**Short Rotation Woody Crops (SRC) plantations for local supply chains and heat use**

**Project No: IEE/13/574**


# *Identification of suitable areas for sustainable production of short rotation coppice (SRC) in Osijek-Baranja and Vukovar-Srijem counties*

***WP 6 – D 6.4***

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SRCplus website: www.srcplus.eu

# Content

## Abbreviations

| | |
|---|---|
| SRC | Short Rotation Coppice |
| OBC | Osijek- Baranja County |
| VSC | Vukovar- Srijem County |
| OG | Official Gazette |
| AL | Agricultural land |

## Glossary

| | |
|---|---|
| ARKOD | National system for land parcel identification (eng. Land Parcel identification System – LPIS) in Croatia |
| P1 | Highly valuable agricultural land |
| P2 | Valuable agricultural land |
| P3 | Other agricultural land |
| PŠ | Other agricultural and forest land |

# 1 Introduction

The goal of this study was to determine the most suitable areas for development of SRC plantations in two counties in eastern Croatia (Osijek-Baranja and Vukovar-Srijem counties) in regards to ecological and socio-economic aspects. The study is developed within the project SRCplus and it builds on materials and data previously available within the same project, namely:

- „Preliminarna selekcija potencijalnih lokacija za podizanje nasada kultura kratkih ophodnji u Osječko-baranjskoj i Vukovarsko –srijemskoj županiji“ (D6.1) and
- „Strategija za održivi uzgoj i korištenje biomase kultura kratkih ophodnji u Osječko-baranjskoj i Vukovarsko-srijemskoj županiji“(D6.2).

In the above mentioned documents, the broad potential areas suitable for sustainable SRC have been identified. The parameters considered for this selection were primarily soil quality and current and intended land use of the agricultural land. Within previously mentioned preliminary broad analysis, parcels from 1-5 ha were considered, reaching total area of 2378 ha. This study is the next step in the analysis that will result in further selection of parcels from already preliminary identified parcels in D6.2.

The main task of the study is to identify suitable areas for SRC development in regards to various ecological (soil, water, plant ecology, biodiversity) and socio-economic (land use, economy of establishment of SRC, rural development) parameters.

# 2 Agriculture and rural development in the region

Eastern Croatia is the lowland area of Croatia with very fertile soils and long tradition in agricultural production and it is often called „The granary of Croatia“. Therefore, the development of the whole region is strongly grounded on agricultural activities. However, as the consequence of this long and intensive agriculture, a negative and degradative effect has been observed in soil quality decrease and the loss of fertile top soil-humus.

Table 1. Land use in OBC and VSC (Source: D6.1)

| | | Osijek-Baranja | Vukovar- Srijem |
|---|---|---|---|
| County surface | | 4.155 $km^2$ | 2.448 $km^2$ |
| Agricultural land (AL) | | 212.013 ha | 145.985 ha |
| Arable land | Share in AL (%) | 95 | 93.3 |
| Orchards | | 1.8 | 1.75 |
| Vineyards | | 1.15 | 1.4 |
| Meadows | | 1.2 | 0.65 |
| Grassland | | 0.9 | 2.90 |
| Share of agricultural land in overall surfaces in the county (%) | | 51 % | 59 % |
| Forest and forest land | | 122.476 ha | 69.383 ha |
| Share of forest and forest land in overall surfaces in the county | | 29,5 % | 28,7 % |

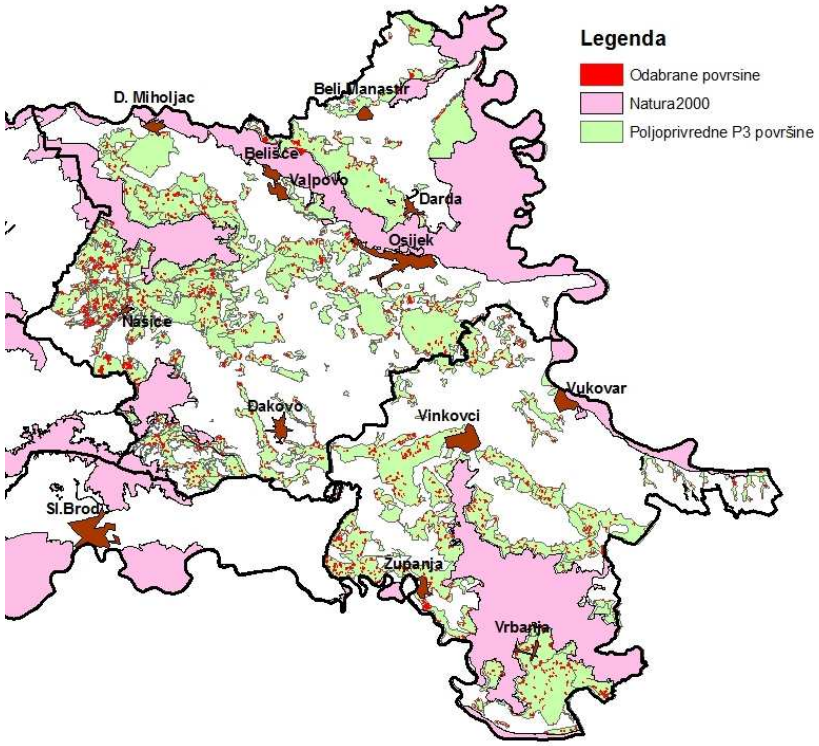
Agriculture land covers over 51% of Osijek- Baranja county and 59% of Vukovar- Srijem county (Table 1.). Detailed description of the region can be found in D6.1.

Table 2. Protected areas in OBC and VSC (Source: D6.1)

| Protection category | Osijek- Baranja | Vukovar- Srijem |
|---|---|---|
| Nature park | 1 (Kopački rit) | 0 |
| Special reserve | 2 (Kopački rit, Podpanj) | 3 (PR šumske vegetacije Lože, Radiševo, Vukovarska ada) |
| Regional park | 1 (Mura-Drava) | 0 |
| Natural monument | 1 | 5 |
| Park architecture monument | 12 | 4 |
| Important landscape | 1 (Erdut) | 3 (Spačva, Virovi, vuka) |
| Forest park | 0 | 3 |

# 3 Areas suitable for SRC

In the previous reports (D6.1 i D6.2) guidelines for selection of suitable areas for SRC development have been chosen. Detail description of the methodology and cartographic materials used can be found described in D6.1. In regards to high importance of agriculture for development of the region, the advantage is given to agricultural production over production of biomass for energy. Therefore, this study considers only agriculture land of lower quality, or land with moderate and limited soil suitability for agricultural production (P3).




Picture 1. Distribution of parcels size 1-5ha in study D6.2.

Within the study, mainly arable land was considered since it represents the biggest share in overall agricultural land (Table 1.), and in order not to diminish land already represented in small shares designated for other agricultural production, such as orchards. Furthermore, the protected areas were excluded from analysis. The areas prone to frequent flooding were also not analysed, as well as land allocated for construction and development, land along roads and below electricity lines. After the initial selection and elimination of land that is registered to receive subsidies in agriculture (in 2014), a significant number of smaller parcels has been identified (Picture 1).

# 4 Parameters for selection of SRC areas

The selection of potential suitable locations for development of SRC production is based on principles of sustainability, where the environment, nature, socio-economic aspects, technical feasibility and current legal aspect were taken in consideration. The main guidelines in selection were:

i. To select surfaces on soils of lower quality (moderate of limited soil suitability) and suitability for agriculture so that SRC production doesn't pose a threat or compete with agricultural production for food and feed.

ii. Select species/clone that can be grown with substitutional yields on selected type of soils.

iii. Select the surfaces that are easy accessible and without major technical limitations.

iv. Select the surfaces that are relatively close to the woodchip consumers in order to minimise the transport cost from SRC plantation to end user of woodchips.

## *4.1 Soil*

Intensive agriculture which is practiced in the region for the last half of the century, resulted in graduate substitution of organic fertilisers with mineral fertilisers. This constant output of organic matter with minimal inputs has led to decrease of humus in soils. The decrease in organic top soil (humus) is considered as one of the biggest problem of agriculture soils in Europe. Considering this negative effect of intensive agriculture on soil quality, the soils considered for SRC development were soils of moderate or limited soil quality for agriculture (P3). The SRC production on these soils, along biomass production, could lead to increase in the level of humus and soil fertility. In order to reach this, at least three rotations would be needed.

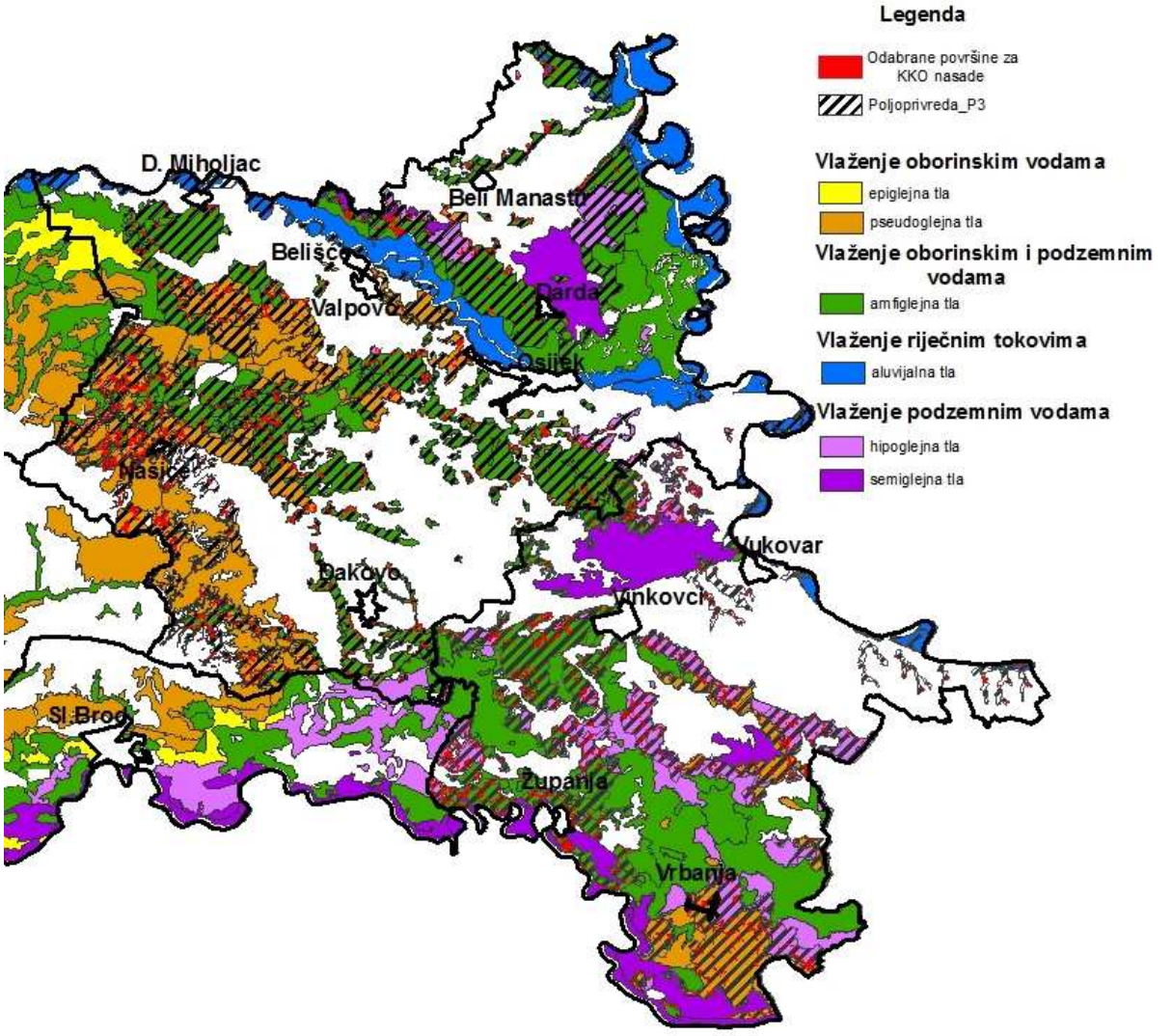
Definition of soils of moderate or limited soil suitability for agriculture refers mostly to the water regime in these soils - level of wetting and water stagnation. Wetting can be alluvial (by rivers and other watercourses), rainfall, groundwater or by combination of rainfall and ground waters. The soils area divided on two main categories: i) Automorphic i ii) Hydromorphic. Automorphic soils are characterised mainly by wetting by rainfall waters while drainage is undisturbed, therefore, there are no permanent waters.
Hydromorphic soils are all other soils that show significant signs of excessive wetting and water stagnation. Wetting can be a result of rainfall, additional (not from the same location), river basin, flood, groundwater. One part of these soils are considered as moderately suitable soils for agriculture (P3) due to longer water stagnation (Picture 2).

Depending on wetting modes, the following types of hydromorphic soils can be differentiated:

- Wetting by rainfall- epigley i pseudogley
- Wetting by groundwater - hypogley i semigley

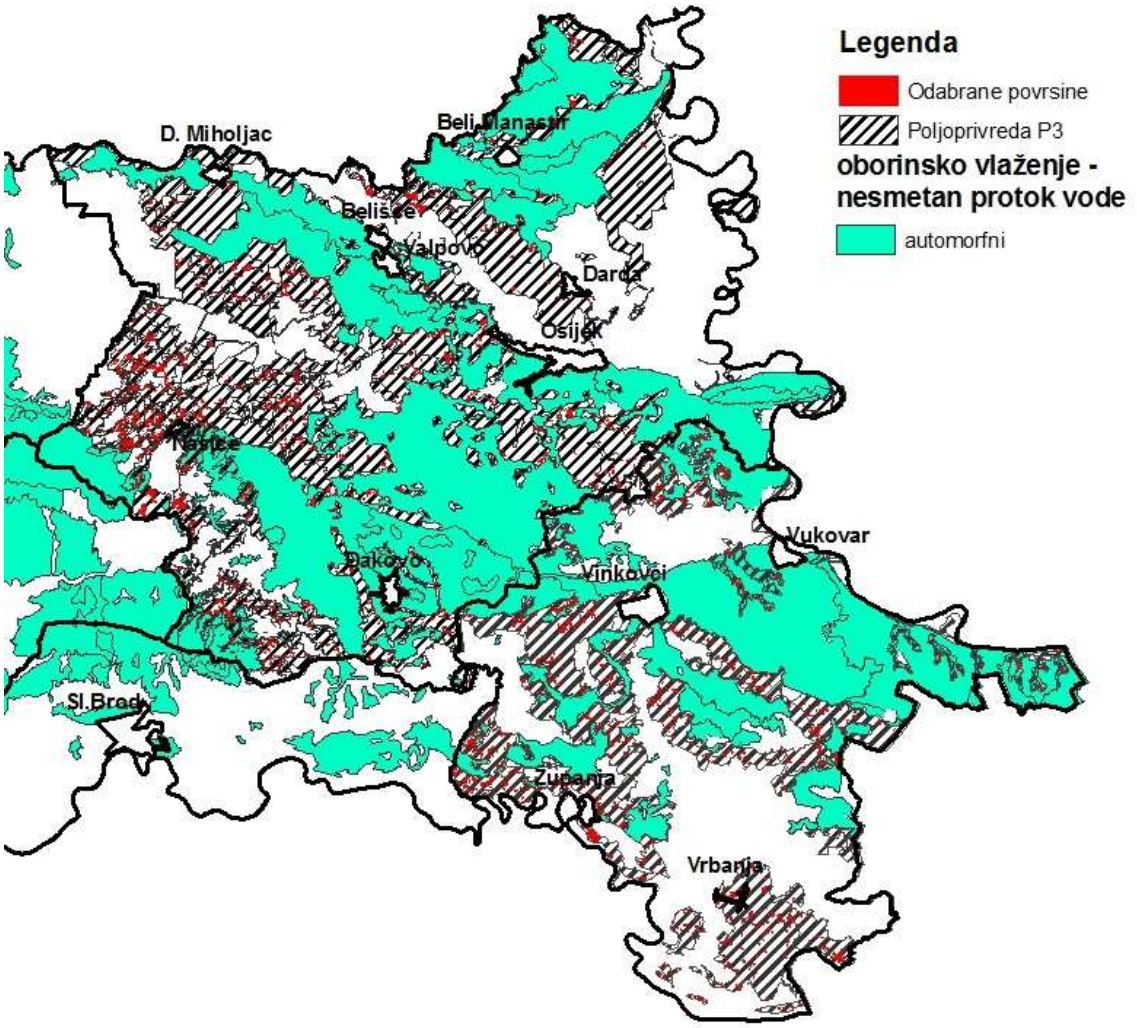
- Wetting by rainfall and groundwater - amphigley
- Wetting by river watercourse – alluvial soils

These soil types are characterised by higher clay share that results in weak drainage and water stagnation. As it can be seen from Picture 2, surfaces defined as moderate or limited soil suitability for agriculture (P3) are surfaces characterised as amphigley, pseudogley and partly hypogley soils.
The suitability of such soils for agricultural production is limited, but it is not limited for production of SRC as willows and poplars can endure relatively well periods of water stagnation. Alluvial soils, in which the wetting is under the influence of rivers courses and are natural habitats for willow and poplars, are not taken in consideration. These surfaces are mostly already under forest or are located in protected areas, meaning that they are not under agricultural production, and therefore are not under category P3.




Picture 2. Soils with signs of excessive wetting and water stagnation, and agricultural land of P3 suitability

Automorphic soils, the soils with rainfall mode of wetting and with no water stagnation are very suitable for agricultural production and therefore are not taken in consideration for SRC development, because ethe advantage is given to food and feed production over energy production. As it can be seen from picture 3, automorphic soils do not fall under agrucaltural soils of limited soil suitability.




Pi
cture 3. Soils with wetting by rainfall and good water drainage procjeđivanjem, and agricultural land of P3 suitability

The development of SRC plantations is recommended on soils with water stagnation, low share of organic matter (in regards to the fact that SRC can increase the organic content and soil fertility after three rotations), soils exposed to erosion (water, wind) which leads to loss of nutrients, an soils polluted with heavy metals, because willows are often used in the process of phytoremediation or purification of polluted soils (even though there is no such soil registered within OBC and VSC). By establishment of SRC, the soil will be prepared for other production purposes after the KKO.

### *4.2 SRC species selection*

In accordance with Article 17 of Ordinance on implementation of direct support for agriculture and IAKS measures of rural development (OG 20/16, 39/2016, 91/2016) the short rotation coppice are cultures with maximum rotation cycles of 8 years and with species: alder *(Alnus glutinosa)*, birch *(Betula sp.)*, hornbeam *(Carpinus sp.)*, chestnut *(Castanea sp)*, ash *(Fraxinus sp.)*, poplar *(Populus sp)*, black locust *(Robinia pseudoacacia)* and willow *(Salix sp.)*.

Areas selected for SRC development are characterised as P3 category of AL suitability with limited water drainage and water stagnation (clay of sandy soils that retain water). These

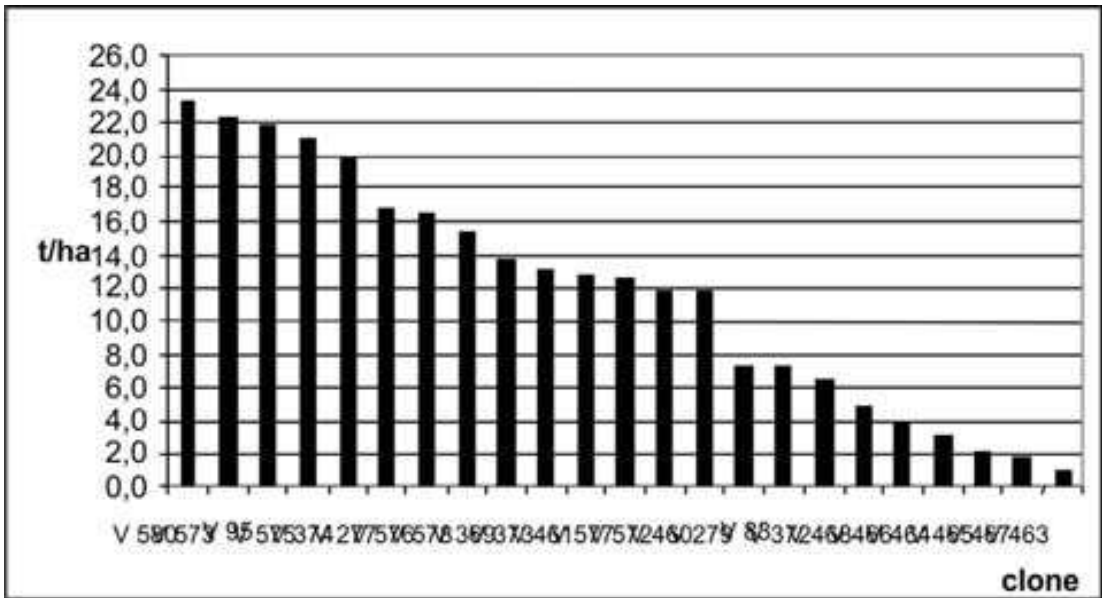
soils are suitable for willows and poplars that can tolerate water stagnation for longer periods. The most suitable are neutral or slightly acidic soils, with pH range 5.5 – 8.0. Selection of species or clone can be made for each parcel separately after detailed soil analysis is made. Considering that OBC and VSC are areas with natural appearance of poplar and willow and long tradition in cultivation of these species, poplars and willow clones can be easily selected from current nurseries in the region.

Next step in the selection of areas is an examination of suitability for willows and poplars, and analysis of ecological, economical and technical aspects of these SRC species.

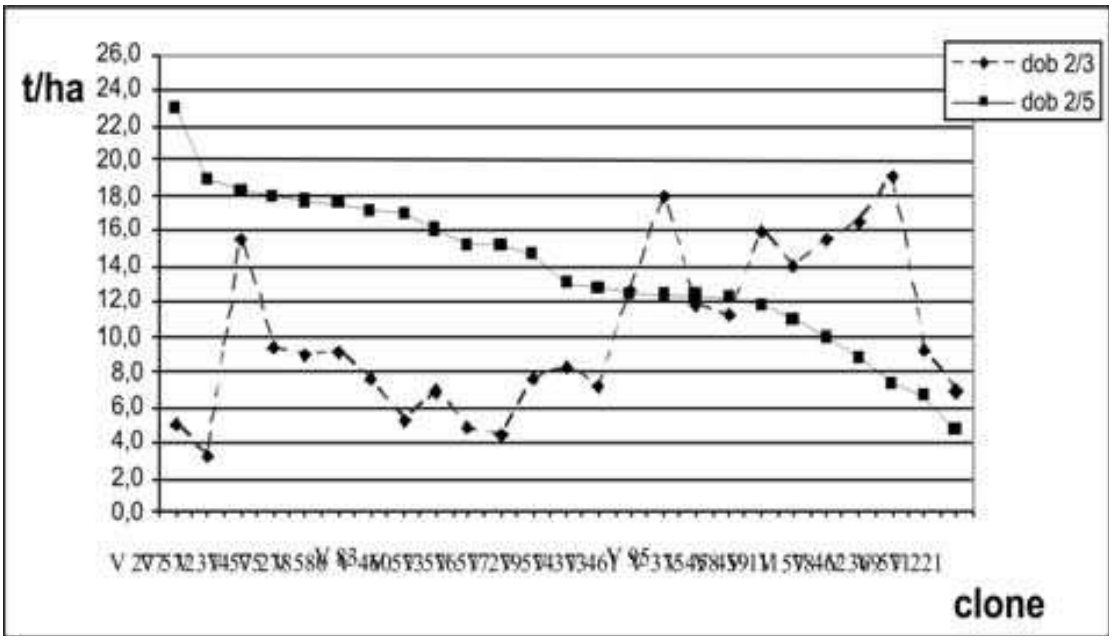
***Willow*** – fast growing species that can reach height of 2m already after one year. Tolerates water with ease and is often found along rivers, because it is considered as pioneer species which function is fast development along rivers and natural forestation of river banks. It grows on clay and sandy loam and water stagnation doesn't' represent a problem for its growth.

The research of yield of various willow clones, which was made for the purpose of establishment of SRC plantations on agricultural surfaces with poor and clay soils, has shown differences in biomass yield between 25 different willow clones (Kajba i Katičić, 2011) over two rotations of two year each (2/3 i 2/5). The average yield of all 25 clones after the first rotation (2/3) was 10.1 t/ha and after the second (2/5) 13.8 t/ha. On the heavy clay soils, the best yields were recorded among Chinese willow clones (V 580 i V 573) and white willow V 95 with an average yield from two rotations on two locations ranging from 12.4 t/ha up to 19.8 t/ha (Graf 1. i Graf 2.). These clones that show good yields on clay soils can be suggested for observed parcels. It is important to mention that no fertilisation was applied at test fields. On the other side, application of fertilisers at the test fields in nursery Valpovo, as well as protection from pests, resulted in significantly higher yields. In these conditions, white willow clone V 95 achieved a yield of 25.8 – 28.8 t/ha (Kajba i Katičić, 2011; Kajba i Andrić 2014).

From registered clones of willow, clones V52, V160 i V95 successfully grow on clay soils. Clones V52 and V160 are clones suitable for longer rotations while clone V95 is suitable for short rotations and production of biomass. Therefore, clone V95 is the clone that is recommended for areas identified within this study.




Graf 1. Biomass yield on the field test Čazma (FT2), after the first rotation, age 2/3 years (Source: Kajba i Katičić, 2011)




Graf 2. Biomass yield at field test Čazma (FT3), after 1st ( 2/3 year) and second rotation (age 2/5) (Source Kajba i Katičić, 2011)

***Poplar*** – fast growing species that reaches height of 3m after one year. As willow, poplar also tolerates well water and can be often find along river beds together with willow. Its fast growth is partly due to urge to out top the flooding. Registered clones that can be found in nurseries (M1 i S1) are suitable exclusively for alluvial soils, while clay soils do not suit them even though they can tolerate water stagnation.

Considering that surfaces suggested by this study are mostly on clay soils, we suggest species or clones that can tolerate water and grow well on such soils. From registered clones of willow and poplars, the best choice seems to be white willow clone V95.

### *4.3 Access to parcels and technical limitations*

In order to minimise the cost of parcel maintenance, transport of woodchips, and to achieve higher yield of biomass, the selected SRC parcels should be easily accessible. This is an important aspect to take in consideration in the process of parcel selection. Furthermore, as previously mentioned, for better results in terms of yield and by that better economic feasibility, it is suggested to use clones that show good growth results on clay soils (V 580, V 573 i V 95). Also, it is recommended to apply fertilisation and weed control in the first year of plantation development.

### *4.4 Proximity of woodchip users*

In order to minimise the cost of transport of biomass from the parcel to end user, we selected surfaces within the radius of 15 km from potential users, either bigger settlement or a city. On pictures 4 and 5 the circles represent 15 km radius around big settlements and cities.

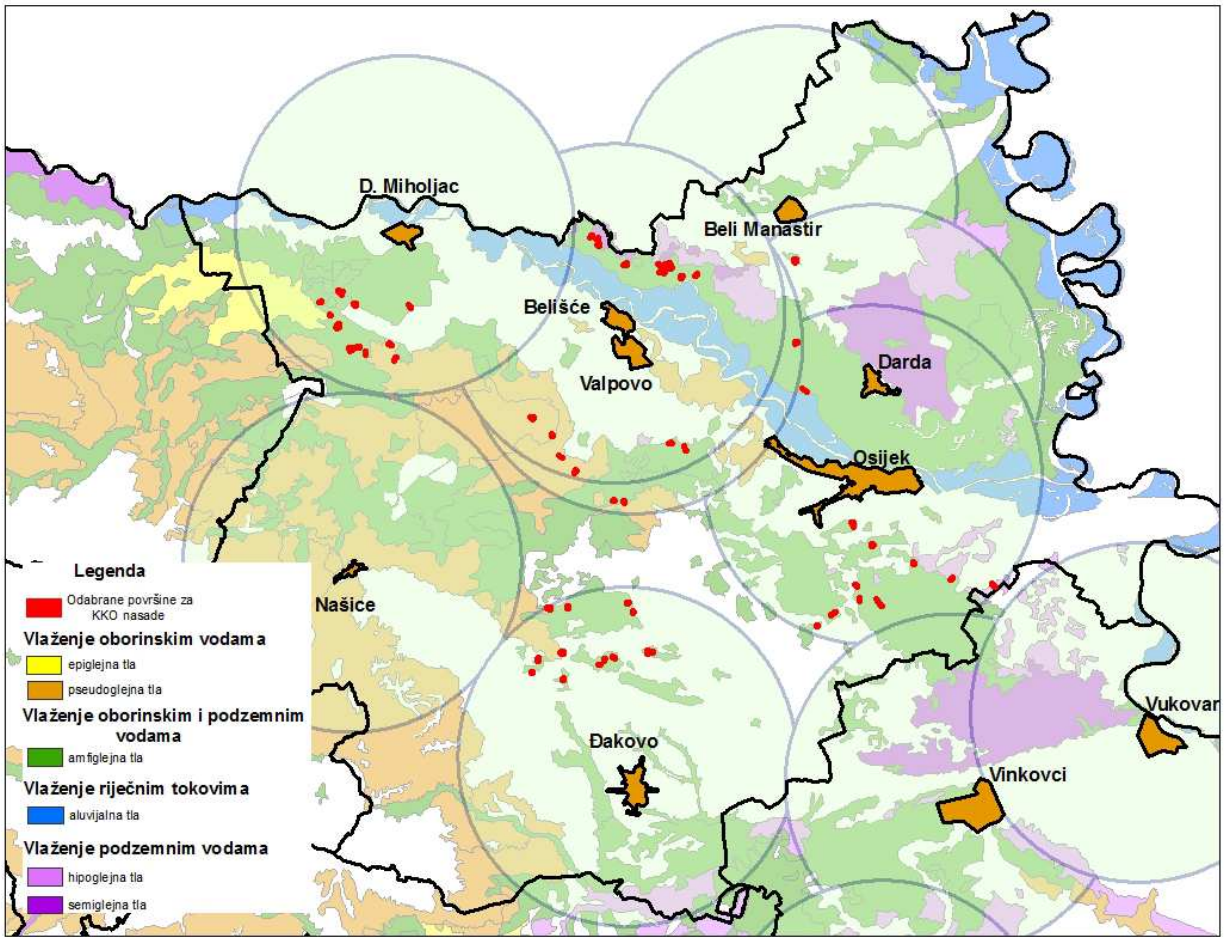
Currently, at the area of the region, there were five plants for energy production from woody biomass (VSC:3, OBC:1 and in the neighbouring county:1). Two more are planned to be opened in 2017 (Darda i Osijek). All these plants are located within the radius of 15 from proposed parcels.

# 5 Analysis of suitable areas

In the SRCplus report D6.2, 1399 parcels size ranging from 1-5ha and overall surface of 2378.7 ha have been identified. Based on the parameters mentioned in the earlier chapters of the study, further analysis has been made which resulted in identification of 61 parcels size 1-5ha with an overall surface of 106ha in OBC and 49 parcels size 1-5ha with overall surface 85 ha in VSC (Picture 4 i 5). Suggested surfaces are located on amphigley and pseudogley soils of P3 category of suitability, meaning that these soils are characterised by water stagnation. Considering that these conditions are favourable for willow clone V95, it is suggested to apply this clone on all identified parcels, even though it is possible to make soil analysis for each parcel in order to have exact results and determine the best clone. The parcels are easy accessible, and are located in 15 km radius from current or planed potential woodchip users (for example settlement). In OBC the focus was on areas along Drava river which are natural habitats for willow and poplar. From the same reason, area around Našice is taken out of consideration during the selection because it is not typical natural habitat for these species, and the area is characterised by certain surface inclination (Picture 4.).

Therefore, in OBC we can say that there are four areas with perspective for SRC development:

- Donji Miholjac
- Belišće/Valpovo
- Osijek/Darda
- Đakovo




Piture 4. Selected areas (61) in Osijek-Baranja county (15km radius)

From the selected areas (picture 5-7), it can be seen that these are located on moderate or limited suitability soils that might not be in agricultural production (picture 5), or are located along marginal lands such as cannals, grasslands (picture 6-7). SRC plantations on these

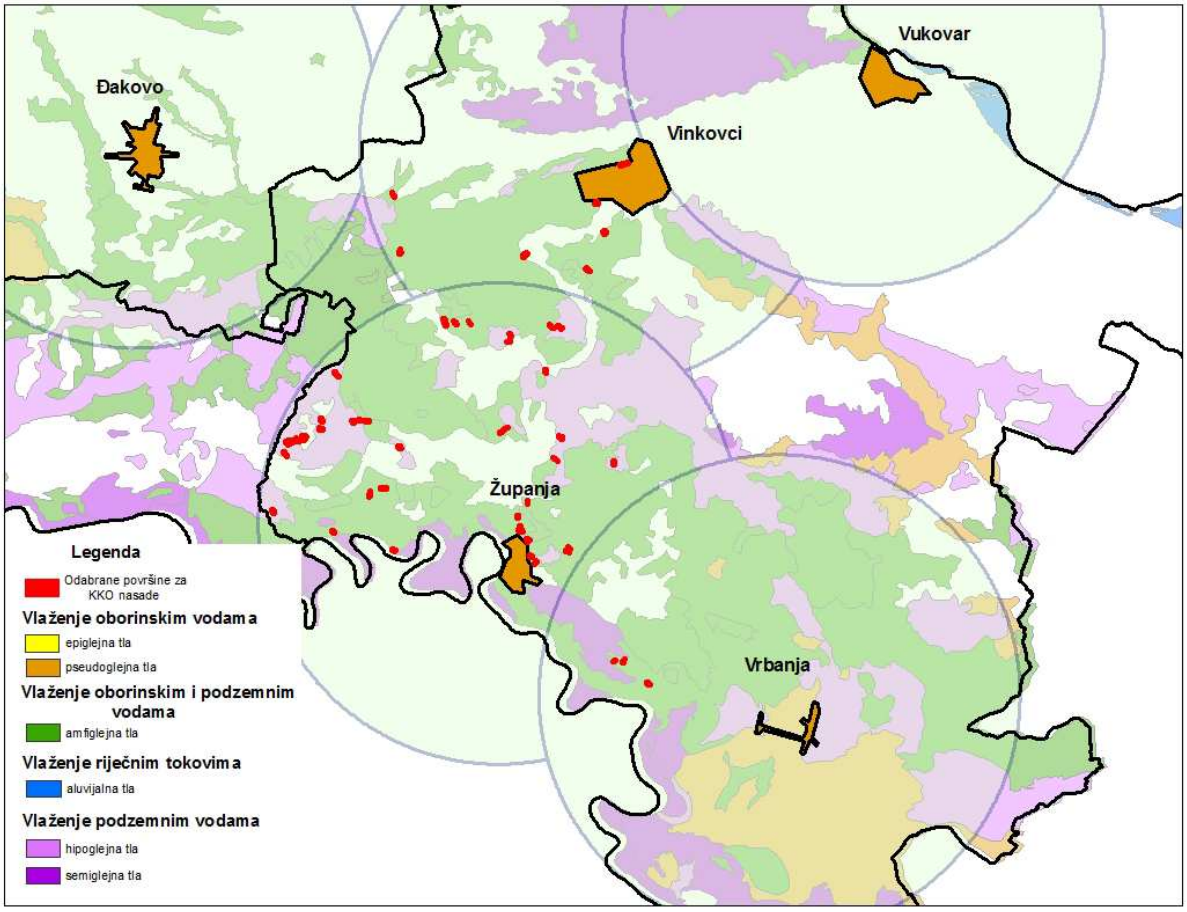
areas can have additional functions such as protection of agricultural land from effects of industrial facilities, such as facility for plastic processing (picture 5) or protection of canals and waterways from exhaustive drainage of nutrient from agricultural surfaces located near these water bodies (picture 7).

Picture 5. Parcel of size 2h next to the facility for plastic processing

Slika 6. Parcel on soil of lower quality, on the edge of unmanaged land

Picture 7. A parcel along the canal

In the area of VSC one cogeneration plants on biomass can be found (Babina Greda), but quite close to another in OBŽ (Strizivojna). Based on this, the parcels were selected in the proximity of Vinkovci and Županja (Picture 8).




Picture 8. Selected areas (49) in Vukovar-Srijem county (15 km radius)

# 6 Potential for SRC woodchip use in OBC i VSC

In report D6.2 a detailed analysis has been made of the possibilities for woodchip use within OBC i VSC territory, where as potential woodchip users were identified:

i) Public sector (public administration buildings, public institutions, schools, hospitals…)

ii) Residential sector mostly in urban areas and bigger settlements

iii) Industry – large heat consumers located in business zones

iv) Cogeneration plants for production of heat and electricity

At the beginning of 2017, in the region (OBC and VSC and neighbouring areas) there were five operational power plant facilities for electricity production from woody biomass:

1. Uni Viridas d.o.o., Babina Greda (cca 10 MW)
2. Strizivojna Hrast (Strizivojna) (3MWel)
3. Slavonija DI in Slavonski Brod (another county but very close to OBC i VSC), the same owner as „Strizivojna Hrast“, and the same technology is used (4.6 MWel i 8 MWth).
4. Vinkovci (cca 300 kW) – gasification technology.
5. SENSE ESCO Belišće (1MW), operational from 2017, gasification technology is used and demands woodchips of hardwood species and without bark.

Power plants that will become operational in 2017:

1. Darda, (cca 250 kW) - gasification technology.
2. HEP, Osijek

From the list of power plants above, it can be seen which are operational and which will become operational soon. It can be seen that the facilities are concentrated within the triangle between Vinkovci-Strizivojana-Babina. There is one facility outside the target counties, but relatively close for woodchip transport from the counties. For OBC the highest potential is identified in area of Belišće-Valpovo and Osijek-Darda. HEP will soon start to operate power plant on woody biomass in Osijek that will be significant woodchip consumer.

# 7 Conclusions and recommendations for SRC plantation development

To achieve economic feasibility of SRC plantations, which is after all the most common motif for SRC plantations development, it is crucial to have secure market, someone who guarantees to buy the SRC woodchips produced. From the study, it can be seen that on the area of OBC and VSC there is a certain number of biomass cogeneration power plants that could be potential users of woodchips from SRC. We could say that energy plantations of SRC are becoming interesting to agricultural producers that have in their possession surfaces of land not suitable for conventional agricultural production.

Within the analysed counties, the most perspective species of SRC are willow and poplar since these two species grow well on soils on this area which are characterised as soils of limited suitability for agricultural production. Regarding the soil, it is necessary to select the clones of willow and poplar that will result in highest yields on the soils typical for the county. The most pricing SRC is willow clone V95 that results in high yield and is suitable for SRC.

In OBZ the highest potential for development of SRC plantations has been identified in area around Belišće, Valpovo and Osijek and Darda. In VSZ, most promising area is a triangle between Vinkovci-Strizivojna-Babina Greda and area around Županja and Vinkovaci. With this study 61 parcel has been identifies as suitable in OBC and 49 in VSC.

# 8 Summary

The establishment of short rotation coppice (SRC) plantations can have beneficial environmental impact however economic viability is still the main drive for cultivation of the SRC. To have a positive financial outcome from cultivating SRC it is necessary to have a market for it.

The present study shows that in the two observed counties a number of biomass power plants have appeared recently, and thus we can say that the energy crops become interesting to farmers who own land that is unsuitable for agricultural production.

The most promising SRC species are willow and poplar, since they grow well on the soils that are in this area characterized as limited-suited for agricultural production. Of course, with respect to the soil, appropriate clones should be selected which will give the highest yields.

The greatest potential for cultivation of the SRC in Osijek-Baranja county is near Belišće-Valpovo and Osijek-Darda while in the Vukovar-Srijem county the most appropriate area would be the triangle: Vinkovci-Strizivojna-Babina Greda ie. Surroundings of Županja and Vinkovci.

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