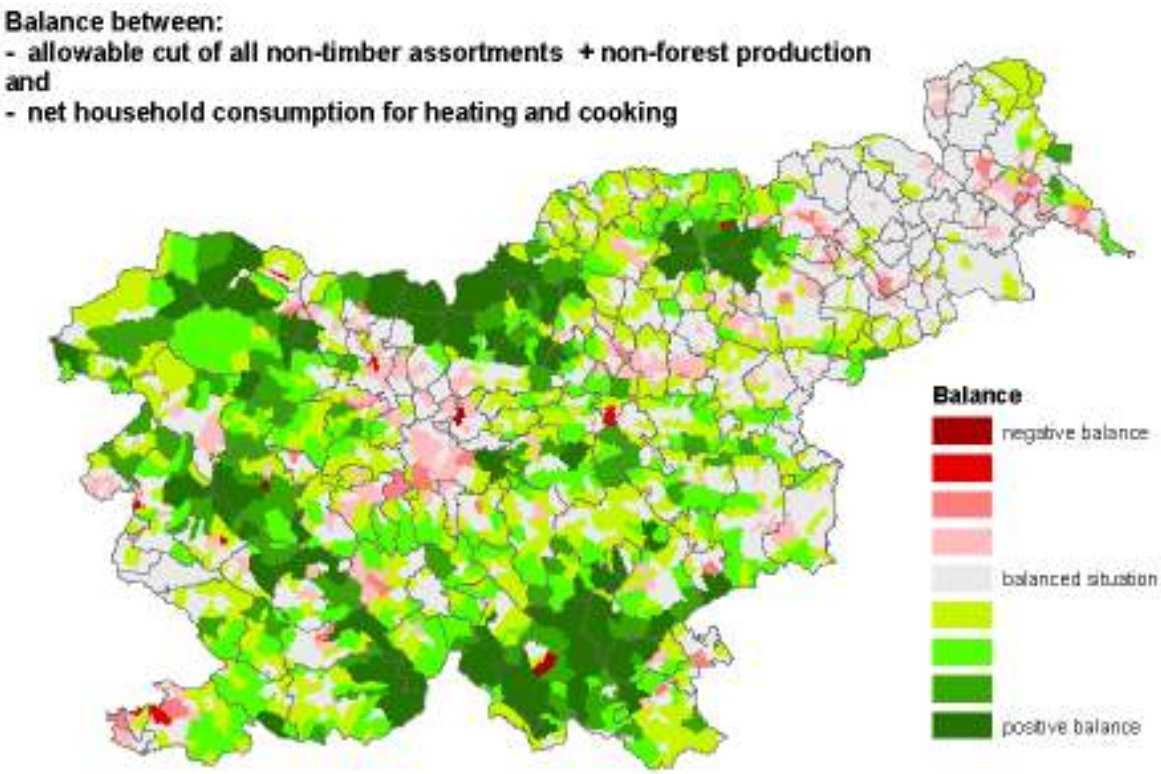

Figure 19: Spatial pattern of potential fuelwood production/consumption balance between current non-timber allowable cut plus the estimated non-forest productivity and household consumption

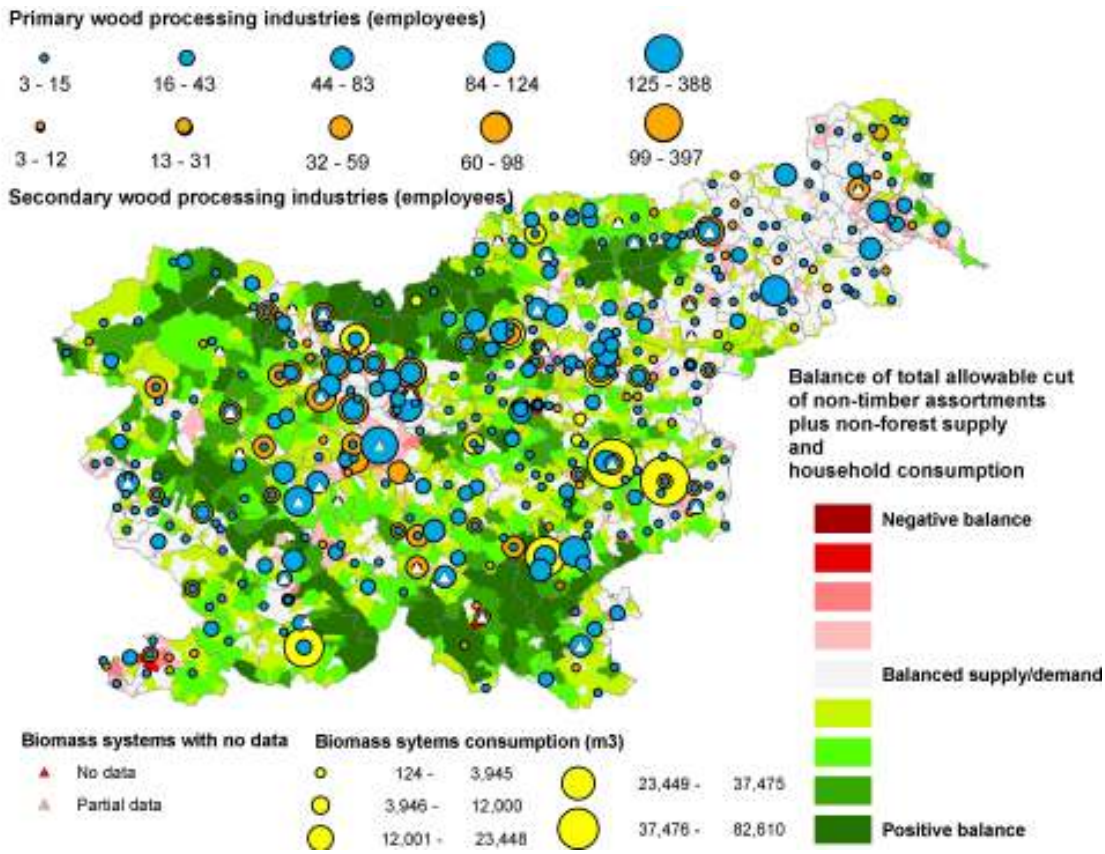

Figure 20: Distribution of wood processing industries and biomass systems on the background of the potential sustainable supply of woody biomass shown in Figure 19

Figure 20 shows the distribution of biomass systems, including district heating systems, combined heat and power plants and other not specified wood-based systems, as well as primary and secondary wood processing industries. Most biomass systems are fed by residues from wood processing industries and many of them are located within the industries themselves to supply part of the energy needed for their production processes. In order to visualize the areas suitable for the installation of new plants, the existing industrial plants are shown on the background of the potential sustainable supply of woody biomass (shown in Figure 19).

3.5 Priority zoning

As example, one priority zoning analysis was carried out. This concerned the areas of the country most suitable for the implementation of field programmes oriented to:

1. the promotion of forest owners associations,
2. the increase of woodfuel production,
3. the execution of thinning in overstocked forests.

The priority zoning was determined through the combination of the following three aspects:

- high wood surplus considering current local consumption and potential sustainable productivity (see Figure 19),
- high fragmentation of forest property (see Figure 12),
- high fraction of forests at early and late pole stages, which are the stages of forest growth that require thinning operations (see Figure 21).

Priority areas were determined by means of an indexing approach in which the range of values of each thematic aspects was first ranked into 5 categories, reflecting a priority level in respect of the problem under analysis (rank 1= low priority; rank 5= high priority).

In the example carried out, the following indices were created:

- Supply/demand balance index: (higher (+) balance = 5; lower (-) balance = 1)
- Property fragmentation index (high fragmentation = 5; lower fragmentation = 1)
- Thinning stage index (higher % of forest at pole stage = 5; lower % = 1)

The combined index, which may be called Thinning Priority Index (TPI) was calculated as follows:

$$TPI_j = \sum_{1}^{3} I_i * P_i$$

where,

TPIj = thinning priority index for each KO "j"

Ii = index for each of the 3 variables used in the analysis, ranging from 1 to 5

Pj = weights, set to 1 in this case

The resulting TPI was again ranked into 3 levels, as shown in Figure 22, where the new high priority index grouped the areas with high indices in respect of all three parameters.

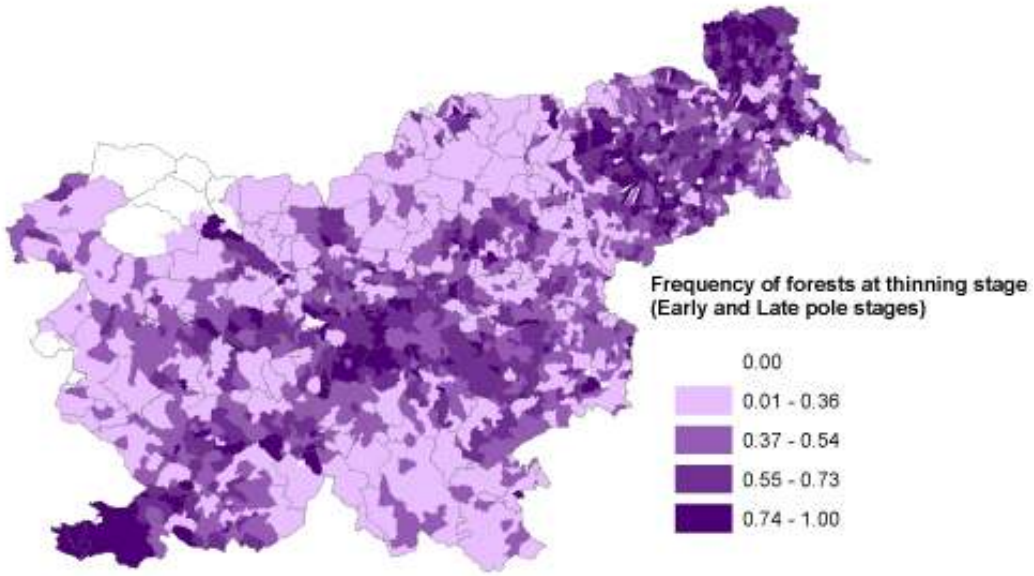

Figure 21: Fraction of cadastral communities' forests requiring thinning operations

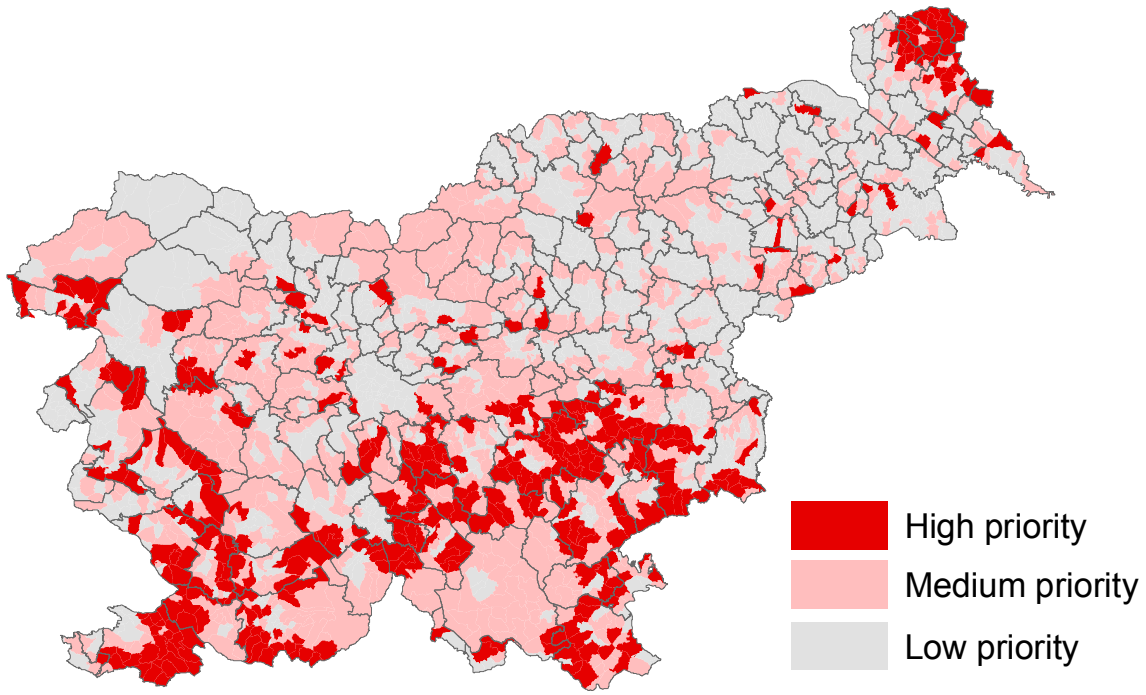

Figure 22: Example of priority zoning derived from the combination of three thematic elements: high property fragmentation; high wood surplus considering current local consumption and potential sustainable productivity; high fraction of forests at thinning stage.

As discussed earlier, WISDOM is conceived as a strategic planning tool to be maintained, deepened and, most important, used by wood energy planners. In this respect, the analytical conclusions and priority zoning so far defined should be considered as the first steps in the analysis of this sector and not the conclusion of a process. The priority zoning carried out, for instance; was an example of analysis rather than the definition of true priorities. Many other aspects can, and hopefully will, be mapped by wood energy planners using the WISDOM geodatabase.

3.6 Slovenia Wood Energy Information System (SWEIS)

Several studies were conducted in the recent past on various aspects of wood energy in Slovenia [5] [6] [10] but the information remained largely fragmented and incomplete. A comprehensive vision of the wood energy sector was missing and, most relevant, there was no clear perception of the forest role in the energy sector and of the share of wood fuels in the national energy mix.

Particularly weak was the information on the level of fuelwood consumption in the household sector, which is by far the main user of wood energy, on the role played by non-forest land uses as sources of fuelwood in rural areas and on the production/consumption of industrial wood residues. The investigation carried out in the framework of the project allowed to fill the information gaps for the fist two items, at least for years of reference data (2000 – 2002) while the third one remained rather approximate.

Additional data from a wide variety of sources was then harmonized and aggregated to produce a first coherent overview of current levels of woodfuels production, import, export and consumption in Slovenia [2] [11] [12] [14]. This information constitutes the Slovenia Wood Energy Information System (SWEIS), which is summarized in Table 7.

SWEIS data is complete for year 2002, for which all components could be assessed. Still missing are the time series of household and industrial consumption, which prevented the computation of total production and consumption estimates for the other years and the estimation of trends.

Concerning the estimates at year 2002, these were computed as follows:

- Insertion of the available information on import and export;
- estimation of household consumption (see WISDOM analysis);

- estimation of industrial consumption;
- estimation of industrial production;
- insertion of charcoal production data;
- estimation of fuelwood production in non-forest lands (see WISDOM analysis);
- finally, calculation of fuelwood production from forest resources.

This procedure of estimation was followed because specific fuelwood production statistics did not exist and under the consideration that fuelwood production is demand-driven and not independent. In fact, in a general national context woodfuel production is equal to woodfuel consumption (minus export plus import), since large accumulations and storage beyond the annual consumption are uncommon.

Besides the estimation of consumption levels, which are essential to the development of the SWEIS, a comprehensive study was done, as part of the WISDOM analysis, to assess the current and potential sustainable woodfuel production and its spatial distribution. Specifically, the following aspects were analyzed in great detail:

the actual and potential sustainable production, from Slovenia managed forests, of wood assortments of non-timber quality suitable for wood energy uses;

the stocking and productivity of woody biomass on non-forest land uses, including abandoned farmlands, mixed agro-forestry systems, meadows, orchards, urban areas, croplands, etc.).

Table 7: SWEIS - Slovenia Wood Energy Information System. National level statistics (in 000 m3)

	1995	1996	1997	1998	1999	2000	2001	2002
Production								(1,952)
Fuelwood								
Forests								1,012[3]
Other landuses								276
Industries (residues)	722	695	669	644	620	597	575	553
Charcoal[1]	1.2	1.2	1.3	1.4	1.4	1.6	1.5	1.9
Black Liquor	109	109	109	109	109	109	109	109
Import								(3)
Fuelwood	12			10	17	2	1	1
Charcoal[1]	2.2	2.1	2.0	1.9	1.9	1.7	1.7	1.8
Black Liquor								
Export								(60)
Fuelwood	75			89	75	62	55	60
Charcoal								
Black Liquor								
Consumption								(1,895)
Household Sector								
Fuelwood								1282
Charcoal[1]	3.4	3.3	3.3	3.3	3.3	3.3	3.2	3.7
Black Liquor								
Other Sectors (industrial, public, etc.)								
Fuelwood			432					500[2]
Charcoal								
Black Liquor	109	109	109	109	109	109	109	109

Notes:

Figures in bold represent reference values. Other figures are extrapolated values.

[1] Estimated wood used for charcoal production. Conversion factor: 1 t of charcoal = 6 m^3 of wood.

[2] Available 2002 data on 31 biomass systems total 391 102 m^3 . Value tentatively expanded to 500 000 m^3 to include the 34 biomass systems for which consumption data is missing.

[3] The Fuelwood from forests was estimated as total production (total consumption + export – import) minus all other production values (Fuelwood from other land uses and industries, Charcoal and black Liquor).

Table 7 accounts for the wood that is used for energy purposes, highlighting the importance of this wood product and referring primarily to the forestry sector. Another essential aspect concerns the contribution of this sector in terms of energy. It is in fact equally important to evaluate the contribution of this sector to meet the national energy demand and to assess its future potential. In order to provide the first elements of analysis, Annex 7 gives the values of Table 7 converted into energy units. A direct comparison between SWEIS energy estimates and the Slovenia Yearbook energy statistics cannot be done, since the energy balance doesn't report woodfuels individually but group all renewables and municipal/industrial waste together.

Again, like for forestry statistics, wood energy is seen as a minor item which receives little attention. It is essential and highly recommended that in future statistical surveys of both forestry and energy sectors specific attention be given to the production and consumption of individual woodfuels.

Key findings resulting from the elaboration of SWEIS are the following:

Approximately 1.9 million m^3 of wood were used as an energy source in Slovenia in 2002, of which 1.3 by the household sector 0.6 by the industrial sector, including biomass energy systems.

The comparison of these consumption estimates with existing fuelwood production data from SFS Statistics lead to the conclusion that "Fuelwood" reported by the Statistical Office of Slovenia (Table 2) represents only a small fraction (some 20 %) of the volumes actually used as fuel.

The gross inadequacy of the "official" fuelwood production data shows in some way that the energy use is not adequately recognized and studied in the national context. Moreover, this situation misleads the analysis of forest role in the energy sector as well as the analysis of the share of wood fuels in the national energy mix.

It appears that there are two fairly independent woodfuel circuits: one household circuit that use mainly fuelwood from forests and farmlands (and marginally charcoal) and one industrial circuit that use mainly residues from wood and pulp and paper industries.

4 Conclusions

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The demand for woodfuels is concentrated on fuelwood (the production and use of charcoal being marginal) and on rural areas. Large part of fuelwood trade is informal as it is either collected by farmers in their own lands and forests or bought locally. Most demand comes from households for heating purposes. Other uses such as district heating and combined heat and power plants (CHP) are still marginal but may grow as viable energy policy alternatives.

Supply issues

It is justified to believe that the potential supply of woodfuels could more than double today's extracted volumes without limiting the timber industry or affecting the growing stock. On the contrary, fuelwood production especially through thinning operations would have a positive effect on forest health condition, on stands resistance to extreme weather conditions and on the quality of timber products.

The current allowable cut (4 million m^3/yr), which is the basis of the sustainable productivity assumed in this study, is very conservative, as it represents less than 60% of the estimated annual increment (over 7 million m^3/yr). Moreover, of the 4 million m^3 of the annual allowable cut only 2.4 were actually extracted on average during the period 1991-2001. Although in recent years the cut fraction has increased to some 2.8 million m^3, the biomass built-up in Slovenia forests represents a serious issue and a threat to the health of Slovenia forests and to the quality of its timbers.

The assortment class "Non-timber assortments commonly used as fuel" represents today's main "forest" fuelwood supply for household use. It is likely that in addition to the amount reported there is a certain amount of "informal" and unrecorded forest extraction.

The assortment class "Non-timber assortments of all species" represents the potential wood energy supply for household and industrial use in the near future, especially if the actual extraction will be increased to match the sustainable production capacity or at least the conservative levels defined by forest managements' allowable cut.

The survey of non-forest woody biomass, conducted in the framework of the project, produced the first objective estimation of wood stocking and annual increment outside forest areas in Slovenia. Survey results indicate that the standing volume in non-forest areas (including meadows, abandoned agriculture, agro-forestry, urban areas, orchards, etc.) amounts to some 11.5 million m^3, with an estimated annual increment of some 400 000 m^3. From this resource, approximately 300 000 m^3 are probably used as fuel every year[2].

The best available information on wood residues from forest industries and their use for energy is in the 1998 study by Slovenian Forestry Institute (SFI) [10], which provides summary data with reference year 1995. For that year the total annual production of wood residues was estimated at 722 000 m^3. Because of decreasing of industrial wood production, as reported by the Slovenia Statistical Office [14], the annual production of wood residues at year 2002 was tentatively estimated at some 553 000 m^3.

[2] These values represent the first estimation ever done of non-forest woody biomass. However, since the variance of tree cover outside the forest is extremely high, the margin of error is very wide and they should be considered indicative only.

Demand issues

At present, almost the entire consumption of fuelwood in Slovenia is absorbed by household uses and principally for heating, for which this fuel provides about one third of the national energy demand. In spite of its relevance, reliable statistics on fuelwood consumption do not exist.

To fill the critical information gap on fuelwood consumption by Slovenia households, new estimates were produced using data from the 2002 Census on dwellings, which allowed estimating the saturation of fuelwood use for space heating by cadastral communities, and previous studies on average energy requirements for space heating and cooking.

The information available on industrial wood energy consumption was fragmented and recent data largely incomplete. Such information was composed by data on 5 district heating systems, 5 combined heat and power plants (CHP) and on 55 industries that have wood-fed boilers of which 21 with some consumption details and 34 without details except their location.

The total consumption from available biomass systems data at year 2002 amounts to some 390.000 m3. This is incomplete since for many units the consumption is not yet known. In consideration of some other references we estimated the consumption of industrial biomass systems on the amount of some 500.000 m^3.

5 Proposed follow-up action

The information so far collected and processed covers the main aspects of wood energy in Slovenia, providing a coherent overview of woodfuel production and consumption patterns.

However, some dataset are preliminary and/or incomplete and other aspects of the analysis need to be further developed. Therefore it is recommended to continue to collect relevant information and to further develop and deepen WISDOM Slovenia with special attention to the following:

- fuelwood consumption time series for the household sector, or related indicators; this information will allow to assess current consumption trends and to elaborate possible scenarios for the near future;
- climatic variables related to heating energy requirements; this information will allow to assess with higher accuracy the heating requirements in various climatic zones of the country and to better estimate fuelwood consumptions;
- new and more complete data on the production of wood residues by forest industries and on their use; the dataset currently available on this topic is incomplete;
- more complete data on woodfuel consumption and energy production by biomass plants.

It is also recommended to complement the study with:

- the analysis of trade and market aspects and other economic parameters as soon as these will be available and
- the analysis of accessibility factors that limit the full exploitation of the country's wood energy potential from a physical, legal and economic perspective.

Official national statistics on woodfuels are incomplete and do not reflect the true role that wood energy plays in both forestry and energy sectors. This is a major limitation in the development of this sector. It is therefore strongly recommended that the Statistical Office of Slovenia define, in collaboration with forestry and energy authorities, a specific set of wood energy variables and that specific attention be given to the production and consumption of individual woodfuels in future statistical surveys of both forestry and energy sectors.

Information which SFS data bases have to provide to keep SWEIS

RESOURCES OF WOOD BIOMASS FOR ENERGY

Forests:

- the surface of forests;
- forest surfaces of different development stages ;
- wood stock and wood increment - according to species and thickness of trees;
- possible annual cut;
- skidding conditions (openness of forests with roads, skidding distances, inclinations of terrain);
- forest surfaces according to ownership (state, community, private forests).

Non-forest lands:

- surfaces of different kinds of non-forest lands;
- average wood stock and wood increment per hectare according to different kinds of non-forest lands.

Wood industry

- the quantity of (non-contaminated) wood residues, suitable for production of energy

Other sources:

- the quantity of produced charcoal;
- the quantity of black liquor in cellulose production.

LOCATIONS OF WOOD BIOMASS CONSUMPTION FOR ENERGY

Households:

- number and surface of dwellings, using mostly or exclusively wood for heating;
- share of occupied dwellings and the share of heated surfaces in occupied dwellings;
- energy needs for heating dwelling (by m2) in different climatic conditions;
- share of households which use wood for cooking and water heating;
- energy needs for cooking and water heating;
- fuel value of wood;
- consumption of charcoal.

Industry and other economic sectors:

- consumption of logs for energy;
- consumption of wood residues for energy;
- consumption of charcoal
- consumption of black liquor.

Import

- quantity of fuelwood,
- quantity of charcoal,
- quantity of black liquor.

Export

- quantity of fuelwood,
- quantity of charcoal,
- quantity of black liquor.

Data regarding forests, non-forest lands and households need to be maintained on the cadastral communities' level, data regarding wood industry on the level of municipalities and data regarding import and export on the state level.

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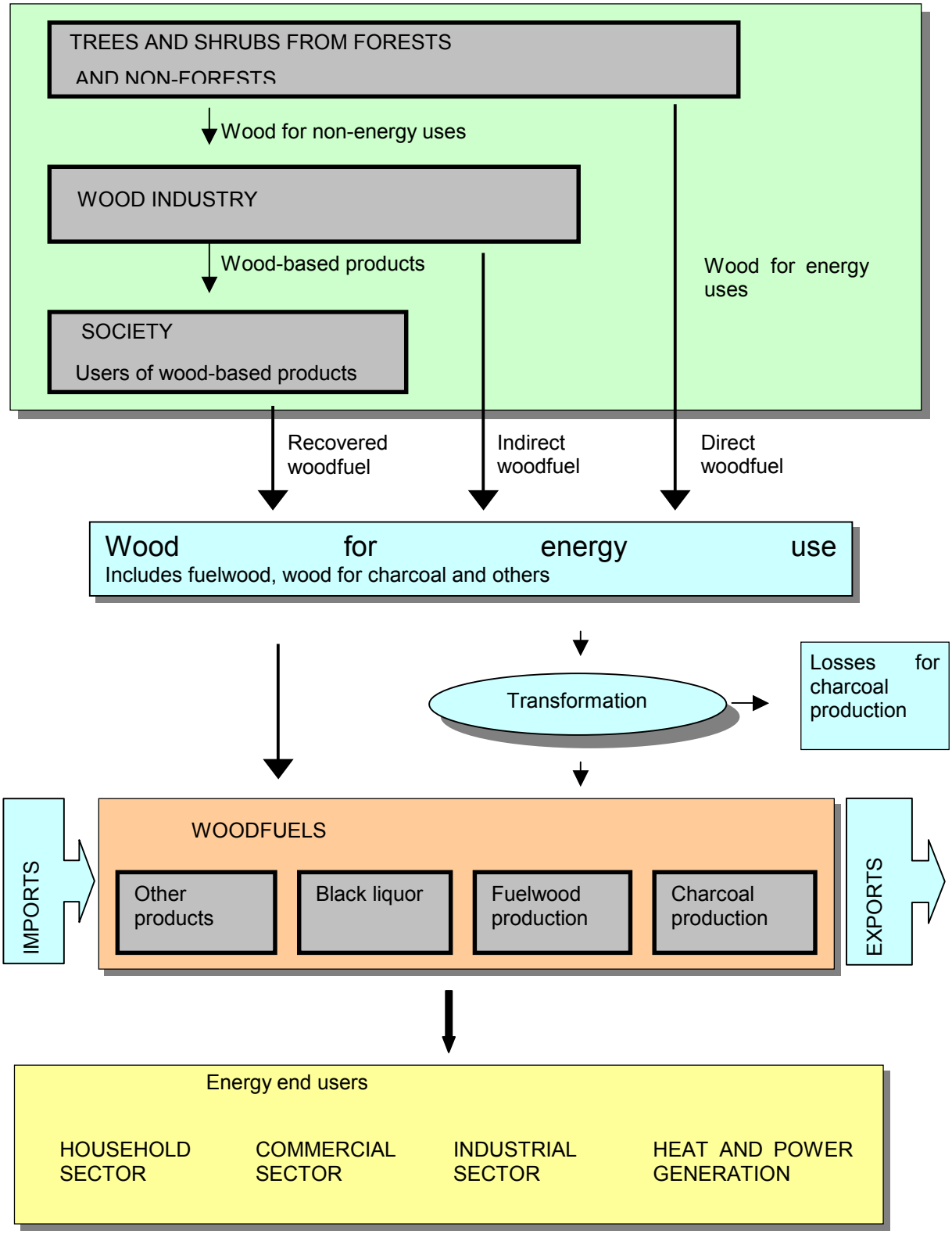
Appendices

Annex 1. Unified Wood Energy Terminology – Conceptual view



Annex 2. Summary of statistical data received from Statistical Office of Slovenia

Variables	Administrative Units (67)	Municipalities (192)	Cadastral communities (KO) (2696)	Settlements (5974)
Urban population				X
Rural population				X
Total Population			X	
No. of dwellings by size classes	X	X	X	
No. of dwellings (and people) using exclusively wood for heating	X	X	X	
No. of dwellings (and people) using wood as primary fuel for heating	X	X	X	
No. of dwellings (and people) using wood as secondary fuel for heating	X	X		
No. of dwellings by heating system (district heating; boiler for several buildings; central [building]; central [apartment]; stoves; no heating system]	X	X		
Dataset to be used to build the profile of fuelwood users: Limited to the subset that uses exclusively or primarily wood for heating				
No. of dwellings by type of housing (one-dwelling house; apartment; other)	X	X		
No. of dwellings by ownership (private property; property of state or public entities; other)	X	X		
No. of dwellings by number of persons (1; 2; 3-5; >5) and No. of households in dwellings	X	X		
No. of dwellings by use of the dwelling (residence; res.& business; business; temporary and permanently unoccupied; leisure; seasonal)	X	X		
No. of dwellings by size classes (<50 m^2; 50-80; 81-110; >110)	X	X		
No. of dwellings with central heating	X	X		
No. of dwellings by type of heating system (central [building]; central [apartment]; stoves]	X	X		
Secondary fuel used for heating - after wood - (coal; fuel oil; electricity; nat. gas; lpg; other)	X	X		
Household reference persons by tenure (owner; tenant; other)	X	X		
Household reference persons by level of education	X	X		
Household reference persons by activity status (employed; self-employed; farmer; unemployed; pensioner; other)	X	X		
Household reference persons by means of transport to work (foot or cycle; bus or train; other)	X	X		

Data on agricultural holdings (census 2000)				
No. of farm holdings and household members	X	X		
Area under agric. holding (total land, utilized agric., abandoned, other non cultivated, forests, barren land)	X	X		
Supplementary activities in agr.h. (wood processing, tourism, cottage industry, forestry services, sale of wood products	X			
Broadleaves and coniferous wood products (logs, poles, pulpwood and boardwood, fuelwood)	X			
Fuelwood produced by holdings with forest	X	X		
Fuelwood produced by holdings without forest	X	X		

Effect of Confidentiality Policy:

The confidentiality policy, which imposes to hide records with very small numbers (for which individual entities –persons, firms, etc.- may be identified) had considerable effect on data at KO level and for some variables even at municipality level. In fact, in order to hide one KO within a municipality and to prevent the deduction of its values, a second KO within the same municipality, selected at random, is hidden.

Annex 3. Household fuelwood consumption estimates

Energy requirements for house heating only						
	Construction year	Requirements by type[1] kWh/m^2	# of dwellings	Group average kWh/ m^2	Group average kWh/ m^2	Total average kWh/ m^2
single family houses	before 1980	185	13203			
		144	1467			
		163	6449	175.8		
		111	0			
		210	1317		169.3	
		151	1518			
	after 1980	111	375			
		111	1820			143.4
		90	337			
apartments in blocks	before 1980	125	11720			
		98	1302			
		90	4565		109.7	
		84	2533			
		75	281			

[1] Depending on levels of insulation and maintenance.

Ref: Estimation of potential emission reduction in Slovenia. Final report. Ministry of Environment. 2002

Estimated additional requirements for cooking and water heating	**31%** of house heating

Ref: Ministry of Energy. Study for energy plan and 2030 projection.

Fraction of Occupied dwellings primarily using wood	0.814
Fraction of 'large dwellings' area (> 80 m^2) among primary wood users	0.59

Ref: [13] Census 2002 (file:Gozd_institut_t4_OB.xls)

Non-heated fraction of large dwellings	0.3

Reporting Consultant's estimate

Dwellings using wood (primarily) – Census 2002	
Total m^2	17,335,126
Estimated occupied and heated	
# 0f dwellings	234,898
Occupied dwellings	191,312

Main conversion factors						
1 kWh =	3600000	joules	=	3.6	MJ	
1 MJ =	0.277778	kWh				
1 CUM wood =	2900	kWh	=	10440	MJ	0.00 assumed efficiency loss
1 CUM wood =	0.725	tons	(average for *fagus* 20%humidity in Germany- average FAO)			
1 CUM wood =	1.54	m^3 stack wood				
1 kg wood =	3.366	kWh				
1 kg wood =	14.4	MJ	=	4.0000032	kWh	

	Energy requirements [1]		0.85	efficiency		0.65	efficiency	
			2465	=kWh/CUM		1885	=kWh/CUM	
	kWh/m^2	MJ/m^2	CUM/m^2	tons/m^2	Stackwood/m^2	CUM/m^2	tons/m^2	Stackwood/m^2
house heating	160	576	0.0649	0.0471	0.0999	0.08488	0.0615	0.1306
total heat. & cooking	208	748.8	0.0844	0.0612	0.1298	0.11034	0.0800	0.1698
Total Slovenia	kWh	TJ	CUM	tons	m^3 stackwood	CUM	tons	m^3 stackwood
house heating	1,858,926,454	6,692	754,128	546,743	1,160,197	986,167	714,971	1,517,180
total heat. & cooking	2,416,604,390	8,700	980,366	710,765	1,508,256	1,282,017	929,462	1,972,334
by dwelling (wf users)	kWh/dw	MJ/dw	CUM/dw	tons/dw	Stackwood/dw	CUM/dw	tons/dw	Stackwood/dw
house heating	9,717	34,980	3.9	2.86	6.1	5.2	3.74	7.9
total heat. & cooking	12,632	45,474	5.1	3.72	7.9	6.7	4.86	10.3
by inhabitant (wf users)	kWh/inh	MJ/inh	CUM/inh	tons/inh	Stackwood/inh	CUM/inh	tons/inh	Stackwood/inh
house heating	3,125	11,249	1.3	0.92	2.0	1.7	1.20	2.6
total heat. & cooking	4,062	14,623	1.6	1.19	2.5	2.2	1.56	3.3

[1] The estimated energy requirement for heating only used, as main reference, the weighted average for single-family houses (see previous page). The total energy requirement for heating and cooking was estimated by adding 30 % to the amount required for heating only.

Annex 4. WISDOM parameters by category

Attribute table of geodatabase KOWISDOM with national summary values. Values associated to Kadastral Obcina (KO) polygons (2697 records)

Spatial / administrative parameters

Field name	Description	unit	totals
SIFKO	Code of Kadastral Obcina (KO), numeric		
KO	Code of Kadastral Obcina (KO), text		
IMEKO	Name of KO		
MAINOB_COD	Code of main municipality (Obcina=OB) where the larger portion of KO is situated		
MAINOB_NAM	Name of main municipality (Obcina=OB) where larger portion of KO lies.		
AREA_HA	Total area of KO in ha (from digital map)	ha	2,028,533
OKRAJ_SIF	Code of OKRAJ administrative unit		
OKRAJ_IME	Name of OKRAJ administrative unit		
GGO	Regional code		

Demand-related parameters

Household

TOT_POP	Total population of KO		1,963,341
URB_POP	Fraction of urban population (as defined in settlement database)		
RUR_POP	Fraction of rural population (as defined in settlement database)		
INH_PRWF	Number of inhabitants using fuwlwood as exclusive or primary fuel for heating		592,418
SATURATION	INH_PRWF / TOT_POP (fraction of population using wood for heating)		
TOT_DW_PRWF	Number of dwellings using fuwlwood as exclusive or primary fuel for heating		233,909
GRS_M2_PRWF	Total surface (m2) of dwellings using fuwlwood as exclusive or primary fuel for heating (occupied and non)	m^2	17,256,817
M3_CONS_HC	Gross volume of wood needed for house heating (77 %) plus water heating and cooking (23 %), (occupied and non)	m^3	1,904,199
M3_CONS_C	Gross volume of wood needed for water heating and cooking (occupied and non)	m^3	439,431
M3_CONS_H	Gross volume of wood needed for house heating only (occupied and non)	m^3	1,464,768
OCCU_DW_PRWF	Number of occupied dwellings using fuelwood as exclusive or primary fuel for heating		190,517
OCCU_M2_PRWF	Total surface (m^2) of occupied dwellings using fuwlwood as exclusive or primary fuel for heating	m^2	14,107,542

HEATED_M2	Estimated heated surface (m^2) of occupied dwellings using fuwlwood as exclusive or primary fuel for heating	m^2	11,598,427
NETM3_CONS_H	Net volume of wood needed for house heating (77 %) (heated surface of occupied dwellings)	m^3	984,481
NETM3_CONS_C	Net volume of wood needed for water heating and cooking (23 %) (occupied dwellings)	m^3	295,344
NETM3_CON_HC	Net volume of wood needed for house heating (77 %) plus water heating and cooking (23 %) (heated surface of occupied dwellings)	m^3	1,279,825

Supply-related parameters

1 – Area and ownership (forestry data)

Field name	Description	unit	totals
TOTFORAREA	Total forest area from SFS database	ha	1,185,306
EXPLAREA	Exlpoitable forest area (categories 1 and 2 only). All other forest variables relate to this area.	ha	1,104,794
OWNERS	Number of forest owners (sum of owners from compartments database. Owners of forest plots in different compartments are double counted). Indicative only. Total count is approx. double of actual number		620,809
OW2_FRACT	Fraction of forest ownership 2: PRIVATE		
OW3_FRACT	Fraction of forest ownership 3: Other Officials (mainly religious institutions)		
OW5_FRACT	Fraction of forest ownership 5: STATE		
OW6_FRACT	Fraction of forest ownership 6: CIVIL (rural) COMMUNITIES		
OW236_FRAC	Fraction of NON-State forest ownerships (2, 3 and 6)		
OW2	Area of forest ownership 2: PRIVATE	ha	801,325
OW3	Area of forest ownership 3: Other Officials (mainly religious institutions)	ha	10,202
OW5	Area of forest ownership 5: STATE	ha	281,107
OW6	Area of forest ownership 6: CIVIL (rural) COMMUNITIES	ha	12,102
PH1AR	Area under Phase Development 1: Seedlings	ha	81,030
PH2AR	Area under Phase Development 2: Early pole stage	ha	87,427
PH3AR	Area under Phase Development 3: Late pole stage	ha	332,462
PH4AR	Area under Phase Development 4: Timber tree	ha	367,812
PH5AR	Area under Phase Development 5: Regeneration forest	ha	80,349
PH6AR	Area under Phase Development 6: Selection forest	ha	10,831
PH7AR	Area under Phase Development 7: Coppices	ha	43,384
PH8AR	Area under Phase Development 8: Former Coppices (under conversion to high forest)	ha	19,639
PH9AR	Area under Phase Development 9: Litter forest	ha	17,727
PH10AR	Area under Phase Development 10: Bush forest	ha	22,252
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 4 = slope >30% dist. <400 m (% of EXPLAREA)		
CL5	Accessibility class 5 = slope >30% dist 400-800 m (% of EXPLAREA)		
CL6	Accessibility class 6 = slope >30% dist. > 800 m (% of EXPLAREA)		

Supply-related parameters

2 – Area (land use data)

Field name	Description	unit	totals
TOT_LU_HA	Total area from Land Use map	ha	2,027,050
NonFor_Area	Total area from Land Use map - forest area (LU_2000)	ha	825,565
LU_1100	Land Use class 1100 Fields and gardens	ha	213,985
LU_1160	Land Use class1160 Hops fields	ha	2,501
LU_1211	Land Use class1211 Vineyard	ha	25,303
LU_1221	Land Use class1221 Intensive orchard	ha	5,049
LU_1222	Land Use class1222 Extensive orchard	ha	19,849
LU_1230	Land Use class1230 Olive trees orchard	ha	1,139
LU_1240	Land Use class1240 Other agr. plantations	ha	43
LU_1310	Land Use class1310 Intensive meadow	ha	159,652
LU_1321	Land Use class1321 Swamp meadow	ha	3,084
LU_1322	Land Use class1322 Extensive meadow	ha	187,930
LU_1410	Land Use class1410 re-growth on old farmland	ha	25,246
LU_1420	Land Use class1420 Forest plantation	ha	586
LU_1500	Land Use class 1500 Mixed use (agric. and forestry)	ha	18,953
LU_2000	Land Use class 2000 Forest and other wooded land	ha	1,201,485
LU_3000	Land Use class 3000 Urban and built up areas, roads	ha	108,194
LU_4100	Land Use class 4100 Swamp	ha	188
LU_4210	Land Use class 4210 Reeds	ha	1,084
LU_4220	Land Use class 4220 Other water logged areas	ha	1,472
LU_5000	Land Use class 5000 Dry areas with grass	ha	9,217
LU_6000	Land Use class 6000 Barren land without grasses	ha	28,777
LU_7000	Land Use class 7000 Water bodies	ha	13,314

Supply-related parameters

3 – Volume data

STOCKTOT	Total forest stocking of all diameter classes > 10 cm DBH	m^3	261,982,273
INCRTOT	Total annual increment of all diameter classes > 10 cm DBH	m^3	6,863,027
TOT_WOOD_G	Annual allowable cut of all timber and non-timber assortments	m^3	3,926,823
PREF_FW_G	Annual allow. cut of non-timber assortments of fuelwood species commonly used (group BCD; see Annex 5)	m^3	1,407,272
TOT_O_FW_G	Annual allowable cut of non-timber assortments of all species (all conifers included)	m^3	2,147,768
CONIF_O	Annual allowable cut of non-timber assortments of Coniferous species (Larix excluded)	m^3	689,556
LARIX_O	Annual allowable cut of non-timber assortments of *larix decidua*	m^3	16,379

HARDBR_O	Annual allowable cut of non-timber assortments of quality hard Broadleaved species	m^3	1,164,850
FWSPECIES	Annual allowable cut of Fuelwood assortments (selected hard Broadleaved species)	m^3	226,043
SOFTBR_O	Annual allowable cut of non-timber assortments of soft Broadleaved species	m^3	50,940
CUT_WOOD_G	Annual actual cut of all timber and non-timber assortments	m^3	2,366,222
CUT_P_FW_G	Annual actual cut of non-timber assortments of fuelwood species commonly used (group BCD; see Annex 5)	m^3	839,700
CUT_T_FW_G	Annual actual cut of non-timber assortments of all species (all conifers included)	m^3	1,283,494
CUT_CONI_O	Annual actual cut of non-timber assortments of Coniferous species (Larix excluded)	m^3	413,495
CUT_LAR_O	Annual actual cut of non-timber assortments of *larix decidua*	m^3	9,958
CUT_H_BR_O	Annual actual cut of non-timber assortments of quality hard Broadleaved species	m^3	697,242
CUT_FWSPP	Annual actual cut of Fuelwood assortments (selected hard Broadleaved species)	m^3	132,499
CUT_S_BR_O	Annual actual cut of non-timber assortments of soft Broadleaved species	m^3	30,299
NonFor_Stock	Stocking of non-forest land use classes	m^3	11,436,452
NonFor_MAI	Mean annual increment of non-forest land use classes	m^3	394,402
NFor_Prod	Estimated sustainable productivity in non-forest land use classes (MAI* 0.7)	m^3	276,081
CutPfw_NFP	Sum of actual cut of preferred FW species + non-forest productivity	m^3	1,115,781

Integration parameters

Production / consumption balances

Field name	Description	unit	totals
BGFWSP_H	Balance of gross allowable volume of fuelwood assortments: FWspecies <minus> NETM3_CONS_H	m^3	-758,438
BGP_FW_H	Balance of gross allowable volume of preferred non-timber assortments: Pref_FW_g <minus> NETM3_CONS_H	m^3	422,791
BGO_FW_H	Balance of gross allowable volume of all non-timber assortments: Tot_O_FW_g <minus> NETM3_CONS_H	m^3	1,163,287
BCUTFWSPH	Balance of gross actual cut of fuelwood assortments: FWspecies <minus> NETM3_CONS_H	m^3	- 851,982
BCUTP_FWH	Balance of gross actual cut of preferred non-timber assortments: Pref_FW_g <minus> NETM3_CONS_H	m^3	-144,781
BCUTO_FWH	Balance of gross actual cut of all non-timber assortments: Tot_O_FW_g <minus> NETM3_CONS_H	m^3	299,013
BGFWSP_HC	Balance of gross allowable volume of fuelwood assortments: FWspecies <minus> NETM3_CONS_HC	m^3	-1,053,782
BGP_FW_HC	Balance of gross allowable volume of preferred non-timber assortments: Pref_FW_g <minus> NETM3_CONS_HC	m^3	127,447
BGO_FW_HC	Balance of gross allowable volume of all non-timber assortments: Tot_O_FW_g <minus> NETM3_CONS_HC	m^3	867,943
BCUTFWSPHC	Balance of gross actual cut of fuelwood assortments: FWspecies <minus> NETM3_CONS_HC	m^3	-1,147,326
BCUTP_FWHC	Balance of gross actual cut of preferred non-timber assortments: Pref_FW_g <minus> NETM3_CONS_HC	m^3	-440,126
BCUTO_FWHC	Balance of gross actual cut of all non-timber assortments: Tot_O_FW_g <minus> NETM3_CONS_HC	m^3	3,669
BGP_NFP_HC	Balance of gross allowable volume of preferred non-timber assortments +nonforest productivity: Pref_FW_g +NFor_Prod <minus> NETM3_CONS_HC	m^3	403,528
BGO_NFP_HC	Balance of gross allowable volume of all non-timber assortments +nonforest productivity: TOT_O_FW_G +NFor_Prod <minus> NETM3_CONS_HC	m^3	1,144,024
BCP_NFP_HC	Balance of gross actual cut of preferred non-timber assortments +nonforest productivity: CUT_P_FW_G +NFor_Prod <minus> NETM3_CONS_HC	m^3	-164,044
BCO_NFP_HC	Balance of gross actual cut of all non-timber assortments +nonforest productivity: CUT_T_FW_G +NFor_Prod <minus> NETM3_CONS_HC	m^3	279,750

Values associated to settlements point data (5997 records)

Spatial / administrative parameters

Field name	Description	unit	totals
SO_CODE	Settlement code as per Statistical Office (old obcina code + settlement code)		
MAP_CODE	Settlement code (new obcina code + settlement code)		
SO_NAME	Settlement name (from Statistical Office)		
OB_ID	Obcina code		
OB_IME	Obcina name		
NA_ID	Settlement code within Obcina from Map		
NA_IME	Settlement name (from settlement map)		
Y_C	Y point coordinate		
X_C	X point coordinate		

Demand-related parameters

Household

SETTLCODE	1= Urban ; 2= Rural		
POP	Population		1,962,479

Demand-related parameters

Biomass plants

BmSyst_Loc	Location name of biomass systems		
Numb_sites	Number of separate biomass systems		65
BioSys_dat	Biomass system information (Y/N) = 31 Y and 34 N		
w_cons_t	Wood consumption in tons (incomplete data)	t	283,547
w_cons_m3	Wood consumption in cubic meters (incomplete data)	m^3	391,102
Cap_h_MW	Power capacity of biomass system (incomplete data)		
Syst_type	Type of system (CHP, DHS, n.a.) (incomplete data)		

Supply-related parameters

Wood industries

Wood industries			
P20	Number of employees in primary wood processing industries (approximate)		
S36	Number of employees in secondary wood processing industries (approximate)		

Annex 5. SFS databases

Database **FOND1x.dbf -** forest compartments' information (approx. 65000 records) at KO level (2697)

KO	Cadastral Community	
TOTAREA	Total forest area	
EXPLAREA	Exploitable area (legal factors) include only categories 1 and 2	
ACCESS_1	slope <30% dist. < 400 m	
ACCESS_2	slope <30% dist 400-800 m	
ACCESS_3	slope <30% dist. > 800 m	
ACCESS_4	slope >30% dist. <400 m	
ACCESS_5	slope >30% dist 400-800 m	
ACCESS_6	slope >30% dist. > 800 m	
OW2	private property	
OW3	property of other officials (mainly religious institutions)	
OW5	state property	
OW6	property of civil (rural) community	
ASOC1	Code of association 1 (see list of species associations)	
ASOC1AR	area of association 1	
ASOC2	=	
ASOC2AR	=	
ASOC3	=	
ASOC3AR	=	
ASOC4	=	
ASOC4AR	=	
ASOC5	=	
ASOC5AR	=	
ASOC6	=	
ASOC6AR	=	
ASOC7	=	
ASOC7AR	=	
ASOC8	=	
ASOC8AR	=	
ASOC9	=	
ASOC9AR	=	
STOCK1	Stocking of diameter class 1	10-30
STOCK2	Stocking of diameter class 2	30-50
STOCK3	Stocking of diameter class 3	> 50
STOCKTOT	Total stocking	
INCR1	Increment of diameter class 1	10-30
INCR2	Increment of diameter class 2	30-50
INCR3	Increment of diameter class 3	> 50
INCRTOT	Total increment	
CUT	Fraction of allowable cut actually cut	
YYEAR	Year of last survey	
PH1AR	area of phase dev. 1	
PH2AR	=	
PH3AR	=	
PH4AR	=	
PH5AR	=	
PH6AR	=	
PH7AR	=	
PH8AR	=	
PH9AR	=	
PH10AR	=	
SPGR_1T	Species group 1 (conifers ex. larix) timber assortments	
SPGR_1O	Species group 1 (larix) other assortments (incl energy use)	
SPGR_2T	Species group 2 (hard broadleaves) timber assortments	
SPGR_2O	Species group 2 (hard broadleaves) other assortments (incl energy use)	
SPGR_3F	Species group 3 (hard broadleaves) fuelwood use only	
SPGR_4T	Species group 4 (soft broadleaves) timber assortments	
SPGR_4O	Species group 4 (soft broadleaves) other assortments (incl energy use)	

Code	phase development
01	SEEDLINGS
02	EARLY POLE STAGE
03	LATE POLE STAGE
04	TIMBER TREE
05	REGENERATION FOREST
06	SELECTION FOREST
07	COPPICE
08	FORMER COPPICE
09	LITTER FOREST
10	BUSH FOREST

Fields of file **KOSORTIX.dbf**, which summarizes forest compartments' information on wood products assortments at cadastral community level according to management plans' 10-years allowable cut.

KO	Cadastral community
GRP	Species grouping under wood energy perspective (see below)
GRPTREE	Tree group code (see below)
GRPNAME	Tree group name (see below)
SORTIM	Main assortment types (see below)
GRPSORT	Assortment grouping under wood energy perspective (see below)
NETOM3	Net volume of 10-year allowable cut
BRUTOM3	Gross volume of 10-year allowable cut
PERCENT	Assortment as percent of GRPTREE total allowable cut

GRP	GRPTREE	GRPNAME
A	11	Spruce tree (Picea abies)
A	21	Fir tree (Abies alba)
A	30	Pine tree (Pinus silvestris, P. nigra)
B	34	Larch (Larix decidua)
A	39	Other Conifers
C	40	Beech tree (Fagus silvatica)
C	50	Oak tree (Quercus robur, Q.sessiliflora, Q. rubra)
C	55	Chestnut tree (Castanea sativa)
C	60	Quality broad leaved trees (Acer pseudoplatanus, Fraxinus excelsior, Tilia cordata,Ulmus sp.,Prunus avium, Juglans)
D	70	Other hard broad leaved trees (Carpinus,Ostrya,Fraxinus ornus,Robinia, Acer campestre,Sorbus, Quercus pubescens)
E	80	Other soft broad leaved trees (Betula,Salix,Laburnum alpinum)
E	90	Poplar, Black Alder (Populus sp., Alnus glutinosa)

GRPSORT	SORTIM
T	Log-Timber I
T	Log-Timber II
T	Log-Timber III
T	Log-Timber
O	Other Timber
O	Cellulose Timber
O	Cord Wood
F	Fuel Wood

Annex 6. Non-forest biomass survey

Slovenia is a biomass rich country, where the forest area is accompanied by other land uses that are often rich of woody biomass and by consistent areas of abandoned farmland that reverts to forest. While forests are studied in detail by forestry institutions and their production capacity is well known, little or no information was available concerning the amount of fuelwood produced outside forests and on the current and potential role of these areas in planning sustainable wood energy systems. On the other hand, it was understood that a significant part of fuelwood trade for household use is informal as fuelwood is either collected by farmers in their own lands and forests or bought locally.

To fill this information gap, and thus to complete the supply module, a specific survey of non-forest fuelwood sources was completed. The survey followed a two-phase approach based on (i) the new 2002 Land Use Map, used as stratification system (see table below), (ii) the available ortophotos coverage, used to estimate the crown cover of woody vegetation, and (iii) field sampling to relate crown cover to woody biomass stocking and increment.

Land use classes – Slovenia.

Land use classes	Total area	Minimum	Relevance for woody biomass
	ha	m^2	
1 Agricultural land			
1100 Fields and gardens	213,985	5000	low
1160 Hops fields	2,501	1000	marginal
1211 Vineyard	25,303	500	marginal
1221 Intensive orchard	5,049	1000	medium
1222 Extensive orchard	19,849	1000	medium
1230 Olive trees orchard	1,139	500	medium
1240 Other agricultural. plantations	43	1000	marginal
1310 Intensive meadow	159,652	5000	medium
1321 Swamp meadow	3,084	5000	marginal
1322 Extensive meadow	187,930	5000	medium
1410 re-growth on old farmland	25,246	5000	high
1420 Forest plantation	586	5000	marginal
1500 Mixed use (agric. and forestry)	18,953	5000	medium
2000 Forest and other wooded land	1,201,485	5000	
3000 Urban and built up areas, roads	108,194	10	low
4 Water logged areas			
4100 Swamp	188	5000	
4210 Reeds	1,084	5000	
4220 Other water logged areas	1,472	5000	
5000 Dry areas with grass	9,217	5000	
6000 Barren land without grasses	28,777	5000	
7000 Water bodies	13,314	10	
Total area	2,027,050		

Land Use Map publication 2002. Approximate reference date 2000 (date of ortophotos)

Sampling scheme to assess non-forest biomass

In the first phase of the two-phase survey, a systematic sample of non-forest land units were analyzed using the digital ortophotos on which the 2002 land use map was based. The selected land units were identified on the digital ortophoto data set and interpreted to assess the average crown coverage of trees and lower woody vegetation, such as bushes and young trees.

Interpretation of cover types

The digital ortophotos offered an excellent base for the interpretation of vegetation cover and for the distinction of cover types. In consideration of photo characteristics and of basic requirements for the subsequent field-measurement phase, the following cover types were defined:

Code	Cover type
1	Bushes and young trees (vegetation below 7 m height)
2	Intensive orchard
3	Extensive orchard
4	Young forest stand (up to the pole stand)
5	Middle-age forest stand (small to medium tree crown size)
6	Grown-up forest stand (medium to large tree crown size)
7	Individual (isolated) trees – crown area < 50 m^2 (diameter < 8m)
8	Individual (isolated) trees – crown area > 50 m^2 (diameter > 8m)
9	Lines of trees (e.g. roadside trees, hedges, etc.) with crown diameter < 8 m
10	Lines of trees (e.g. roadside trees, hedges, etc.) with crown diameter > 8 m

All interpretation was carried out visually on computer monitor. Each interpretation class was digitized as a closed polygon and coded according to cover type.

Cover types 1 and 4 referred to shrubs, bushes and young trees whose average height was estimated to be below 7 m. 1 referred to individual plants or small groups and 4 to larger formations.

The two orchard cover types referred to systematic layouts, usually composed by smaller crowns (2) and to older, irregular formations, usually composed by larger crowns (3). These two classes were found within or outside the classes defined as “orchards” in the land use map (in urban areas, for instance).

Dense stands were separated according to the size of tree crowns, into middle-age (5) and grow-up (6). A comparison with nearby forests allowed to separate stands that appeared younger from stands that appeared more mature.

Individual trees were divided into two main types: small to medium trees, with crown diameter below 8 m (7) and medium to large trees, with crown diameters above 8 m (8). Similarly, trees in lines were separated according to the width of the line. When tree rows wee wider, including two or more trees, they were classified as forest stands.

Other specifications:

Minimum interpretation unit

The minimum interpreted crown area was 3 x 3 m (3 x 3 mm at scale 1:1000)

Sub-sample of large polygons

In case of **large polygons** (>100 ha) the interpretation was done on a representative fraction of the entire polygon area. The polygon was intersected with a **1 ha grid** and the interpretation area was a systematic sample of the grid cells. The intensity of the systematic sample (1 on 2, 1 on 3, 1on 4, etc.) depended on

the size of the polygon, with a **minimum of 20 interpreted sub units** (grid cells) well distributed over the polygon.

The class 3000 (Urban and built up, inclusive of roads) was practically one unique polygon over the entire Slovenia, since all urban centers are connected by thin stripes (roads). Therefore, **in case of class 3000**, and only in this case, the sampling unit was defined by the intersection between the class polygon and **a circle of 250 m. radius** around the selected 4x4 Km grid point.

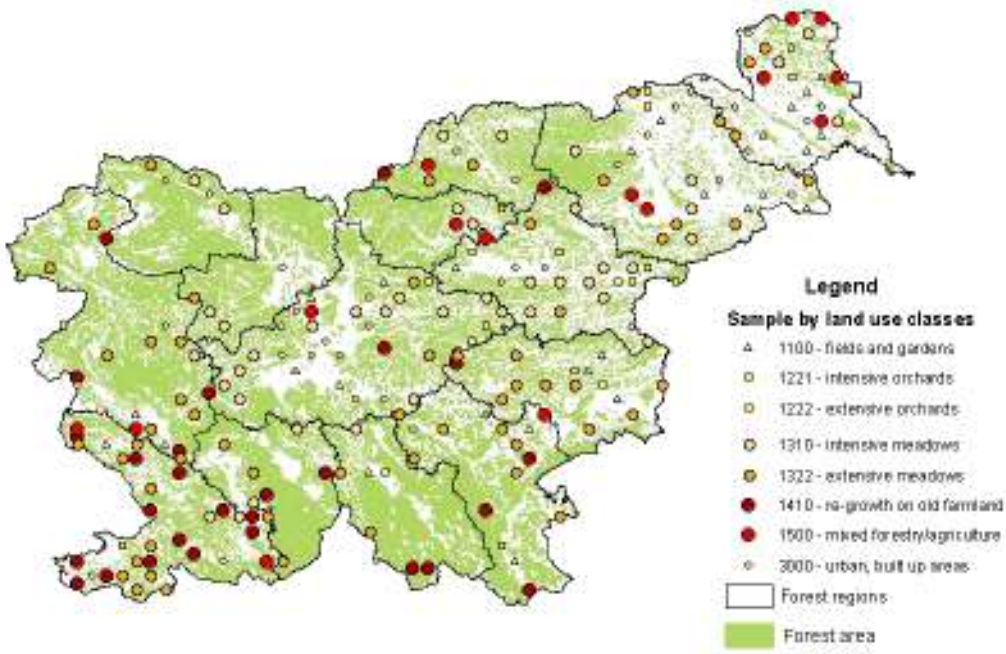
Sample selection

The following table and figure show the distribution of the sample using a 4x4 Km grid (the same used by Slovenia Forestry Institute for permanent forest sample plots) and including only the classes of interest.

Summary of sample selection

Code	Land use classes	Total area	Total 4x4km points	Remarks	selection frequency	Selected points
1100	Fields and gardens	213,985	136	Very low sample	1on4	32
1221	Intensive orchard	5,049	2	All orchards aggregated	1on1	18
1222	Extensive orchard	19,849	16			
1310	Intensive meadow	159,652	101	Low sample	1on2	42
1322	Extensive meadow	187,930	118	Low sample	1on2	58
1410	Re-growth on old farmland	25,246	11	double sample	2on1	28
1500	Mixed use (agric. and forestry)	18,953	15	Full sample	1on1	15
3000	Urban and built up areas, roads	108,194	68	Low sample	1on2	33
			471			227

Sample distribution map:



Example of ortophoto with land use class (red) and crown cover types (yellow). The land use class of the selected class polygon is 1410 (re-growth in abandoned farmland). The Crown Type classes are: 3, 4, 5 and 6.

Field measurements

Annex 6 contains a list of land use units which were selected at random, out of 227 from the present woody cover types point of view, to calculate the average amount of wood stock (and also increment) for different woody cover types. In the selection of land use units we took into account practical circumstances which facilitated our work and improved the estimation of average wood stock of woody cover types (first of all adequate size and form of land use unit and presence of different woody cover types).

In the selected land use units of woody cover type wood stock was measured in the most strongly represented polygon of woody cover type in the unit. Exceptions were necessary to provide the sufficient number of measured polygons and were explicitly stated in the instruction for the realization of field measurements.

Smaller polygons of individual woody cover types (normally about 75-150 % of surfaces, determined for individual woody cover types and are stated in continuation) were measured entirely (in this case, polygons, smaller than 75 % of the required surface were included into measurement only exceptionally and in such case we measured several – the sum had to be at least 75 % of the required surface of the woody cover type polygon). In bigger polygons we traced plots (one plot in a polygon) to measure wood stock, of the following dimensions by individual woody cover types (plots of rectangular shapes with the same surface are also allowed):

Sizes of sample plots for wood stock measurements of different woody cover types

20 x 20 m	**01** - Bushes and young trees, **04** - Young forest stand (up to the pole stands)
30 x 30 m	**02** - Intensive orchard, **03** - Extensive orchard, **05** - Middle-age forest stand
40 x 40 m	**06** - Grown-up forest stand
30 m	**09** - Lines of trees with crown diameter under 8 m, **10 -** Lines of trees with crown diameter above 8 m

The position of the plot inside the polygon was marked on the map and in case of lines of trees, the measured part was marked.

In every land use unit up to 5 individual trees of the most frequent woody cover types in the unit were measured and were stated in the survey of land use units at the given unit (01 - bushes, 03 – fruit-trees, 07 – crown diameter under 8 m, 08 crown diameter over 8 m). Those land use units, where exceptionally up to 10 individual trees or bushes were measured to ensure a large enough sample, they were explicitly stated in the instruction for the realization of field measurements.

In all woody cover types we measured trees and bushes from a diameter of 5 cm onwards.

In order to determine the tariffs for calculation of wood stock (and also increment) we measured, in every polygon, the height of three thickest trees, and with individual trees we measured the height of one of 5 or 10 with a measured diameter and tree species determined.

The calculation of the average wood stock for individual land use types (in m^3/ha) was done in two modes:

Direct mode

Calculation of average wood stock value for individual non-forest land use types directly through shares of individual woody cover types inside individual land use types – on the basis of a known average wood stock (in m3/ha) of different woody cover types. Calculation is faster and simpler but it does not provide calculation of precision or trust interval of the desired average wood stock value for an individual non-forest land use type.

Indirect mode

Calculation of average wood stock value for individual non-forest land use types through calculated average wood stock values of individual land use units (from 227), which provides calculation of precision or trust interval of the desired average wood stock value for an individual non-forest land use type.

List of land use units where sample estimation of wood stock eas made on non-forest lands

For organizational reasons territories of collection differed slightly from regional division of SFS.

Ljubljana:

Nr	**Unit number**	Land use code	Framework of present woody cover types (approximately according to representation)	Location
1.	1159	3000	6, 5, 10, 8, 7, 1, 9	Dolsko
2.	1227	1310	6, 5, 4, 8, 7, 9, 10	Zagorje
3.	1217	3000	9, 10, 8, 7, 1	Medvode
4.	843	3000	9, 7, 8, 5, 10, 2, 3	Ponova vas by Grosuplje
5.	1273	1322	6, 5, 9, 7, 1	South of Železniki
6.	897	1310	4, 8, 7	Hotedrščica
7.	835	1310	5	Logatec
8.	1031	1221	2	Ljubljana-Bizovik
9.	1103	1221	2	Podkum

Brežice:

Nr	**Unit number**	Land use code	Framework of present woody cover types (approximately according to representation)	Location
1.	793	1500	6, 5, 10, 9, 8, 1	Škocjan by Otočec
2.	921	1322	5	Raka
3.	917	1322	5, 6, 4, 8, 7, 1, 9	Tržišče
4.	923	1221	2	Krško
5.	984	1221	2	Brestanica-Sevnica

Note: On one of plots 793 or. 917 measure two polygons of mature trees or two plots in mature tree stands (6).
On plot 793 measure 3 polygons of forest trees in lines with thick trees (10).

Celje:

Nr	**Unit number**	Land use code	Framework of present woody cover types (approximately according to representation)	Location
1.	1545	1500	5, 4, 6, 9, 7, 1	North of Polzela
2.	1611	1322	5, 9, 10, 8	Dobrna
3.	1301	1310	6, 4, 8	Loka
4.	1672	1222	3	Velenje
5.	1366	1222	3	Šmarje pri Jelšah
6.	1481	1222	3	Braslovče
7.	1487	1222	3, 5	Vojnik

Note: On one of plots 1545 or. 1672 measure two polygons of mature trees or two plots in mature tree stands (6).
On plot 1611 measure 3 polygons of forest trees in lines with thick trees (10).

Maribor:

Nr	**Unit number**	Land use code	Framework of present woody cover types (approximately according to representation)	Location
1.	2003	1322	5, 8, 7, 1	Cerkvenjak
2.	2125	3000	8, 10, 4, 1, 9, 3	Northeast of Maribor
3.	2123	1222	3	Šentilj
4.	2186	1222	3, 4, 1	Šentilj

Sežana:

Nr	**Unit number**	Land use code	Framework of present woody cover types (approximately according to representation)	Location
1.	639	1322	1, 9, 7, 4, 10	Štanjel
2.	451	1322	9, 7, 1	Divača
3.	269	1410	5, 4, 8, 7, 1	Knežak-Ilirska Bistrica
4.	2517	1410	5	Obrov

Survey results

1 – CROWN COVER

Average - percent crown cover

LU class	Units	% all Crown Types	% lower veget.	% tree cover	Crown types (CT) Bushes	Intens. Orchard	Extens. Orchard	Young Forest	Middle Forest	Grown Forest	Small Trees	Large Trees	Small-trees line	Big-trees line
					1	2	3	4	5	6	7	8	9	10
1100	32	2.3	0.4	1.9	0.3		0.0	0.0	0.5	0.6	0.1	0.1	0.4	0.0
1221	2	64.5		64.5		58.5				6.0				
1222	16	38.4	11.7	26.7	5.8	1.9	6.1	5.9	12.3	0.6	1.3	0.8	3.4	0.4
1310	42	5.9	0.9	5.0	0.5	0.0	0.2	0.4	0.7	2.4	0.4	0.4	0.8	0.1
1322	58	14.5	2.9	11.6	1.0		0.0	1.9	2.8	5.1	0.5	0.4	2.6	0.2
1410	28	57.4	20.0	37.5	1.2		0.1	18.8	23.9	11.7	0.4	0.2	1.0	0.1
1500	15	63.5	6.0	57.5	1.6			4.4	20.7	33.0	0.2	0.3	2.6	0.7
3000	33	11.1	1.8	9.4	1.7	0.3	0.3	0.1	1.7	3.4	0.5	0.5	2.2	0.4
ALL	227	21.5	4.9	16.6	1.3	0.9	0.5	3.6	6.3	6.0	0.5	0.4	1.7	0.2

Coefficient of Variation - percent crown cover

1100	32	129	268	139	299		566	330	402	173	247	247	195	218
1221	2	54		54		45				141				
1222	16	39	102	53	102	400	228	195	125	232	170	219	193	400
1310	42	79	148	79	113	525	319	279	186	131	232	151	133	217
1322	58	63	118	75	81		540	177	149	131	95	148	179	185
1410	28	52	99	69	144		529	106	94	146	170	209	144	388
1500	15	26	142	36	215			196	101	98	271	265	226	304
3000	33	64	88	73	83	320	240	391	161	183	67	97	127	152
ALL	227	116	208	124	187	763	734	276	212	222	191	190	210	339

lower veget = CT 1 and 4 tree cover = all other CT

2 - STOCKING AND INCREMENT

Class code	Mean Stocking m^3/ha	Mean Increment m^3/ha/year	sd Stock	sd Incr	CV%	CV%	Area ha	total stock m^3/ha	total increment m^3/ha/year
1100	3.0	0.10	3.6	0.12	119.56	121.69	213,985	649,466	21,958
1221	33.1	1.12	26.1	0.89	78.84	79.53	5,049	167,004	5,675
1222	32.1	1.14	15.7	0.54	48.94	47.83	19,849	637,212	22,591
1310	8.5	0.28	7.0	0.24	82.43	85.27	159,652	1,358,629	44,579
1322	19.5	0.67	14.4	0.50	73.74	73.77	187,930	3,670,979	126,499
1410	57.4	2.16	36.2	1.29	63.11	59.84	25,246	1,449,435	54,498
1500	94.6	3.30	46.2	1.54	48.82	46.58	18,953	1,792,963	62,624
3000	15.6	0.51	12.6	0.43	80.44	83.75	108,194	1,691,725	55,430

Annex 7. SWEIS in energy units

SWEIS - Slovenia Wood Energy Information System. National level statistics.

Values in PJ.

	1995	1996	1997	1998	1999	2000	2001	2002
Production								14.0
Fuelwood								
Forests								6.9[1]
Other landuses								1.9
Industries (residues)	4.9	4.7	4.5	4.4	4.2	4.1	3.9	3.8
Charcoal[1]	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.06
Black Liquor	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Import								
Fuelwood	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Charcoal	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.06
Black Liquor								
Export								
Fuelwood	0.5	0.0	0.0	0.6	0.5	0.4	0.4	0.4
Charcoal								
Black Liquor								
Consumption								
Household Sector								
Fuelwood								8.7
Charcoal	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11
Black Liquor								
Other Sectors (industrial, public, etc.)								
Fuelwood			2.9					3.4[1]
Charcoal								
Black Liquor	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45

Notes:

Figures in bold represent reference values. Other figures are extrapolated values.

[1] See note in Table 1 , main text.