Biomass Energy Europe

Illustration case for Croatia

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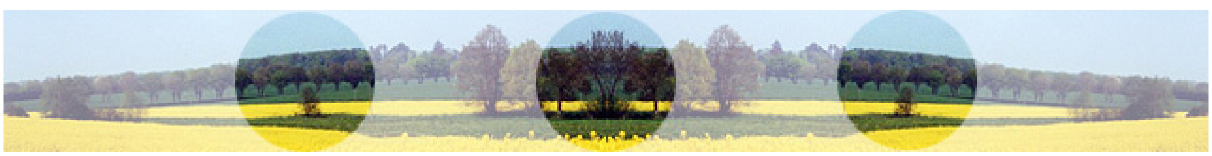

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Content

Abstract

Introduction
The main objective of the illustration case for Croatia is to estimate the energy and technical potential of fast-growing broadleaved species energy plantations on abandoned land or on land where agricultural production is not profitable, with a special emphasis on willows as a typical energy crop in South-East Europe.

Methodology
The methodology utilised for the purpose of estimating the SRC potential within this illustration case is based on the BEE Methods Handbook and corresponds to the basic spatially explicit method. It was selected based on the available data required to apply it. The main source of data used is contained within the Basic pedological map of the Republic Croatia, which forms the basis for the estimation of soil suitability for any kind of designated utilization.

Potentials
The theoretical potential for short rotation energy crops production in Croatia was estimated as following:

- Forest area suitable for energy crops – a total of 51 200 ha was estimated to be suitable for SRC, producing in total 470 200 t DM/y or 8,7 PJ
- Agricultural areas with moderately suitable soils and limited soil suitability – a total of 617 000 ha was estimated to be suitable for SRC, producing a total of 7 404 000 t DM/y or 136,2 PJ

The technical potential for short rotation energy crops production in Croatia was estimated as following:

- Forest area suitable for energy crops – a total of 46 850 ha was estimated to be suitable for SRC, producing in total 430 000 t DM/y or 7,9 PJ
- Agricultural areas with moderately suitable soils and limited soil suitability – a total of 235 650 ha was estimated to be suitable for SRC, producing a total of 2 827 800 t DM/y or 52,1 PJ

Analysis
In spite of the considerable potential for short rotation energy crops production, currently a very small amount of the available area is utilised in Croatia. The issues and problems to be addressed in order to increase this production include a change in policy approach, especially aimed at small landowners, introduction of incentives and subsidies, lack of knowledge and experience in growing energy crops and generally a lack of cooperation between relevant stakeholders.

The main sustainability issues regarding short rotation energy crops utilisation in Croatia are related to environmental considerations, specifically the Natura 2000. These issues have been taken into consideration when assessing the technical potential for energy crops in Croatia.

Conclusions
There have been no issues identified with the application of the methodology, while recommendations regarding improvement of available data have been drawn in chapter 5.1. and essentially are related to the upgrading and harmonisation of the Basic pedological map of the Republic of Croatia.

1. Introduction

The main objective of the illustration case for Croatia is to estimate the energy and technical potential of fast-growing broadleaved species energy plantations on abandoned land or on land where agricultural production is not profitable, with a special emphasis on willows as a typical energy crop in South-East Europe.

The patterns of energy crop production and consumption, and their associated social, economic and environmental impacts, are site-specific. Broad generalisations about the energy crop's situation and impacts across regions, or even within the same country, have often resulted in misleading conclusions, poor planning and ineffective implementation. Adequately assessing the implications of the current patterns of energy crop production and use, and the sustainable potential of that resource, requires a holistic view and a good knowledge of the spatial patterns of woodfuel supply and demand. There is a need to conduct spatial analyses of woodfuel supply and demand that are able to articulate the local heterogeneity at the regional and European levels. There is a critical lack of studies providing full-country coverage and based on a consistent integration of data at lower geographical scales in Croatia, but also in the whole Western Balkan region.

Looking at the achievements regarding energy crops utilisation in Croatia, the most important ones are related to the research and investigation of productivity of various types of crops. Specifically, clonal tests of short rotation crops were established in different regions in Croatia and the goal was to determine the potential of biomass production of selected clones in short rotations of 2 years, on the site not favourable for growing more valuable species of forest trees (Bogdan et al, 2006). The production of biomass per hectare was estimated in regard to the clones, mean dry biomass of shoots, survival, spacing, and the average number of shoots per stump.

A number of clones capable of starting initial production cultures are currently available; however, in order for biomass production in short rotations to be recognized as a useful and cost-effective form of providing energy supplies, a lot of work remains to be done in many areas, not least in the area of plant improvement. The aim of these field experiments is to select the clones of the max. production potential with the stem quality, and those poplar and willow clones which will give the satisfactory production on the so called atypical habitats for poplar and willow silviculture (e.i. the oak and ash habitats) and which can come in useful for the establishment of pre-cultivation for the purpose of easier reforestation of common oak and narrow-leaved ash. There are relatively many atypical habitats for the cultivation of poplar and especially stemlike willow silviculture in the area of the Sava river.

For the purpose of greater productivity, after the each rotation, shoots should be reduced to one or two per stump. Research should be continued in the direction identification and selection of a greater number of clones with specific adaptability to unfavourable sites, and the production of biomass on marginal sites could be significantly increased with the application of more intense growth (agricultural treatments) and protection measures.

2. Methodology

The methodology utilised for the purpose of estimating the SRC potential within this illustration case is based on the BEE Methods Handbook, specifically in reference to chapter 4.3. (*Energy crops - basic and advanced spatially explicit method*). According to the terminology introduced in the Handbook, the methodology for this illustration case corresponds to the basic spatially explicit method, whereas the methodology was selected mostly based on the available data required to apply it.

The main source of data used is contained within the Basic pedological map of the Republic Croatia. The map was created as a result of the project coordinated by the Ministry of Science and Technology which lasted from 1985 to 1996 and forms the basis for the estimation of soil suitability for any kind of designated utilization.

Based on the different types of soils, the current utilisation and their characteristics (percentage of rocks and stone, inclination, ecological depth of soil, dreined soil, dominant mode of moistering, etc.) the total area suitable for the production of energy crops was estimated. This area was further reduced based on the information available regarding the implementation of the EU Natura 2000 network in Croatia, and thus obtaining the available area relevant to the theoretical potential.

In order to obtain the technical potential the available area for SRC was further reduced after taking into account that certain parts of the land are not suitable to the currently available harvesting mechanisation. These land parts include areas near alluvial river banks and deposits, areas near floody rivers, swampy areas and areas with a steep inclination.

Taking into account the different productivities of different soil types, the costs of production in terms of monetary units per tonne was estimated.

3. Potential for biomass

3.1. Available areas for SRC cultivation

Of the total continental land area of Croatia (5 662 031 ha) agricultural land covers 2 955 728 ha or 52.2. %. Permanently unsuitable land for agricultural production in Croatia amounts to 806 648 ha. This land could be used for the establishment of forest plantations and also bioenergy could be produced. The main data aggregated for the whole of Croatia are shown in Tables 1 and 2.

Table 1. Total area in Croatia, area of pedological soil classification in agriculture, forested area and settled area (Tomić et al. 2008)

Area	1000 ha	% of total area	% of agricultural area
Total area in Croatia	5 662.0	100.0	
Forested area	2 608.4	46.1	
Area under water	53.4	0.9	
Settled area	44.6	0.8	
Agricultural area	2 955.7	52.2	100.00
Automorphous soils	*1 502.1*		*50.82*
Hydromorphous soils	*1 087.9*		*36.81*
Halomorphous soils	*0.4*		*0.01*
Subaqual soils	*0.3*		*0.01*
Rocky soils	*365.0*		*12.35*

Table 2. Suitability of agricultural area (soil) for the growth of agrocultures (ha)

Area with suitable soils	Area with moderately suitable soils	Area with limited soil suitability	Area with temporarily unsuitable soils	Area with permanently unsuitable soils	Total agricultural area (soil)
605 739	468 420	463 597	611 324	806 648	2 955 728

Annual reforestation corresponds to 350 to 400 ha of poplar and 20 ha of willow plantation/cultures is stable in last decade (not increase or decrease). The important fact for this production is that 78 % of the forest area in Croatia is owned by the state, and concerning poplar and willow plantations, this percentage is a little bit lower and amounts to 66 %. The existence of the so called ‘marginal’ land, which is not suitable for agricultural production, either privately or state owned, presents the potential for further development and increase of the production, which is nowadays reduced mainly to reforestation of the new plantations.

Croatia possesses 2 688 687 ha of forest and forest land with 397 963 000 m^3 of growing stock which increments annually by 10 526 000 m^3. The annual allowable cut is 6 564 000 m^3 of gross volume. Of the total annual cut about 40 % or 2 625 600 m^3 of timber is used for processing, 20 % or 1 312 800 m^3 for of fuelwood and the remaining 40 % or 2 625 000 is left in the forest as waste. Of this residue 62.5 % or 1 641 000 m^3 could be used for bioenergy production, while 37 % or 984 000 m^3 would remain in the forest as waste. If this amount suitable for bioenergy is added to the quantity of 1 312

800 m^3 of fuelwood, the total quantity of energy wood that could already be placed on the energy market amounts to 2 953 800 m^3, which is 45 % of total annual cut. The aggregated data for Croatia is shown in Table 3.

Table 3. Total area of forest and forest lands in Croatia

Forest area and forest land (ha)					
	Stocked forests	Unstocked forest land		Unfertile forest land	Total
		Suitable for forests	Unsuitable for forest		
Managed forests	2 168 874	181 658	27 037	38 536	2 416 105
Protective forests	130 630	18 781	1 503	3 623	154 537
Forests of special assignament	103 278	8 026	4 410	2 326	118 040
Total	2 402 782	208 465	32 950	44 485	2 688 682

As indicated in the methodology description, the basis for the estimation of available area suitable for energy crops production is the Basic pedological map of the Republic of Croatia. The data within the map are available in database as well as GIS format and Figure 1 shows the visual representation of the data for the whole of Croatia. Different soil types are indicated by different colors and the map includes a total of 65 soil types based on current utilisation and soil characteristics. The pedological characteristics of soil types included in the map are shown in Annex I.

After taking into account the current land utilisation and eliminating the land which is already used for agricultural purposes as well as forested land, the following results regarding the maximum land availability in Croatia are obtained:

- Forest area suitable for energy crops – maximum of approximately 180 000 ha (unstocked forest land, suitable for forests, see Table 3)
- Agricultural areas with moderately suitable soils and limited soil suitability – maximum of approximately 900 000 ha (see Table 2, area with moderately suitable soil and area with limited soil suitability)

Figure 1. Basic pedological map of the Republic of Croatia

3.2. Estimation of potential

3.2.1. Theoretical potential

Based on pedological study of agricultural areas, specialized pedological maps of the Republic of Croatia and a hydropedological map were constructed which designate potential areas for the cultivation of agricultures. The Croatian agricultural sector also offers potential possibilities for renewable energy production through biofuel production in uncultivated areas. A part of the areas with temporarily unsuitable soils (611 324 ha) and areas with permanently unsuitable soils (806 648 ha) could be used for the establishment of short rotation cultures of forest tree species in the period of 15 years at most.

Taking into account the various soil characteristics which define limiting factors for energy crops production, the available area indicated in chapter 4.1. is further reduced. This area is then used in order to obtain the theoretical potential for energy crops cultivation in Croatia.

The main results can be summarized as follows:

- Forest area suitable for energy crops – out of the maximum of 180 000 ha (uncovered forest land), a total of 51 200 ha was estimated to be suitable for SRC
- Agricultural areas with moderately suitable soils and limited soil suitability – out of the maximum of 900 000 ha a total of 617 100 ha was estimated to be suitable for SRC.

Of the total forest area suitable for energy crops, about 31 000 ha are heavy hydromorphous clay type of soils and 20,200 ha are slightly better clay type of soil. Therefore, the production of about 8 t DM per ha*y^{-1} on average can be expected in the area of 31 000 ha, with this average rising to 11 t DM per ha*y^{-1} in better sites. Although some tested clones show the production higher than 20 t DM per ha*y^{-1}, it is more realistic to expect the average production mentioned. This estimate does not envisage the use of any intensive agrotechnical measures (additional nutrition during the first two-year rotation cycles, pest control, and others).

On average, based on the testing and research conducted in Croatia described within the previous chapters, with six rotations (six cutting operations executed two years apart) a maximum average production of 12 t DM per ha/y can be expected on the agricultural area with moderately suitable soils and limited soil suitability.

Taking into account the limitations and mentioned values, the total yield corresponding to the theoretical potential amounts to 7 874 200 t DM/y. Applying the standard energy content for willow wood of 18.4 MJ/kg DM (FAO 2004) this translates into 144.9 PJ/y.

3.2.2. Technical potential

The estimation of the technical potential is based on the theoretical potential presented in the previous chapter, while taking in consideration the status and limitations of technology for harvesting energy crops which can be applied in Croatia. These considerations are mainly derived from the type of soil and terrain as in certain cases the terrain configuration and soil type practically limit and or prohibit the use of harvesting machinery. Specifically, the following areas were identified as unsuitable for harvesting short rotation crops in Croatia:

- areas within or in the vicinity of alluvial deposits near the main Croatian rivers and their confluents;
- areas within parts of Posavina, Podravina and Pokuplje (swampy areas near rivers Sava, Drava and Kupa);
- areas within parts of Dalmacija, Istra, Gorski kotar and Lika (partly mountain areas with too steep inclination for effective harvesting).

Even though Croatia is not yet a member of the European Union, its Nature protection act has already implemented many mechanisms that transpose the EU Habitats Directive provisions in regards to naturally pretected areas. Specifically, Croatia will have to propose sites for the Natura 2000 Network for over 250 species and 70 habitat types that occur in Croatia. Up to now around 1000 possible sites have been identified which have been put out to public consultation.

After taking into account the location and area of the Natura 2000 sites, as well as the areas unsuitable for harvesting, and deducing it from the numbers presented in the previous chapter, the following area remains in regards to the technical potential for energy crops in Croatia:

- Forest area suitable for energy crops: 46 850 ha
- Agricultural area with moderately suitable soils and limited soil suitability: 235 650 ha

Of the total forest area, about 28 450 ha are heavy hydromorphous clay type of soils and 18 400 ha are slightly better clay type of soil. The production of about 8 t DM per ha*y^{-1} on average can be expected on the first type of soils, with this average rising to 11 t DM per ha*y^{-1} in better sites.

A maximum average production of 12 t DM per ha/y can be expected on the agricultural area with moderately suitable soils and limited soil suitability

Taking into account the mentioned values, the total yield corresponding to the theoretical potential amounts to 3 257 800 t DM/y. Applying the standard energy content for willow wood of 18.4 MJ/kg DM this translates into 60 PJ/y.

3.2.3. Economic indicators (costs of production)

There are some economical studies about energy crops profitability, based on experimental field cultivation of 1 – 50 ha in the eastern regions of Europe, but not fully operated in a commercial way. Those studies present establishment cost of 1 500 – 2 500 € for willow and some studies seem to overestimate incomes because of possible yields of > 20 DM per ha*y^{-1}. Today, costs for the short rotation coppice willow are in range of 4.3 to 5.8 €/GJ, depending on the region. For comparison, costs for straw and forest residues are between 2.4 €/GJ and 5 €/GJ. For the future, it can be expected that biomass costs will equalize throughout Europe and drop to about 3.5 €/GJ to 4 €/GJ free plant gate.

According to the tariff system of *Hrvatske Šume d.o.o.* (Croatian Forests Ltd), the cost of establishing one ha of a short rotation willow coppice (9000 ps/ha) is about 30 000 kuna/ha (4 000 €). Research to date has confirmed that these crops are the most suitable for production and cultivation in heavier types of hydromorphic soils. The above sum includes the cost of soil preparation (ploughing and disc-harrowing), the price of seedlings (cuttings) and two tending operations during the first year of the establishment of the culture. Additional tending costs are estimated at 18 000 kn/ha (2 400 €). These costs include 20 wages for hilling and two between-the-row rotations with mechanization. The total cost of establishing and cultivating one hectare of SRC is thus estimated at 48 000 kn (6 400 €).

On average, with six rotations (six cutting operations executed two years apart) and with an average production of 12 t DM per ha*y-1, the overall production for a 12-year period is estimated at 144 t DM per ha*. The average annual sequestration of 15 t CO2 ha-1 in the same period amounts to 144 t CO2 ha-1 in all.

The calculation for short rotation coppices of willow clones over the 12 production years is as follows:

- Total establishment and maintenance costs of one ha SRC = 48 000 kn (6 400 €),
- A total of 144 t DM per ha* will be produced,
- The cost of produced biomass is 48,000 kn / 144 t = 333 kn (i.e. 45.6 €/t)
- The total quantity of sequestered CO_2 emissions is estimated at 144 t CO_2/ha

It is important to point out that, contrary to some neighbouring countries, and due to the lack of stimulating measures of the state, plantation afforestation is still restricted mainly to the state owned land.

Certain measures of state policy on the use of land, as well as the fiscal and incentive measures (tax exemption, credit, provision of plant material and technology support) could help poplar and willow cultivation on privately owned marginal land. These processes, to a lesser degree, are initially present, but on the local level.

The calculation of a SRC establishment does not include support by the Ministry. Unlike Croatia, support in the form of exemption from land taxes for the period of 15 years is a common practice in the EU countries. Costs of establishing and maintaining 1 ha by a private farmer would be much lower compared to the cost of Croatian Forests Ltd due to the use of the farmer's own modified agricultural mechanization and labour force.

4. Analysis and discussion

4.1. Data gaps and methodological challenges

The methodology and data utilisation/requirements for the estimated theoretical and technical potential for short rotation crops in Croatia are based on the Basic pedological map of the Republic of Croatia, which was created as a result of the project coordinated by the Ministry of Science and Technology which lasted from 1985 to 1996. In that regard the following can be concluded regarding the adequacy of used data:

1. The Basic pedological map of Croatia was developed in 1996, and while it is a fact that soil type changes are rather slow and take many years, a data update is considered necessary ;

2. The GIS format (spatial unit) of the data available within the Basic pedological map of Croatia is an old format and is not compatible with other GIS data for Croatia. Specifically, the basic spatial unit used in most cases for GIS modelling in Croatia is the level of municipalities (550 entries for Croatia) or settlements (6736 entries). An example of such modelling is the application of the WISDOM methodology and tool (developed by FAO) to Croatia, which contains detailed data on the supply and demand of forest biomass (Domac, Trossero, 2009). On the contrary, the Basic pedological map of Croatia uses spatial units according to land types, thus it is not possible to directly include and apply the information within the pedological map in other GIS data.

However, the update and harmonisation of the Basic pedological map of Croatia represents an extensive work and is not within scope of BEE project, but this update is potentially interesting for possible future projects.

4.2. Current status of biomass and energy crops utilisation in Croatia

Energy production from biomass, except for fuelwood and wood-processing industry waste, has not been used in a larger scale so far in Croatia. By establishment of intensive plantations of fast-growing broadleaved forest tree species on lands that are abandoned or where agricultural production is not profitable, which in Croatia are estimated to cover approximately 50 000 ha, it is possible to start solving global but also many local problems in a positive direction. The soft broadleaved species plantations in short rotations can be established as energy plantations (biomass production for energy, biomass dry matter, biochemical and thermochemical biomass conversion, plantations for wood chips and pulpwood production). These endeavours are in line with both the world trends for better utilisation of energy sources and the biomass energy utilisation strategy of the national energy programme BIOEN (Domac et al., 1998, 2001). Additional benefits could be numerous socio-economic positive aspects of bioenergy plantations and biomass use (employment, additional income, increase of economic activity, rural diversification and others).

The current status of short rotation crops in Croatia is still at an early development phase. As described in the introduction, considerable research activities have been undertaken by relevant institutions (Faculty of Forestry University of Zagreb, Forestry Institute and others) with the main objective to find genotypes which, with minimum nutrients, will produce the maximum quantity of biomass. This involves selecting, by means of the research, the most productive clone, giving maximum biomass production, and, thus, ensuring its participation in the primary energy consumption as well as in other forms of utilising the biomass of fast-growing forest trees. According to the results of the field and laboratory research, the genetic differentiation of tested clones with respect to biomass production in fresh and dry matter has been determined.

Table 4 shows the summary statistics of poplar and willows in Croatia for years 2004 and 2007.

The multiclonic approach in poplar and willow plantations is being practiced in the Republic of Croatia. The clone arrangement is mosaic. For the purpose of the exact identification of single clones in the nursery reproduction, as well as in the planting on the ground, the plans are being kept. All the poplar and willow selected clones are entered into the live archives in order to preserve the selected material through the 'ex situ' method, and for the indentification of particular clones.

The selection of the arborescent willows (*Salix* sp.) has been carried out in the natural populations on the area of Croatia. The plant breeding was done in the intra- and interspecies species hybridization. Establishing of the SRC plantations in short rotations can be established as biomass production for energy, biomass dry matter, biochemical and thermochemical biomass conversion, plantations for wood chips and pulpwood production.

Table 4. Summary statistics of poplars and willows in Croatia for 2004 and 2007 (Kajba et al, 2007)

Poplars and Willows Forest categories		2004					2007				
		Area (000 ha)	% of presence versus other Sp.(*)	Purpose			Area (000 ha)	% of presence versus other Sp.(*)	Purpose		
				Production (%)	Protection (%)	Other (%)			Production (%)	Protection (%)	Other (%)
Indigenous	Poplars	7	15				9	10	95	5	
	Willows	7	5				10	5	71	29	
	Mix P & W						14	25	70	30	
	Total	**14**	--------------	--------------	--------------	-------------	**33**	--------------	--------------	--------------	-------------
Planted	Poplars	13					12		93	7	
	Willows	4					3		89	11	
	Mix P & W						2	5	86	14	
	Total	**17**	--------------	--------------	--------------	-------------	**17**	--------------	--------------	--------------	-------------
Overall total		**31**	--------------	--------------	--------------	-------------	**50**	--------------	--------------	--------------	-------------

4.3. Implementation issues in Croatia

The main issues regarding the utilisation of short rotation energy crops in Croatia are summarized in Table 5. Other information presented within this table include practical implementation problems (specifically, the causes and effects of these problems), the governmental strategy to deal with these problems and issues, major stakeholders relevant to SRC in Croatia, other projects within the sector with which a synergy is possible, potential donor organisations in the sector and justification components.

Table 5. Summary of main problems and issues regarding short rotation energy crops utilisation including Croatia (FAO 2009, according to Kajba, 2009)

Problem Identified	Major Issues	Government Strategy	Major Stakeholders	Other Projects in the Sector	Other Donors in the Sector	Justification Components
Policy approach: smallholders in the country are not actors of the process (policy and institutional) **Causes:** • Legislative and regulatory discontinuity • Lack of fiscal incentives and subsidies • Lack of Public awareness programs • State Industry vs. private industry **Effects:** • Difficulty in engaging in long term land investment as tree plantations require • Unused land/ abandoned land/ land degradation (poor land use planning **IWA** (**I**mpact **W**ithout **A**ctions): • Further degradation/ decreased rural development	**Negative issues** - Political/economic transition – lack of coherent consistent legal regulatory frameworkss - Technically insufficient approach to farming, poplar plantation, cultivation, poplar related initiatives - More restrictive environmental regulations - Low economic level of rural communities - Unsatisfactory public and political awareness	**- Poor and uninformed governmental decision process**	• Government – public agencies • Public forest enterprises • Forestry extension services	• BENWOOD(ap) • BIOPROS(ap) • NOVELTREE (r&dp) • ENERGYPOPLAR(r&dp) • PLEN • Establishment of clone archives (bilateral Bosnia Herzegovina – *Italy)*	• IFAD • EU • Co financing public local agencies • IBRD • Governments • EBRD • Private foundations • INTERREG	• Align with EU regulations regarding: renewable energy, water waste management, Natura 2000, Kyoto Process, 20/20/20/ climate-energy, • Green Danube corridor linking regional collaboration Romania, Bulgaria, Ukraine, Moldavia • Rural development Programs of all the countries in the area • Convention on Biodiversity • Supporting the transition of production means from public to private environment • Supporting a correct legislative drafting process with proper information • It is time for drafting or refining

Problem Identified	Major Issues	Government Strategy	Major Stakeholders	Other Projects in the Sector	Other Donors in the Sector	Justification Components
						medium and long term governmental strategies • Poplar Commissions
Lack of Transfer of Knowledge (ToK)/ extension of services. **Causes:** • Poor institutional framework for TOK • Insufficient development of a multifunctional approach • Tendency to abandon/sell land (poor commitment) **Effects:** • Inefficient utilization of land **IWA**: • Further degradation/ decreased rural development	**Positive issues** - Improving economic competition - Attractiveness to foreign investors - Large potentials for forest environmental services - Availability of land - Large potential of bioremediation	**- No/poor involvement of population and private stakeholders in this process**	• Land owners • Investors • Members of the rural communities • Forest and farmers associations • Natura 2000 administrations			• Creating an enabling environment for private farming sector • Avoiding land degradation • Need for land inventories and support for ongoing inventories
Insufficient data about suitability and availability of land **Causes:** • Lack of technical/professional infrastructures • Unsatisfactory land use planning **Effects:** • Lack of technical support for policy makers • Reduced revenues potential for land owners **IWA**: • Inadequate decisions and strategies			• Companies dealing with poplar planting and wood transformation • Bioenergy • Bio-refineries			• Existing Institution sto be able to provide technical support: Forestry Extension Services, Chamber of Foresters and Wood technologies (Croatia), European Biomass Industry Associations, Romanian Forest Research Institute, International

Problem Identified	Major Issues	Government Strategy	Major Stakeholders	Other Projects in the Sector	Other Donors in the Sector	Justification Components
						Energy Agency, Romanian State Forest Administration,
Insufficient collaboration between stakeholders **Causes**: • Lack of communication and info exchange **Effects:** • Conflicts, insufficient fundamental regulations			• NGO s • Local communities			• Functioning National Poplar Commissions
Insufficient reproduction material and technology transfer **Causes:** • Lack of institutional collaboration • Change in site conditions • Lack of connections between farmers and research institutions • Lack of tailor made approach **Effects:** • Unexploited potential resources • Narrow genetic base and adaptability • Modest levels of investments **IWA:** • Risks of emvironmental disasters • Poor technical implementation of planned poplar plantations • Strongly reduced revenues for stakeholders (farmers, ……) • Discontinuity of the supply chain of the products • Market / industry poor development			• Established market structures • Research institutions • Education institutions			

4.4. Sustainability issues in Croatia

The main sustainability issues regarding short rotation energy crops utilisation in Croatia are related to environmental considerations, specifically the Natura 2000. As described in chapter 4.2., these issues have been taken into consideration when assessing the technical potential for energy crops in Croatia.

Other sustainability issues, especially regarding socio-economic sustainability, were not possible to be included in the short energy crops potential assessment. The BEE Methods Handbook provides detailed explanations and illustrations on the issues and difficulties in including socio-economic sustainability parameters in biomass potential assessment. In essence, the main problem lies in the fact that social issues are not possible to be defined and quantified without taking into account the local context, i.e. without obtaining feedback from local stakeholders.

5. Conclusions and recommendations

This illustration case presents the results of the analysis of energy potential of fast-growing broadleaved species plantations in Croatia. The methodology used for the analysis is based on the BEE Methods Handbook and corresponds to the basic spatially explicit method, which was chosen based on the availability of the data required for its application.

The main source of data used for the analysis is contained within the Basic pedological map of the Republic Croatia, created as a result of the project coordinated by the Ministry of Science and Technology. The determination of the available area for short rotation crops production is based on taking into account the current land utilisation and eliminating the land which is already used for agricultural purposes as well as forested land.

Taking into account the various soil characteristics which define limiting factors for energy crops production the theoretical potential for short rotation energy crops production in Croatia was estimated as following:

- Forest area suitable for energy crops – a total of 51 200 ha was estimated to be suitable for SRC, producing in total 470 200 t DM/y or 8,7 PJ
- Agricultural areas with moderately suitable soils and limited soil suitability – a total of 617 000 ha was estimated to be suitable for SRC, producing a total of 7 404 000 t DM/y or 136,2 PJ

Taking into account the location and area of the Natura 2000 sites, as well as the areas unsuitable for harvesting due to various reasons, the technical potential for short rotation energy crops production in Croatia was estimated as following:

- Forest area suitable for energy crops – a total of 46 850 ha was estimated to be suitable for SRC, producing in total 430 000 t DM/y or 7,9 PJ
- Agricultural areas with moderately suitable soils and limited soil suitability – a total of 235 650 ha was estimated to be suitable for SRC, producing a total of 2 827 800 t DM/y or 52,1 PJ

In spite of the considerable potential for short rotation energy crops production, currently a very small amount of the available area is utilised in Croatia, as presented in chapter 5. The issues and problems to be addressed in order to increase this production include a change in policy approach, especially aimed at small landowners, introduction of incentives and subsidies, lack of knowledge and experience in growing energy crops and generally a lack of cooperation between relevant stakeholders.

There have been no issues identified with the application of the methodology as described within the BEE Methods Handbook, while recommendations regarding improvement of available data have been drawn in chapter 5.1. and essentially are related to the upgrading and harmonisation of the Basic pedological map of the Republic of Croatia.

6. References

Bogdan, S., D. Kajba & I. Katičić, 2006: Produkcija biomase u klonskim testovima stablastih vrba na marginalnim staništima u Hrvatskoj. Glas. šum. pokuse, pos. izd. 5, 261-275.

Domac, J., M. Beronja, N. Dobričević, M. Đikić, D. Grbeša, V. Jelavić, Ž. Jurić, T. Krička, S. Matić, M. Oršanić, N. Pavičić, S. Pliestić, D. Salopek, L. Staničić, F. Tomić, Ž. Tomšić, V. Vučić, 1998: Bioen Program korištenja biomase i otpada: Prethodni rezultati i buduće aktivnosti. Energetski institut "Hrvoje Požar". Zagreb. 180 str. , 1998

Domac, J., M. Beronja, S. Fijan, B. Jelavić, V. Jelavić, N. Krajnc, D. Kajba, T. Krička, V. Krstulović, H. Petrić, I. Raguzin, S. Risović, L. Staničić, H. Šunjić, 2001: Bioen Program korištenja energije biomase i otpada. Nove spoznaje i provedba. 144 str., 2001

Domac, J., Trossero, M. (editors) WISDOM CROATIA - Spatial woodfuel production and consumption analysis applying the Woodfuels Integrated Supply/Demand Overview Mapping (WISDOM) methodology, Report published by the UN Food and Agriculture Organisation within the project TCP/CRO/3101 (A) Development of a sustainable charcoal industry in Croatia; 2009

FAO, Unified Bioenergy Terminology (UBET), December 2004

Kajba, D., 1999a: Short Rotation Crops in Croatia. U: Christersson, L. & S. Ledin (ur.), Proceeding of the first meeting of IEA, Bioenergy Task 17. June 4-6 1998., Uppsala. Sweden. SLU. str. 37-40.

Kajba, D., 1999b: Arborescent Willow Biomass Production in Short Rotations. U: Overend, R.P. & E. Chornet (ur.) Proc. of the fourth Biomass Conference of the Americas. August 29 - September 2. Oakland. California. USA. str. 55-60.

Kajba, D., A. Krstinić, N. Komlenović, 1998: Proizvodnja biomase stablastih vrba u kratkim ophodnjama. Šumarski list 3-4: 139-145.

Kajba, D., S. Bogdan, I. Katičić – Trupčević, 2004: Produkcija biomase bijele vrbe u klonskom testu Dravica (Šumarija Darda). Šumarski list 9-10: 509-515.

Kajba, D., S. Bogdan & I. Katičić, 2007: Selekcija klonova vrba za produkciju biomase u kratkim ophodnjama. Obnovljivi izvori energije u Republici Hrvatskoj (energija biomase, bioplina i biogoriva), HGK, Osijek, 27.-29. svibnja 2007., Zbornik radova:107-113.

Kajba, D., S. Bogdan & I. Katičić, 2007: Produkcija biomase vrba u pokusnim kulturama kratkih ophodnji u Hrvatskoj. HAZU – Zbornik radova znanstvenog skupa: Poljoprivreda i šumarstvo kao proizvođači obnovljivih izvora energije, Matić, S. (ed.): 99-105.

Kajba, D., Contribution of Poplars and Willows to Sustainable Livelihoods and Land-use in Croatia: Status and Needs, Presentation at the International Workshop "Improve the contribution of Poplars and Willows in meeting sustainable livelihoods and land-use in selected Mediterranean and Central Asian countries" FAO Project GCP/INT/059/ITA, Izmit, Turkey, 27-31 July 2009

Tomić, F., Krička, T. & S. Matić, 2008: Available agricultural areas and the use of forests for biofuel production in Croatia, Šumarski list 7-8:323-330.

Annex: Pedological characteristics of soils as included in the pedological map of Croatia

No. of cartography unit	Assesment for cultivation	Utilization	Rocks %	Stone %	Inclina-tion %	Ecologicaldepth of soil (cm)	Drained soil	Dominant mode of moistering
1	2	3	4	5	6	7	8	9
1	P-1, p_1	arable land	0	0	0-3	>100	good	automorphyc
2	P-1, p_1	arable land	0	0	0-1	>100	good	automorphyc
3	P-1, p_1	arable land	0	0	0-1	>100	good	semiclay
4	P-1, p_1	arable land	0	0	0-1	>100	good	semiclay
5	P-1, p_1	arable land	0	0	0-1	40-200	good	semiclay
6	P-2, n, e, p_2	arable land and vineyard	0	0	5-15	50-120	good	automorphyc
7	P-2, n, e, p_2	vineyard	0	0	5-15	50-100	good	automorphyc
8	P-2, dr_o, p_1	arable land	0	0	0-10	70-150	moderately good	automorphyc
9	P-2, dr_o, p_1	arable land and orchards	0	0	0-2	70-150	moderately good	automorphyc
10	P-2, dr_o, p_1	arable land, forest and orchards	0	0	3-15	70-150	moderately good	automorphyc
11	P-2, dr_o, p_3	forest, arable land and orchards	0	0	5-20	50-150	moderately good	automorphyc
12	P-2, dr_o, v, p_1	arable land	0	0	0-1	50-100	poor	amphyclay
13	P-2, sk_2, n, p_2	arable land, pasture and forest	0	0	0-3	50-100	moderately good	automorphyc amphyclay
14	P-2, st_2, p_1	arable land and forest	0-3	0	0-5	70-200	good	automorphyc
15	P-2, st_2, p_1	arable land and vineyard	0-1	0	0-3	50-100	good	automorphyc
16	P-3, e, p_1	arable land and pasture	0	0	0-30	30-200	good to partly excess	automorphyc
17	P-3, n,du_2, p_1	vineyard, arable land and forest	0	0	8-30	30-150	good	automorphyc

No. of cartography unit	Assesment for cultivation	Utilization	Rocks %	Stone %	Inclina-tion %	Ecologicaldepth of soil (cm)	Drained soil	Dominant mode of moistering
1	2	3	4	5	6	7	8	9
18	P-3, n, e, p_2	forest and vineyard	0	0	10-45	50-100	good	automorphyc
19	P-3, n, k, p_3	forest, arable land and orchards	0	0	0-15	50-150	good	automorphyc
20	P-3, vt, n, p_1	vineyars and arable land	0	0	5-20	50-150	fragmentary	automorphyc
21	P-3, vt, n, p_1	arable land and vineyars	0	0	5-20	50-100	fragmentary	automorphyc
22	P-3, Kv, p_3	Arable land	0	0	0-5	30-70	excessive	automorphyc
23	P-3, du_1, Kv, p_3	arable land and forest	0	0	0-5	30-120	excessive	automorphyc
24	P-3, k, sk_2, p_3	arable land and forest	0	0	10-35	50-90	good	automorphyc
25	P-3, st_2, n, p_1	arable land and forest	0-8	0-1	3-15	50-120	good	automorphyc
26	P-3, v, dr_o, p_3	arable land and forest	0	0	0-2	40-70	fragmentary	semiclay
27	P-3, v, dr_o, p_3	arable land and forest	0	0	0-5	40-70	fragmentary	semiclay
28	P-3, v, dr_o, n, p_3	forest and arable land	0	0	3-15	70-150	moderately good	semiclay
29	P-3, v, dr_o, n, p_3	forest and arable land	0	0	3-20	50-200	moderately good	semiclay
30	P-3, sk_1, du_2, p_2	Arable land, vineyards and orchards	0-10	2-10	3-8	30-100	partly excessive	automorphyc
31	P-3, sk_2, p_2	arable land, gardens, vineyards and orchards	0-1	0-5	0-5	50-150	partly excessive	automorphyc
32	P-3, st_2, p_2	arable land and forest	2-10	0	0-7	50-200	good	automorphyc
33	P-3, st_2, k, p_3	forest, arable land and pasture	2-5	0	0-5	70-150	good	automorphyc
34	N-1, sk_1, p_3	forest šume, vineyards and gardens	1-5	5-30	8-30	20-120	excessive	automorphyc
35	N-1, sk_2, du_2, p_1	pasture, arable land and forest	0-1	0-3	0-5	30-150	partly excessive	automorphyc

No. of cartography unit	Assesment for cultivation	Utilization	Rocks %	Stone %	Inclina-tion %	Ecologicaldepth of soil (cm)	Drained soil	Dominant mode of moistering
1	2	3	4	5	6	7	8	9
36	N-1, sk_2,du_1, k, p_3	Forest and pastures	0-1	0-1	3-8	30-60	partly excessive	automorphyc
37	N-1, V, v, dr_1, p_3	pastures	0	0	0-1	20-50	very poor	amphyclay
38	N-1, V, p_3	reed	0	0	0-1	10-20	very poor	hypoclay
39	N-1, sa(na), p_3	pastures	0	0	0-1	20-60	poor	hypoclay
40	N-1, su	forest and reed	0	0	0-1	10-20	very poor	hypoclay and epyclay
41	N-1, pv,V,p_2	forest (arable land), pasture	0	0	0-1	50-120	fragmentary (good)	alluvium
42	N-1, pv,V,p_2	forest and arable land	0	0	0-1	30-80	fragmentary	hypoclay
43	N-1, V, v, dr_1, p_3	forest, arable land and pastures	0	0	0-1	20-90	poor	amphyclay and hypoclay
44	N-1, V, v, dr_1, p_3	forest, arable land and pastures	0	0	0-1	20-90	poor	amphyclay and hypoclay
45	N-1, V, v, dr_1, p_3	pastures, forest and arable l	0	0	0-1	30-80	poor	amphyclay and hypoclay
46	N-1, V, v, dr_1, p_3	forest, pastures and arable land	0	0	0-1	30-100	poor	amphyclay and hypoclay
47	N-1, V, v, dr_0, p_3	forest, pastures and arable land	0	0	0-2	30-100	poor	pseudoclay-clay
48	N-1, v, V, dr_1, vt, p_3	forest, pastures and arable land	0	0	0-2	30-70	poor	amphyclay
49	N-2, n, sk_2, p_1	forest and pastures	50-90	5-30	15-45	20-30	partly excessive	automorphyc
50	N-2, n, sk_2, k, p_3	forest and pastures	0-1	0-15	8-45	40-80	good	automorphyc
51	N-2, n, sk_2, k, p_3	forest and pastures	0-1	5-10	15-45	30-60	partly excessive	automorphyc
52	N-2, n, sk_2, k, p_3	forest and pastures	0-1	5-10	8-25	30-120	partly excessive	automorphyc
53	N-2, n, st_2, du_2, p_1	forest	20-30	10-30	16-45	30-80	partly excessive	automorphyc
54	N-2, ka,st_1, dr_2, p_3	karst	50-90	30-60	5-30	5-15	excessive	automorphyc

No. of cartography unit	Assesment for cultivation	Utilization	Rocks %	Stone %	Inclina-tion %	Ecologicaldepth of soil (cm)	Drained soil	Dominant mode of moistering
1	2	3	4	5	6	7	8	9
55	N-2, st_1, du_2, p_1	forest	50-70	10-20	3-30	30-50	partly excessive	automorphyc
56	N-2, st_1, n, p_1	forest	50-80	10-20	3-30	30-50	partly excessive	automorphyc
57	N-2, st_1, n, p_1	forest	50-70	10-30	3-30	30-70	partly excessive	automorphyc
58	N-2, st_1, n, p_1	forest	50-60	5-30	10-45	40-80	good	automorphyc
59	N-2, st_1, p_2	forest	50-70	10-20	3-30	50-90	good	automorphyc
60	N-2, st_2, n, p_1	forest	20-50	10-30	8-30	30-60	partly excessive	automorphyc
61	N-2, st_2, du_1, p_1	forest	30-50	20-40	16-45	10-30	partly excessive	automorphyc
62	N-2, st_2, du_1, p_1	forest and pastures	5-20	3-5	3-15	20-50	partly excessive	automorphyc
63	N-2, k, sk_2, p_3	forest	0-1	0	0-15	40-100	good	automorphyc
64	N-2, k, sk_2, p_3	forest	0-1	0	0-15	40-100	good	automorphyc
65	N-2, v, V,dr_1,vt,p_3	pastures and forest	0	0	0-1	10-50	very poor	epyclay

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