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

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www.srcplus.eu

Identification of suitable areas for SRC production in Vidzeme planning region

WP6 – Task 6.4

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1 Introduction

This study report was prepared in the framework of project 'SRCplus', identification No IEE/13/574/S12.675729, of programme 'Intelligent Energy Europe'. The study was conducted by the Institute of Agricultural Resources and Economics according to the contract concluded between LTD 'Ekodoma' and the Institute. For conducting study 'Evaluation of the potential for sustainable growth of SRC in five parishes of the Vidzeme region' the following terms of reference were established:

- Based on the defined in the strategy (D6.2.) aspect of sustainability (effect on the land use, the landscape, waters, soil etc.) to evaluate the most appropriate places for arranging plantations of Short Rotation Woody Crops (SRC) in the five defined in the strategy parishes of the Vidzeme region;
- To conduct analysis of the aforesaid and the main social economic aspects related to arrangement of the plantations;
- To prepare proposals for selection of additional criteria regarding arrangement of plantations of SRC in the region.

One of the tasks within the study was to present the results of evaluation during the national seminar. The seminal held on 31st of May2016 in Madona and authors of this study presented the work 'Evaluation of the farmland suitability and potential for arrangement of SRC plantations'focused on different options for implementation of plantations of short rotation energy crops.

The study was prepared through familiarising oneself with the former results of the SRCplus project both in Latvia (the Vidzeme region) and in the project partnership countries. The report was prepared by Dr. geogr. Mr. Pēteris Lakovskis and Dr. oec. Mr. Alberts Auziņš, the researchers of the Institute of Agricultural Resources and Economics. Within the framework of the study the materials and conclusions from the national and international seminars of the project were used as well as interviews with particular specialists were conducted. Special gratitude goes to Ms Lāsma Apsīte, the representative of LTD 'Ecomark', for the consultations during the period of preparing the report.

2 Data an methods

2.1 Data

To develop the report, the former results of the SRCplus project were used, i.e., the available reports (D.6.1., D.6.2., and D.6.3.) with included in those results and conclusions. Additionally, the available data regarding the total areas of AL (i.e., agricultural lands) in parishes and regions according to the data of the State Land Service in 2014 were also used. The report was developed by the experts based on data analysis, calculations and evaluation thereof.

Evaluation of the economic efficiency of SRC plantations was prepared on the basis of the information from the handbook 'Sustainable Short Rotation Coppice' (I. Dimitriou, D. Rutz, 2015.), the materials and conclusions reached in the national and international seminars of the project as well as on the information provided by LTD 'ECOMARK'.

2.2 Methodology of cost effectiveness evaluation

Evaluation of the economic efficiency of SRC was performed by applying the method of discounted cash flow. The method of discounted cash flow was chosen due to the following reasons:

1) The life cycle of the SRC plantations is very long – typically it exceeds 20 years;
2) The income and expenditure flow is very uneven in time, for instance, income occurs periodically only – once per 3-5 years, significant expenditure occurs at the beginning of the life cycle etc.;
3) The expected future income and expenditure are not particularly known, they fluctuate and only their average values may be prognosticated.

Taking into consideration the fact that it is not possible to feasibly prognosticate the nominal income and expenditure in 5, 10 and more years, the cash flow discounting has been performed by applying actual quantities instead of the nominal ones, i.e., the actual flow (income and expenditure are expressed in the today prices) and the actual discount rate.[1] All the income and expenditure are discounted by using the following general equation:

$$PV = \frac{CF_i}{(1+r)^i}, \quad (1)$$

To characterise the economic efficiency of the SRC growing two output indicators have been used:

1) Net discounted cash flow (NPV) or net discounted value;
2) Conditional prime cost of woodchip or the minimum price of woodchip at which NPV=0.

NPV has been calculated as the total amount of all the spot values of the cash flows created during the life cycle:

$$NPV = \sum_{j=0}^{n} PV_j, \quad (2)$$

Considering that the presumptions have been generally evaluated on average per 1 ha, NPV is calculated on average per 1 ha. Thereby NPV characterises the average

[1] Use of actual quantities is recommended also by the EC guidelines for the cost-benefit analysis (*Guide to Cost-Benefit Analysis of Investment Projects*. 2014)

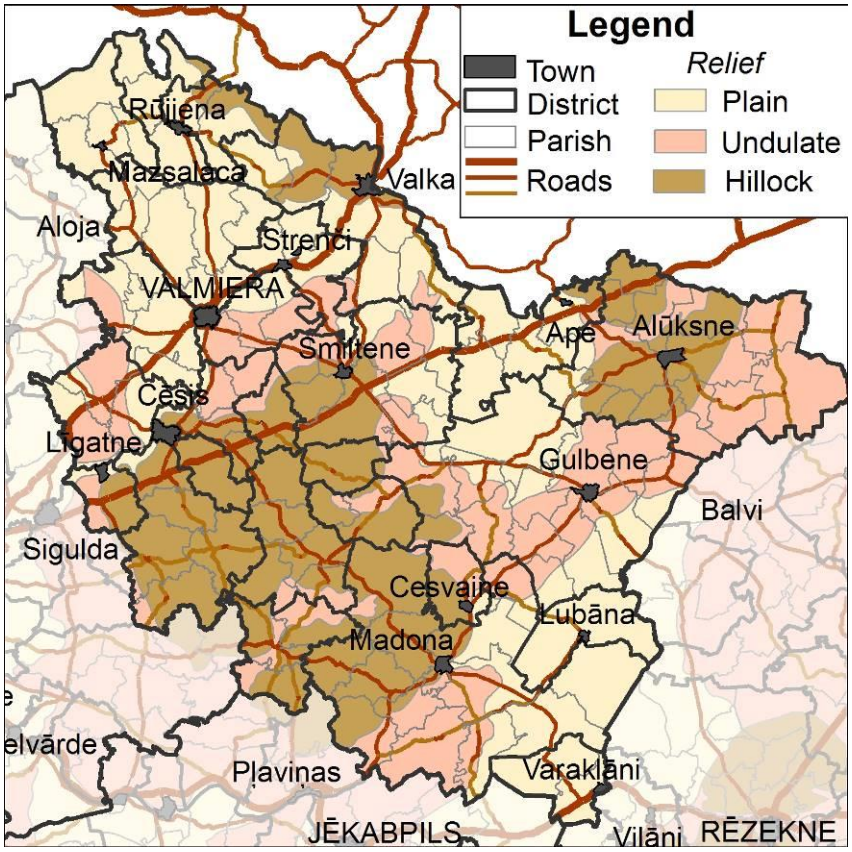
economic profit that occurs during entire life cycle of the SRC growing and that has been assessed in the spot value. According to the general meaning of NPV the evaluated variety is supposed to be economically efficient provided NPV>0, and economically inefficient if NPV<0.

The conditional prime cost of woodchip is calculated as the minimum price of woodchip (EUR/MWh) at which NPV=0. Thereby this indicator represents the limit of price at which the respective variety becomes economically efficient.

3 List of areas under consideration

During the project potential for arrangement of SRC plantations in Vidzeme region has been evaluated. Due to the relief (plains, undulated plains or hilly areas) (see Fig. 3.1), as well as characteristics of silts and soils Vidzeme is one of the most wooded regions of Latvia. Since the late 20th century the structure of the land use has significantly changed in Vidzeme and these trends of change continued also at the beginning of the 21st century, as well after Latvia joined EU. The changes are to be characterised by reduction of AL and following increase of areas covered by brushwood and forests. Such changes of the land use structure are affected both by the natural and the socioeconomic factors. It should be mentioned that along with changes of the land use structure also significant changes in the structure of the population density and socioeconomic changes have taken place.

Figure 3.1. Map of Vidzeme region



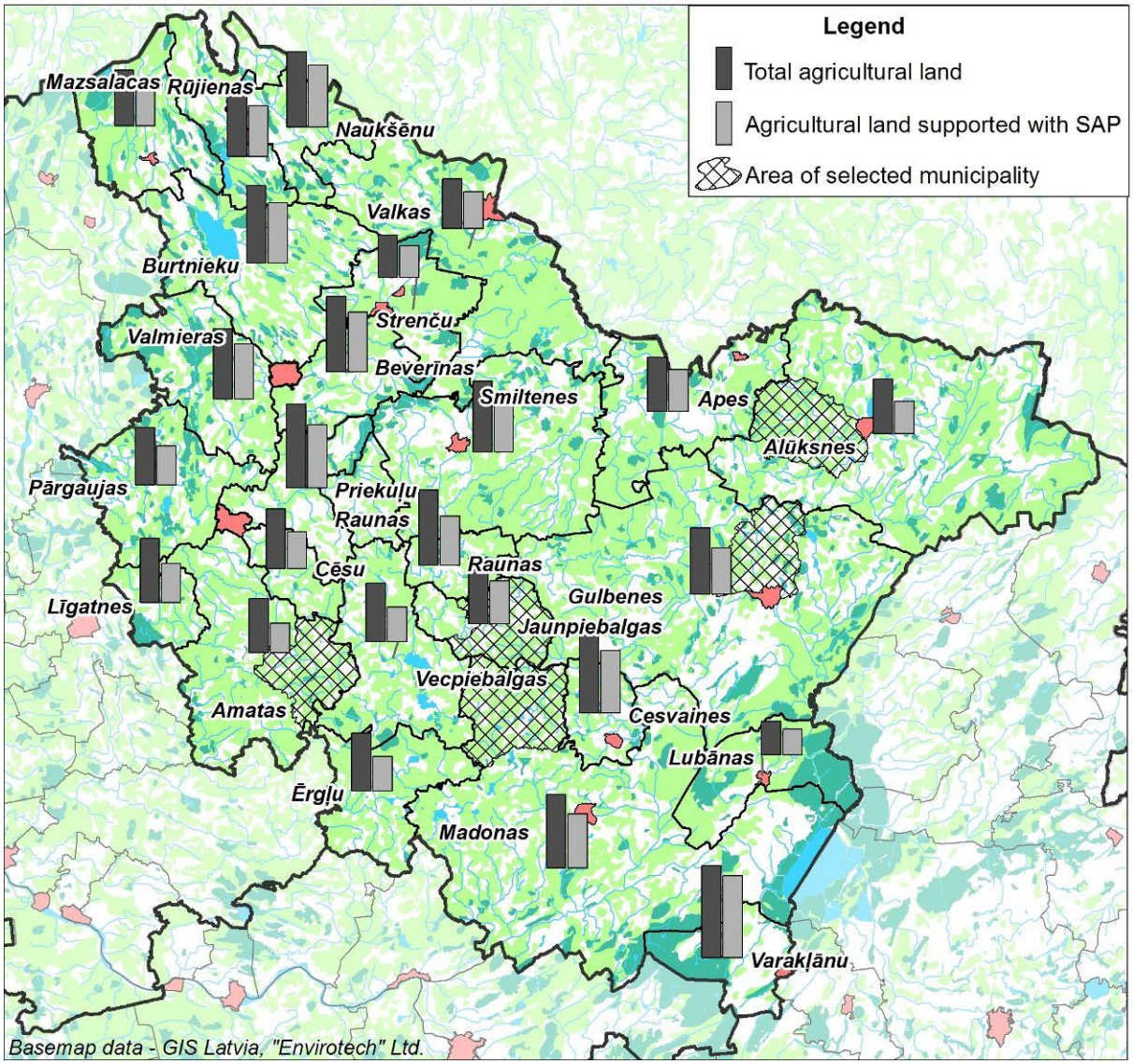
The marginalisation processes in Vidzeme have been developing for more than twenty years. Therefore, significant areas of former agricultural land can be spotted in various stages of overgrowing. Comparing the total areas of the agricultural land in Vidzeme (State Land Service, 2014) and the AL areas for which the single area payments are received (Rural Support Service, 2014), it may be concluded that in 2014, in the Vidzeme region, ~29% of AL can be considered as unmanaged areas. Proportion of such land parcels in the Vidzeme region differs territorially. For instance, in the Amata, Vecpiebalga and Ērgļi districts the AL areas for which the single area payments is not received exceeds 40%, whereas in the Varakļāni and Naukšēni districts such areas do not reach 20%. In the recent years only (since 2010) the proportion of unmanaged AL areas has been slightly reducing in the region. However, significant proportion of unmanaged agricultural land parcels is typical to Vidzeme, which is well demonstrated by the margin between the total AL area and the area applied for the single area payments (see Fig. 3.2).

More effective use of unmanaged and neglected AL is a significant potential resource and a challenge in the regional development. One of the possibilities is to use such

unmanaged areas for arrangement of SRC plantations. Therefore evaluation of the potential SRC areas in the Vidzeme region is an important pre-condition for more effective land management in the future.

The five parishes in the Vidzeme region and the sustainability criteria for the perennial plantation arrangement have been previously chosen in the progress of the SRCplus project through the sustainability analysis of the potential SRC plantations. The said five territories are located in the central part of Vidzeme. They are the Liezēre, Alsviķi, Beļava, Skujene and Jaunpiebalga parishes. In all these parishes, decrease of the AL areas has been observed since 2010, and in these parishes the proportion of unmanaged agricultural land parcels is significant. The Alsviķi and Beļava parishes border the regionally significant towns, Alūksne and Gulbene respectively. The other selected parishes are located within the distance of 15-25 km from the regionally significant towns (see Fig. 3.2).

Figure 3.2. Areas of total agricultural land and supported agricultural land with SAP in Vidzeme region



4 Sustainability aspects under consideration

Within the project so far 13 sustainability criteria for the SRC plantation arrangement are applied and approbated. Sustainability criteria for the perennial plantations include several factors of the plantation effect – effect to the land use, to the water and soil quality, to the biological diversity etc. In the available materials regarding the SRC plantations, the information is partly based on the findings regarding arrangement of plantations in the previously intensively used AL areas, yet the priority of the Vidzeme region is more effective use of unmanaged AL areas. The importance of the sustainability criteria may vary in different areas, for instance, it differs in the areas where the forest areas are most present (including in many places in the Vidzeme region) or the territories that are dominated by the intensively cultivated AL areas (for instance in the Rietumzemgale region in Latvia). Based on the former policy of the Latvia state regarding the use of the agricultural land and already examined results of the SRCplus project, development and arrangement of SRC plantations in the Vidzeme region would mostly be connected with more effective use (gaining revenue from previously non-used areas) of the previously unused, unmanaged or low quality agricultural lands. Thereby in such territories the most important sustainability criteria for arrangement of SRC plantations are the ones related to the natural conditions. Whereas in most intensive agricultural regions arrangement of perennial plantations are to be less related to the economic profitability (as growing of croppers or technical cultures will likely be more profitable), but arrangement of plantations may serve as a solution for decreasing the water and soil pollution, improving the biological diversity and maintaining and improving the landscape structure, also even as option for *greening*.

Additional analysis and evaluation of the sustainability criteria previously defined in the Strategy for sustainable SRC production (D6.2.) has been conducted in this section. The analysis of the criteria is performed by evaluating their significance for Vidzeme region and for five parishes selected and analyzed in D6.2. Potential for implementation of the sustainable SRC plantations in the five parishes is analysed in D.2.6.

Land of the value below 25 units

From the state and regional strategic planning point of view application of the minimum soil quality units is a right solution the efficient use of low quality soil areas.

However, in practice selection of the place for arrangement of the SRC plantations is often affected by different factors, like availability of land, accessibility etc. As before the arrangement of perennial plantations in AL several agro-technical measures have to be implemented, often it is difficult to conduct such agro-technical measures in the areas below 25 units and it involves high costs. It should be mantioned that in the program “Afforestation of the Latvian Rural development programme 2014-2020” afforestration activity is supported also in the areas where the fertility does not exceed 25 units. Thereby such territories get afforested in many places. Also the previous experience confirms that perennial plantations are often arranged in the lands with the quality evaluation above 25 units. Thereby already in the initial selection of the potential location for SRC arrangement the minimum units should be set higher – land of the value below 30 units. So far in Latvia no spatial data regarding the soil quality are publicly available, yet digitalisation of the data regarding the soils is conducted in 2016 and it is planned that the information will be available in site – geolatvija.lv.

Thereby currently it is not possible to evaluate if land proposed for the SRC plantations in five parishes is selected based on the soil quality indicators.

Land under the high-voltage electric lines / Land near the railway lines / Land near the main motorways

Land under / along the mentioned linear infrastructural objects in particular sections could be used for arrangement of SRC. In Latvia territories along the linear infrastructural objects typically are not used and maintained. So far such practice is not developed and there are no positive practical examples. Use of such territories typically is better organised in countries with highly intensive land use and mutual competition between different

activities. Approbation of the criteria conducted in D6.2 strategy and the identified locations for the potential plantations in five parishes testify that the most significant criteria is the land along the motorways. As proved by the economic analysis this is a very significant factor defining accessibility of plantations and transportation costs. Thereby criteria *Land under the high-voltage electric lines* and *Land near the railway lines* currently have medium signifficance in selection of the potential locations.

Normative regulation in Latvia is not adjusted in order to clearly identify the permitted activities regarding the arrangement of SRC plantations in the protective zones. Although the Law on the Protective Zones (11.03.1997.) does not strongly forbid arrangement of perennial plantations. However such activities to be approved by the operator of motorway, railway and the electric line.

Land bordering with forest areas

Land covered by forests takes highest share in Vidzeme region. The most popular landscape types in the region are woodlands and the mosaic type landscape with the dominating woodlands. Therefore, AL areas typically are bordering with the forest areas. Applying this criterion is complicated in practice as it has no relevant and effective indicator. The proportion of the forests in the territory only partly characterises this criteria. As said before, open rural landscapes continue to decrease in Vidzeme therefore when applying this criterion it is suggested to establish the minimum area of the AL patch to which such a criteria could not be applied. Whereas for bigger areas of agricultural lands a proportion of the area should be established in to which arrangement of SRC plantation is possible.

Implementation of SRC plantations in the spots/areas selected in D6.2. strategy will decrease already small share of the open landscape territories in the Jaunpiebalga, Skujene, Alsviķi and Liezēre parishes. In order to diminish the influence to the visual changes of the landscapes, it is possible to locate the plantations closer to the margins (ecotones) of the forest areas instead of locating them very close to the roads.

Sites of the archaeology, architectural monuments and culture history objects

Exclusion of the protective zones around the culture monuments from the list of potential locations for the SRC plantations is well reasoned. Information regarding the culture monuments and the protection zones thereof can be found in the territorial plans of the regional municipalities. According to the normative acts the protective zones may be specified. In the rural areas where the protective zone is 500 m around the culture monuments (especially around the archaeology monuments), cultivation of the agricultural lands is performed according to the accustomed practice therefore in specified cases if the cultural and historical significance of the site is not affected arrangement of the SRC plantations is possible.

The territories of the Hunters Associations and the sites of bee-farms

As it is said in the conclusion of the D6.2 report, this criterion has secondary / minor signifficance on the regional as well as state level. Therefore use of this criterion during the selection of the potential SRC territories is no further necessary.

Territories of micro-reserves and protected biotopes

Influence to the biological diversity in relation with the SRC plantations is a significant criterion. During the selection of the potential locations for perennial plantations the influence to the biological diversity is to be considered on various scales / levels. On the regional (landscape) level the influence is to be evaluated through the potential changes of the landscape structure, especially in the areas of the protected landscapes that are found in considerable areas in Vidzeme. However, also outside the territories of the protected landscapes in Vidzeme the typical to Latvia cultural landscapes of the mosaic type can be widely found. In such landscape territories the main attention is to be paid to the protection and conservation of the open agricultural landscapes (including preservation of the ecological functions of the AL patches in the landscape structure). Thereby it is not advisable to develop large continuous SRC plantations. Whereas on the local scale the location of the

protected biotopes should be analysed, especially exclusion of the protected grassland biotopes and biologically valuable grasslands from the potential areas of the SRC plantations should be considered.

Arrangement of short rotation plantations does not affect the biological diversity or it even may create a positive effect thereon in the territories dominated by intensively cultivated agricultural lands (homogenous agricultural landscapes). In these territories, short rotation coppice plantations create both more diverse structure of the land use methods (thereby also the habitats appropriate for different species) and the diverse microclimate; it may also serve as a buffer zone for decreasing pollution in the water courses and water bodies or as the migration corridor for the varied animal species. It should be also mentioned that in Latvia such areas with intensively cultivated agricultural lands are mostly found in the West Zemgale region. Also in Vidzeme they are found in some places but not in five selected parishes. When selecting the potential places for the SRC plantations in five parishes, the effect on the biological diversity is taken into consideration as the potential territories are prospected outside the highly protected nature territories. When developing the detailed selection of the plantation sites, the location of the protected grassland biotopes and biologically valuable grasslands should be considered. As the micro-reserves are hardly found in the agricultural lands in Latvia, it is suggested to specify the title of this criterion – *Highly protected nature territories, protected biotopes and biologically valuable grasslands.*

Polluted and potentially polluted sites

Application of the criteria is very relevant. A special emphasis should be applied to the polluted and potentially polluted sites as well as the degraded territories that cover larger areas – recovered landfills, exhausted sites of mineral deposits, former military objects etc. However, also location of SRC plantations around the point polluted and potentially polluted sites would be preferable as they create conditional buffer zone and also they visually cover the polluted sites that are often comprised by deserted and ruined production plants and alike.

In total, when selecting the potential sites for the SRC plantations in the chosen parishes, the criteria of the potentially polluted sites is taken into consideration especially in the Alsviķi parish where the plantation sites are projected near or in the potentially polluted sites. The meaning of this criterion should be widened by including in it also the mineral deposits and other degraded territories.

The territories near large cattle sheds

Application of the criteria is relevant yet it is to be evaluated as medium significant. Presence of the animal farms is related to possibility to utilise manure or digestate in the SRC plantations. It should be mentioned that fertilising of the SRC plantations is practicable only at the beginning of each rotation cycle when fertiliser is needed in considerable amount for the following 3-4 years, therefore demand for fertiliser may be irregular.

It also should be mentioned that in many places the matters of storing and utilising of manure have been currently solved owing to which availability of additional fertiliser is limited. The climate and natural conditions in Vidzeme provide that in many places the AL areas are used in cattle-breeding thereby cattle sheds are also regularly found in the area. Although in the former two years the cutlery sector in Latvia has been affected by the crisis, thus application of the criteria in determining the potential SRC sites is essential, especially when conducting a detailed selection on the local scale. In the performed selection of the potential sites the criteria has been properly applied, especially in the Alsviķi, Skujene and Liezēre parishes where the potential SRC sites are located close to the large cattle sheds.

The territories near the sewage sludge treatment plants

Utilisation of the sewage waters in the SRC plantations is an effective solution as it allows usage of the sewage sludge. Storage and further usage of sludge often is a problem for the sewage water treatment plants. Application of sewage sludge increases the expected harvest in SRC plantations. Thereby this criteria is significant in selection of the SRC sites. It is important that fertilisation of the SRC plantations is practicable only at the beginning of

each rotation cycle when the sewage sludge is needed in large amounts for the following 3 years (about 12 t/ha). Such amount of sewage sludge is not provided by the small sewage treatment plants in the villages. From the analysed parishes only the sewage plant in the Jaunpiebalga parish produces the amount of sludge that is nearly sufficient just for 1 ha of plantations whereas in the other analysed parishes the amount of sludge is insignificant (0.5 – 2 t per year) therefore utilisation in the SRC plantations is not practicable or is possible only for very small areas / amounts. Thereby application of the criteria dyuring the selection of the potential sites it is suggested to separate more perspective areas – around higher capacity sewage plants of towns or large villages, from the less perspective. This criterion is suggested to be related also to the potential usage of ashes from the boiler houses for fertilising of the SRC plantations.

The flood risk areas

When selecting the potential sites of the SRC plantations this criterion should be treated as medium significant. The flood risk areas are indicated in the plannings of the local municipalities. The flood prone areas are shown only in one of the evaluated five parishes (the Jaunpiebalga parish) and it is of a very small area. When using such territories the risk to lose the potential harvest and investments should be always taken into consideration. In case of the flood prone areas the criteria of the protected nature territories / values is also essential as the flood-lands are often ecologically significant (also protected) areas. It is suggested to specify this criteria by including also the territories of the wetlands of AL where growing of other agricultural crops is not practicable.

The criteria for the selection of sites the SRC plantations were aprobated within the SRCplus project and are described above. Additionally it is suggested to include a criteria of *the territories to which specific requirements are provided in the territorial (spatial) plannings*. Although in Latvia (including Vidzeme) definition of such territories in the territorial plannings is not common. However, legislation of the territorial planning foresees definition of such territories (for instance, territories of a highly valuable landscape, roads of the landscape value, territories of the cultural and historical value etc.) in the graphic section of the territorial planning.

In general application of the aforesaid sustainability criteria is appropriate for spatial exploration of the potential SRC plantation sites on the strategic and larger scale. Some corrections to be done for the selected criteria; some of them are minor for arrangement of the sustainable SRC plantations and it is suggested not to apply them. It should be also mentioned that selection of a plantation site may be locally (on a detailed scale) affected also by other factors, for instance, the land ownership rights, the rent of the land, the agro-ecological quality of the area and alike.

5 Evaluation of cost effectiveness for SRC

Considering the materials available and the former conclusions of the SRCplus project it should be mentioned that there is lack of information regarding the economics of the SRC plantations.Therefore in the section regarding the socioeconomic aspects highest attention is paid on evaluation of the economic efficiency of the SRC plantations. The executed calculations are applicable both to the five selected parishes and the Vidzeme region in general. Evaluation of the economic efficiency is conducted for the entire life cycle of the SRC plantations, including initial establishement of the plantation and several rotation cycles.

Willows are the most commonly used species for the SRC plantations. According to the information presented by the Rural Support Service, in 2014 plantation of willows was supported for the area of 466 ha. Plantation of aspen tree and grey alder was supported for the ten time smaller area. In general, SRC plantations takes a highest share, however part of these areas cannot be subsidised as agricultural land.It should be mentioned that up to now the trustfull information regarding the costs, productivity, the agro-technical measures etc. is available only for the plantation of willows. Therefore in this study the economic efficiency has been evaluated for the plantation of willows. Life cycle of the willow plantation used for the economic analysis is described in Table 5.1.

Table 5.1. Life cycle of the willow plantation

Discount period	Year	Quarter	Management activities
	1	I	
0		II	Overgrow elimination Chemical weed control (herbicides)
0		III	
0		IV	Ploughing
	2	I	
0		II	Before-planting processing (loosening etc.) Fertilization Removal of roots and rocks Planting Mechanical weed control
		III	
1		IV	Cutback
	3	I	
2		II	Repeated mechanical weed control
		III	
		IV	
	4	I	

Discount period	Year	Quarter	Management activities
		II	
		III	
		IV	
	5	I	
		II	
		III	
5		IV	Harvesting), biomass removal from the site
5	6	I	
5		II	Plantation fertilization (if applicable)
6		III	Biomass chipping and selling [end of 1st rotation]
		IV	
	7	I	
		II	
		III	
		IV	
	8	I	
		II	
		III	
8		IV	Harvesting), biomass removal from the site
8	9	I	
8		II	Plantation fertilization (if applicable)
9		III	Biomass chipping and selling [end of 2nd rotation]
		IV	
	10	I	
		II	
		III	
		IV	

Discount period	Year	Quarter	Management activities
	11	I	
		II	
		III	
11		IV	Harvesting), biomass removal from the site
11	12	I	
11		II	Plantation fertilization (if applicable)
12		III	Biomass chipping and selling [end of 3rd rotation]
		IV	
	13	I	
		II	
		III	
		IV	
	14	I	
		II	
		III	
14		IV	Harvesting), biomass removal from the site
14	15	I	
14		II	Plantation fertilization (if applicable)
15		III	Biomass chipping and selling [end of 4th rotation]
		IV	
	16	I	
		II	
		III	
		IV	
	17	I	
		II	
		III	

Discount period	Year	Quarter	Management activities
17		IV	Harvesting), biomass removal from the site
17	18	I	
17		II	Plantation fertilization (if applicable)
18		III	Biomass chipping and selling [end of 5th rotation]
		IV	
	19	I	
		II	
		III	
		IV	
	20	I	
		II	
		III	
20		IV	Harvesting), biomass removal from the site
20	21	I	
20		II	Plantation fertilization (if applicable)
21		III	Biomass chipping and selling [end of 6th rotation]
		IV	
	22	I	
		II	
		III	
		IV	
	23	I	
		II	
		III	
23		IV	Harvesting), biomass removal from the site
23	24	I	
		II	

Discount period	Year	Quarter	Management activities
24		III	Biomass chipping and selling [end of 7th rotation]**Replanting or removal of plantation**
		IV	

Source: AREI's estimate based on handbook (I.Dimitriou and D.Rutz, 2015) and ECOMARC, Ltd information

In the general life cycle of willow plantation (see Table 5.1) it is foreseen that willows are chipped not during the harvest but later when the material has naturally dried and the moisture content has decreased. Later chipping is advisable as woodchips with lower moisture content are commonly requested. Moreover, higher demand of semi-dryed wood chips in future has to be considered.

Evaluation of the economic efficiency of SRC has been conducted by applying the discounted cash flow method. It has to be mentioned that discounting is reducing the spot value of the future revenue, as well asthe spot value of the future expenses. Therefore for the evaluation of economic efficiency a conservative approach has been observed by applying the expenses to a closer discount period but the income – to a further discount period. In total, in assignation of the cash flows the following principles have been applied:

1) The cash flows that occur at the beginning of the respective year (first half) are assigned to the previous discount period;
2) The cash flows that occur at the end of the respective year (second half) are assigned to the discount period of that year;
3) The expenses of initial development of the SRC plantations including planting and the first mechanical weeds control are assigned to the zero discount period even though essential part of these expenses occur in the first half of the 2nd year;
4) The expenses of cutback are assigned to the 1st discount period even though these expenses occur at the end of the 2nd year;
5) The expenses related to chipping and transportation of the woodchips are assigned to the same discount period as the income from woodchip sellingas these expenses occur virtually simultaneously with the income.

The aforesaid principles ensure conservative calculation of NPV and decrease possibility that in the result of discounting the spot value of some expenses may get decreased without reason. The applied discount periods are provided in Table 5.1.

Evaluation of the economic efficiency has been conducted for the following scenarios / alternatives:

1) **(V1)** - Only the direct income and expenses from willow plantationare evaluated
2) **(V2)** – Is the (V1) scenario completed with an assumption that reduction of land tax (NĪN) occurs additionally for the unmanaged AL
3) **(V3)** – Is the (V1) scenario completed with an assumption that plantations are subsidised (*area payments*);
4) **(V4) -** Is the (V1) scenario completed with an assumption that both the income from the subsidies (*area payments*) and the reduction of the land tax for unmanaged AL additionally occurs.

For evaluation of the economic efficiency of the SRC plantations several assumptions were made. The actual discount rate assumed as 5% per year. The discount rate is assumed considering following factors:

1) Duration of the life cycle for willow plantation is 24 years;
2) The expected income and expenses are rather fluctuating – it is quite probable that the income may be lower and the expenses – higher than planned;
3) In Latvia (and not only) people consider the income in 3 and more years as less valuable than current income of the same amount;
4) In Latvia SRC are mostly cultivated by the farmers (entrepreneurs) and they are not supposed to be the holders of well-diversified portfolios. Therefore additional risk premium is to be applied in order to consider also the specific risk.

For the cost evaluation the costs of soil preparation and cultivation of the plantations are also important. Although these costs may differ in various situations. Based on information available and opinion of specialists working in the sector the following assumptions regarding the average costs and other indicators were applied (see Table 5.2). Thereby the total expenses for the soil preparation are projected as 320 EUR/ha on average. Regarding the planting expenses the following assumptions have been applied:

1) The average consumption of the planting material – 15 000 cuttings/ha[2];
2) The price of the planting material – 0,065 EUR/cutting.

The average expenses for planting are 1'250 EUR/ha. It should be mentioned that the expenses for the planting works reflect the expenses if planting is performed by the specialised equipment. It is possible that if planting manually the planting expenses in the fields of small area could be lower. However, due to lack of information expenses for manual planting have not been evaluated. Furthermore in big areas the average costs per one hectare will decrease.

Table 5.2. Costs of the measures for the soil preparation, arrangement and cultivation of perennial willow plantations

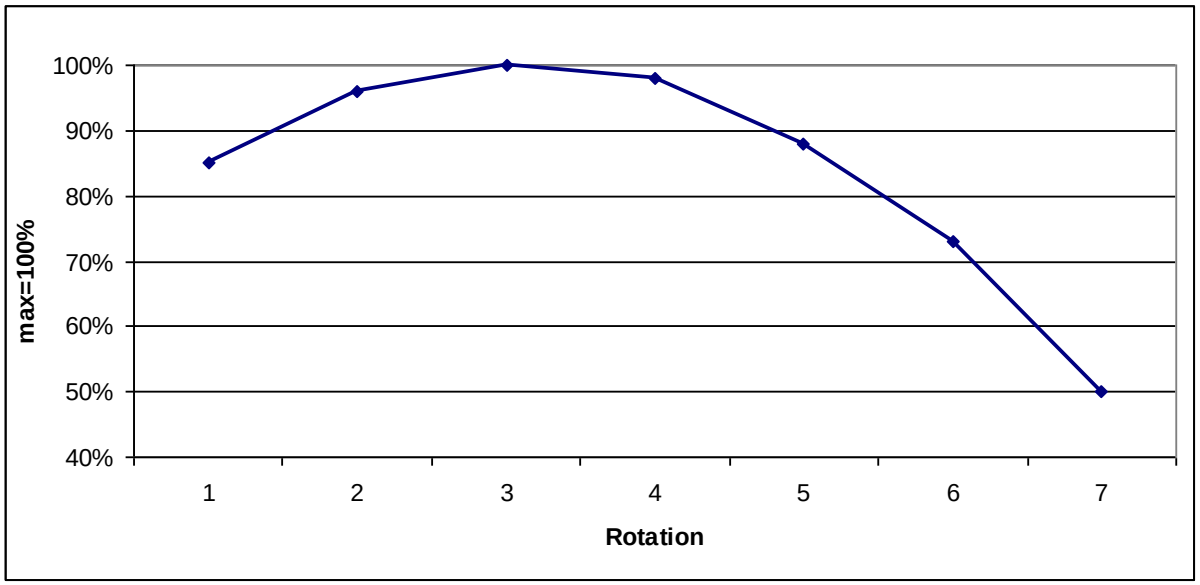
Soil preparation and plantings management	
Activities	***Costs, EUR/ha***
Overgrow removal	100
Chemical weed control (herbicides)	60
Ploughing	80
Before planting processing (loosening etc.)	50
Roots and rock removal	30
Planting (service)	275
Plantings management	
Mechanical weed control	50
Cut to stump (necessity for 25% of areas)	70
Repeated mechanical weed control (necessity for the same 25% of areas)	50

Source: AREI's estimate based on handbook (I.Dimitriou and D.Rutz, 2015) and ECOMARC, Ltd information

The average expenses for truncating and repeated weed control have been calculated by multiplying the proportion of the areas where truncating is needed with the expenses of truncating and repeated weed control.

The yield of biomass is not projected as equal for the rotation cycles. On the basis of the conducted evaluation it is assumed that the dynamics of the willow yield is parabolic: for the first rotation cycle productivity reaches approximately 85% of the nominal yield; by the third rotation cycle the yield increases up to 100% of the nominal productivity with the following decrease of productivity till 50% of the nominal productivity for the seventh cycle. The prognosis of the relative yield is provided in Figure 5.1.

[2] Evaluated according to the handbook 'Sustainable Short Rotation Coppice' by I. Dimitriou and D. Rutz (2015) and information provided by LTD 'ECOMARK'



Source: AREI's estimate

Figure 5.1. Dynamics of relative yield of willow

The nominal yield (i.e., yield in the 3rd rotation cycle) has been evaluated for the soil fertility of 36 units. Information regarding the actual yield of willows growing at Latvian conditiona are available for the same type of soil. However it should be mentioned that in practice the quality units of AL will mostly be lower. On the basis of the available information regarding the yield in the 1st rotation cycle it is assumed that the nominal willow yield is 18.2 $t_{dry\ matter}/ha$[3]. Additionally it is assumed that if the soil fertility is lower than 36 units, the yield is proportionally lower.

Regarding the harvesting the following assumptions are applied:

1) The average moisture content of willows during harvesting – 53%;
2) Harvesting expenses (with bush trimmer or similar equipment) – 200 EUR/ha;
3) The average density of the harvested material – 275 kg/m^3[3];
4) Expenses for biomass removal from the site – 1.85 EUR/m^3.

It is assumed that the material after harvesting and removal from the site (lumping) will naturally dry till the moisture content of 30% to reach the M30 class requirements. The following assumptions are applied regarding the chipping and transportation of woodchips the:

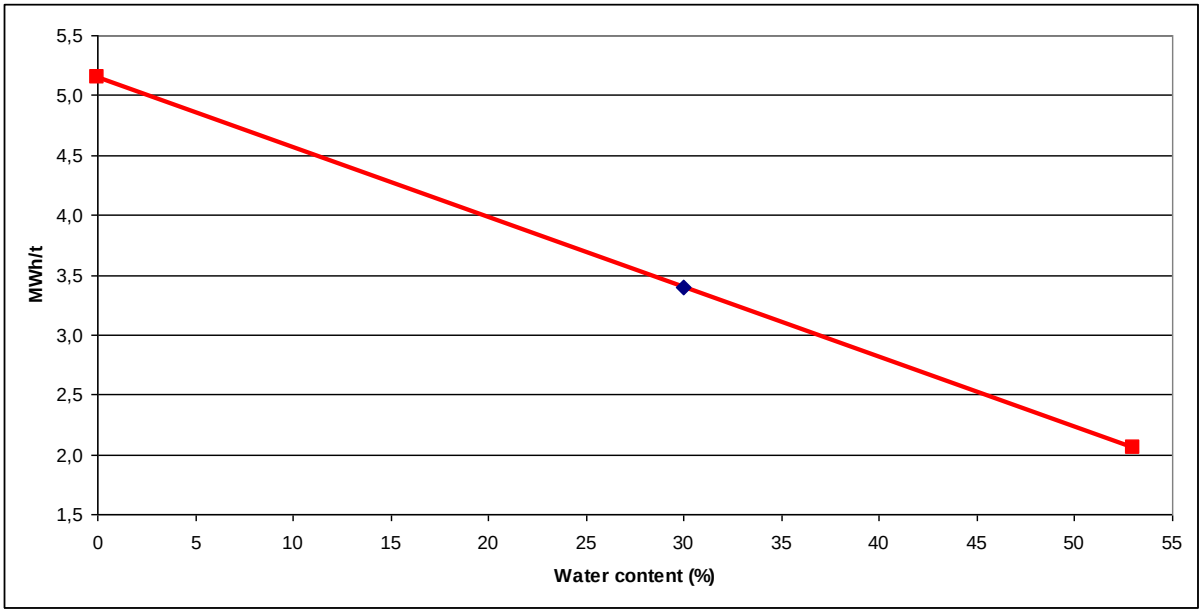
1) Average density of woodchips (M30 class)[4] – 229 kg/loose m^3;
2) Chipping expenses – 2.85 EUR/loose m^3;
3) Average amount of woodchip per load – 95 loose m^3;
4) Average distance till consumer[5] – 50 km;
5) Average transportation expenses – 1.00 EUR/km.

Transportation expenses are calculated assuming that the distance is paid twice - 'there and back'.

The price of woodchips is assumed as 13.50 EUR/MWh. The heating value of woodchip (lowest heating value) is evaluated considering linear relation between the moisture content of woodchips and lowest heating value (MWh/t). This linear relation is

[3] Mass of one stack or a cargo metre; evaluated through extrapolation according to the data of the prepared by I. Dimitriou and D. Rutz handbook 'Sustainable Short Rotation Coppice' (2015)
[4] Average value of the provided density range provided in the prepared by I. Dimitriou and D. Rutz manual 'Sustainable Short Rotation Coppice' (2015)
[5] According to the maximum distance that is determined in the sustainability criteria

provided in Figure 5.2. Based on the relation provided the heating value for the woodchips with 30% moisture content (M30 class woodchips) is abtained - 3.401 MWh/t on average.



Source: AREI's estimate based on woodchip analyses carried out by ECOMARK, Ltd

Figure 5.2. Lowest heating value of willow woodchips in function of moisture content[6]

In order to evaluate reduction of the land tax for unmanaged AL, the following assumptions are applied:

1) Additional land tax (NĪN) rate – 1.5% of the cadastral value;
2) Average cadastral value of AL – 650 EUR/ha[7].

In order to evaluate the income from the subsidies (*area payments*), the following assumptions are applied:

1) Single rate of the single area payments – 55 EUR/ha;
2) Rate of the payment for agricultural practices beneficial for the climate and the environment (*greening payment*) – 33 EUR/ha;
3) Rate of the payments to areas facing natural or other specific constraints (ADSI) measures – 45 EUR/ha as majority of the Vidzeme region belongs to the 2nd category.

The single area payment and greening rates are determined according to the current rates. The ADSI rate is determined applying the current rate for the areas of the 2nd category - 55 EUR/ha for the parishes analysed. However, it should be mentioned that in future the rates may decrease due to the growth of the declared AL areas as well as the situation is unclear regarding the area payments after 2020.

In order to evaluate the effect of fertilisation by the sewage water sludge, the following additional assumptions are applied:

1) Average yield growth as a result of fertilisation – 30%[8];
2) Consumption of sludge during one rotation cycle – 12 t/ha;

[6] shown a relationship is similar to the curve given I.Dimitriou un D.Rutz handbook "Sustainable Short Rotation Coppice" (2015.)

[7] AREI evaluated average cadastral value of AL where currently willow plantations have been arranged.

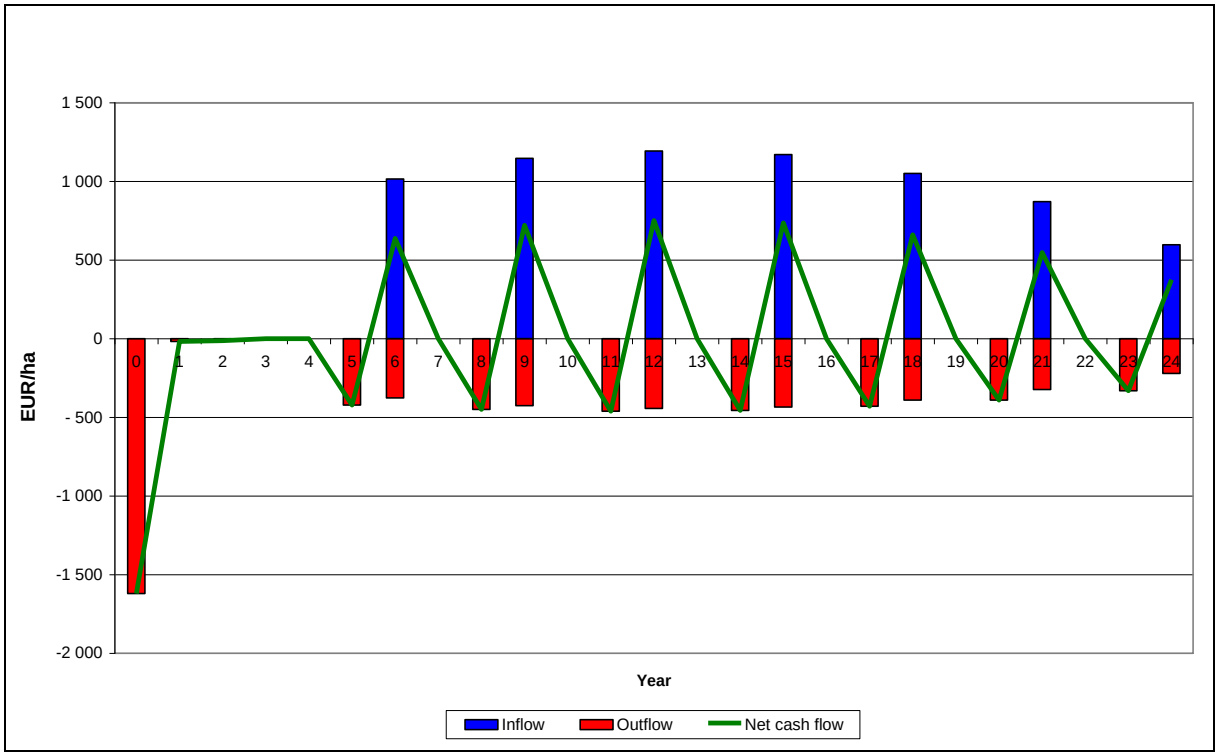
[8] Evaluated in accordance with the information provided by LTD 'ECOMARK' and the Latvian State Forest Research Institute 'Silava'

3) Average size of sludge cargo – 15 t;
4) Average transporting expenses – the same as for woodchip (1.00 EUR/km);
5) Average distance from the source of sludge[9] – 20 km;
6) Expenses for fertilisation with the sludge – the same as for mechanical weed control (50 EUR/ha).

It is assumed that fertilisation with wastewater sludge is performed only at the beginning of each rotation cycle– at the year of planting or the year when coppice is cut. Expenses for the fertilisation with sludge are not prospected in the first rotation cycle as deposition of wastewater treatment sludge is possible within the framework of the existing land cultivation works and no additional deposition is needed.

Results of the economic efficiency evaluation

Based on the aforesaid methodology and assumptions the cash flows are calculated for all the scenarios (V1, V2, V3, V4) at different levels of the land quality (soil fertility) evaluation. The evaluation is performed for the soil with fertility of 36, 30 and 25 units. Additionally, evaluation of willow plantation is performed for the scenarious with and without application of the wastewater treatment sludge as a fertiliser. General cash flow of growing willows is provided in Figure 5.3. The cash flow presented is an undiscounted cash flow for the scenarioV1 - the soil fertility of 36 units, without fertilising.



Source: AREI's calculation

Figure 5.3. General cash flow for the cultivation of willow

The calculated net discounted values (NPV) for all the evaluated scenarios are provided in Table 3. Based on evaluation results it can be concluded that cultivation of willows per se (without subsidies or other additional sources of incomes) or scenario V1 is not economically feasible either when the plantations are fertilised or not with the sludge (see Table 5.3). It should be mentioned that also the scenario when additional reduction of land tax for the unmanaged AL occurs or V2 is not economically feasible. According to the

[9] According to the maximum distance determined in the sustainability criteria

calculations cultivation of willows becomes economically feasible only when activity is subsidised and *area payments* are received (scenarios V3 and V4). Only in these cases NPV exceeds 0.

Table 5.3. NPV for cultivation of willow (EUR/ha)

Scenario	Soil fertility (quality units)		
	36	**30**	**25**
Without fertilisation			
V1	-924	-1 167	-1 371
V2	-792	-1 036	-1 239
V3	784	541	338
V4	916	672	469
Using sewage sludge as fertiliser			
V1	-793	-1 110	-1 374
V2	-662	-978	-1 242
V3	915	598	334
V4	1 047	730	466

Remark: NPV is calculated at woodhip price 13,50 EUR/MWh

Source: AREI's calculation

As poorer soil fertility leads to lower yield of SRC the NPV is bigger for the cases with better soil fertility. It should be mentioned that fertilising with the sludge improves NPV only in cases if the soil fertility is 36 and 30 units – owing to fertilising NPV increases respectively for 131 EUR/ha and 58 EUR/ha. If the soil fertility is 25 units, fertilising even decreases NPV by 3 EUR/ha. Such results are related to the fact that the expenses on fertiliser (delivery and application of the sludge) are equal at all the soil fertility levels but the yield is different. If the soil fertility is very poor, potentional benefits (in terms of higher yield) from the fertilisation are smaller compared tothe costs of the fertiliser.

The calculated conditional prime cost of woodchips or the minimum price at which NPV=0, is provided in Table 5.4. In general it is apparent that the poorer is the soil fertility, the higher is the conditional prime cost of woodchips (see Table 5.4). This relation is valid for the all scenarios with or without fertilising. It should be mentioned that only for the cases with subsidies (versions V3 and V4) the conditional prime cost of woodchip is lower than 13.50 EUR/MWh.

Table 5.4. Woodchip break-even price (EUR/MWh)

Variant of estimate	Soil fertility (quality units)		
	36	**30**	**25**
Without fertilisation			
1	16.91	18.67	20.78
2	16.42	18.09	20.09
3	10.60	11.10	11.71
4	10.12	10.52	11.01
Using sewage sludge as fertiliser			
1	15.75	17.28	19.12
2	15.38	16.83	18.58
3	10.90	11.46	12.13
4	10.53	11.01	11.59

Remark: Break-even price is a minimal price at which NPV=0

Source: AREI's calculation

It should be additionally mentioned that the use of sludge for fertilising decreases the conditional prime cost of woodchip in the cases V1 and V2. Furthermore, for the scenariosV3 and V4 the effect of fertilising is the opposite – the conditional prime cost increases even though also NPV increases. This effect is related to the fact that the influence of fertilising on NPV depends on the sale price of woodchip: the lower price of woodchip is, the smaller is the positive effect (the income growth decreases but the permanent expenses for purchase and application of fertiliser do not change). At particular price of woodchips NPV stays the same either in case with fertilising or not, but if the price decreases even more, the fertilising has a negative effect on NPV. It should be also mentioned that it is possible to acquire manure or other organic fertiliser from the neighbouring territories thereby decreasing the expenses related to the transporting costs.

The aforesaid marginal price of woodchip at the soil fertility of 36 units is 11.89 EUR/MWh, at the 30 units – 13.30 EUR/MWh; at the 25 units – 13.56 MWh. As for the scenarios V3 and V4 the prime cost of the woodchip is lower compared to the marginal pricesmentioned, fertilising with the sludge creates the opposite effect and increases the conditional prime cost.

Taking into consideration that at the given yield levels growing willows per se (scenario V1) is economically not feasible (NPV<0), the minimum nominal yield is additionally evaluated at which NPV=0:

1) If the plantations are not fertilised, the nominal yield 29.7 $t_{dry\ matter}$/ha, which is respectively 1.63 times more than the biomass yield assumed and used within the analysis;
2) If the plantations are fertilised, the minimum nominal yield is 33.5 $t_{dry\ matter}$/ha, which is respectively 1.43 times more than the biomass yield assumed and used within the analysis.

According to the additionally performed evaluation, if the nominal yield without fertilising is 18.2$_{dry\ matter}$/ha (the level used in the assumptions), the yield increase caused by fertilising with the sludge should be at least 84% in order to achieve NPV=0. Thereby the yield increase should be at least 2.81 times bigger that the level used in the assumptions (30%).

The distance covered by the machinery during the arrangement and cultivation of SRC is significant for the economic efficiency of plantations, as well as distance to cover till the consumer of woodchips.For instance, if the distance is reduced from 50 km to 20 km the NPV at the soil fertility of 36 units increases for 220 EUR/ha, at the 30 units – for 183 EUR/ha, at the 25 units – for 153 EUR/ha. If the sludge to be used for fertilising purposes, the most perspective territories for arranging the perennial plantations would be around the towns in the Vidzeme region (see Figure 5.4), as well as around the larger villages. Surely, also the boiler houses in smaller villages will need woodchip therefore arrangement of the SRC plantations may be profitable to all the local authorities in the region. However, the transportation factor is highly significant in selecting the sites for the perennial plantations. When the transporting distance decreases, the principle of short supply chains become more important that is an essential precondition for the regional development.

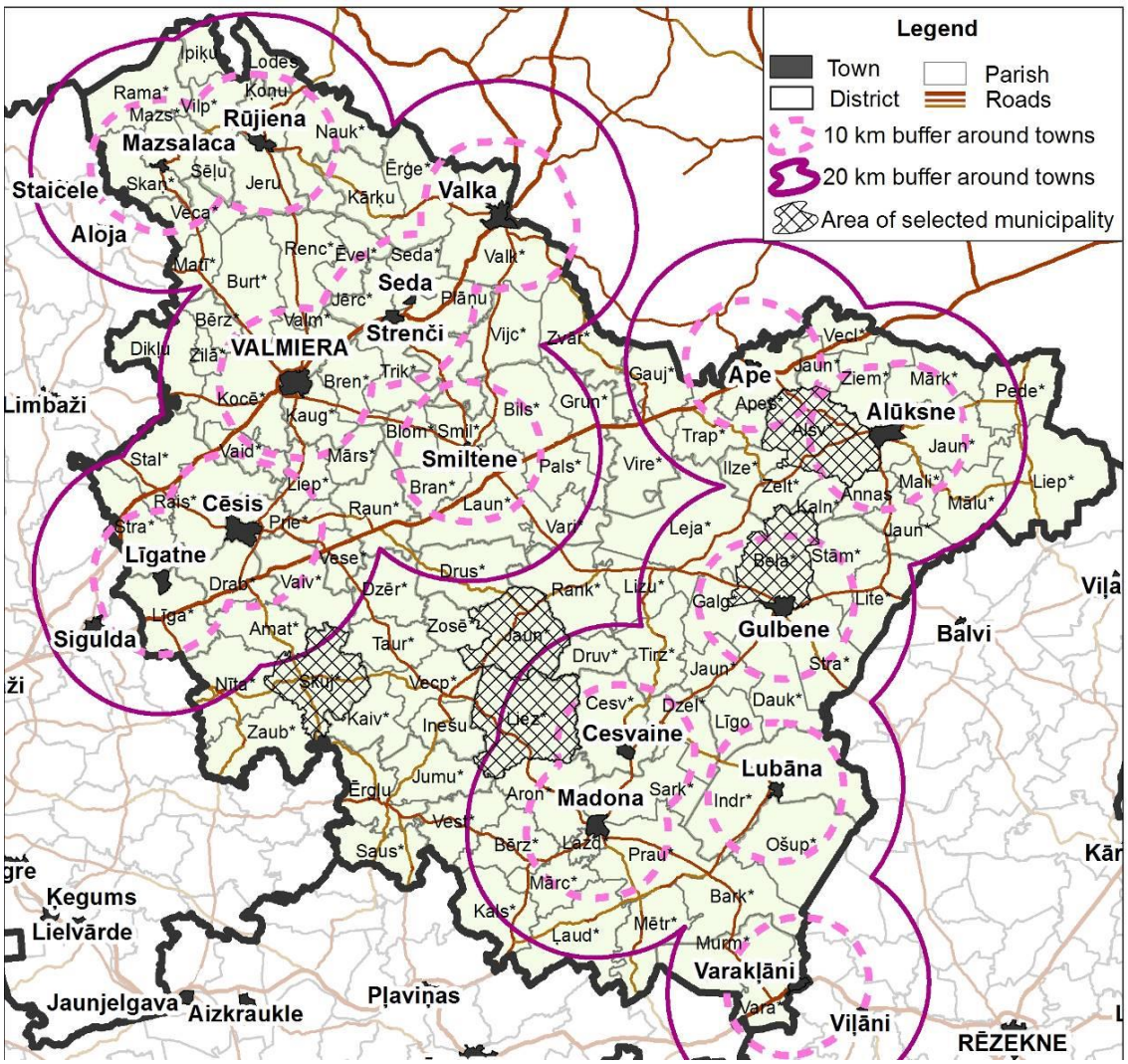


Figure 5.4. Perspective areas around towns in Vidzeme region

6 Findings, conclusions and recommendations the suitable areas for the sustainable SRC plantations in Vidzeme planning region

The sustainability criteria described in the strategy (D6.2.) are appropriate for spatial exploration on the regional and local (parish) scale of the potential sites for the SRC plantations in the Vidzeme planning region.

Based on evaluation and approbation of the sustainability criteria in the five parishes it may be concluded that some more detailed specification should be provided to the selected criteria. Some criteria are not significant for the arrangement of sustainable SRC plantations; therefore it should not be applied. Additionally the criteria regarding the territories with specific requirement applied in the territorial planning should be employed.

The most significant criteria for determining the potential sites for the SRC plantations are the units of the quality evaluation of the agricultural land, specifically protected nature territories, protected biotopes and biologically valuable grasslands, pollutes and potentially polluted sites, as well as the territories near the sewage water treatment plants (over 10t of sludge per year).

On the local scale the selection of the SRC plantation site is affected by other factors (land ownership rights, the agro-ecological properties of the area and alike).

Significance of the sustainability criteria may differ in function of the landscape. For instance, it differs for the territories with the dominating forest areas or for the intensively cultivated agricultural areas.

Considering the executed analysis of the sustainability criteria and evaluation of the economic efficiency it can be concluded that the most appropriate territories for arranging the SRC plantations are located in the Alsviķi and Beļava parishes.

Considering the former policy regarding the agricultural land and results of the SRCplus project already researched, development and arrangement of SRC plantations in the Vidzeme region should be organised for better and more efficient use of the unmanaged or low quality agricultural lands. It means that additional investments for the land preparation and establishement of plantations should be considered.

As both wastewater treatment and the heat supply (boiler houses) are mostly operated by the companies established by the local authorities as well as the land belong to the local authorities, a potentially perspective solution may be involvement of the local authorities in management of the perennial plantations. Such a solution will also facilitate the use of sludge and ash (from the boiler houses) in SRC plantation for the fertilisation purposes.

Results of the economic efficiency evaluation shows that cultivation of willows without subsidies *(area payments)* or any other external support at the current price of woodchips is not economically feasible. Also fertilising of the willow plantations with the sludge (using the fertiliser in the amount indicated in the evaluation) is not making cultivation of willows profitable; however fertilising has particular positive effect and decreases negative NPV. Use of the wood ashes should be mentioned as one of the alternatives for fertilisation of SRC. Currently ashes are typically deposited and the use of ash for the fertilisation purposes can be organised based of mutual benefits. However, in Latvia currently there is no information regarding the effect of wood ash on the yield of SRC.

Existing rates of subsidies (*area payments*) cultivation of willows is economically profitable at the soils with fertility of 25 units, including the cases when the plantations are not fertilised. In this aspect it may be concluded that cultivation of willows is very similar to other agricultural activities as nearly none other agricultural activity in a long term is not economically profitable without the subsidies.

Significant effect on the economic efficiency of willow cultivation is made by the distance to till the consumers of woodchips. When the distance decreases from 50 km to 20 km, the NPV indicator at the soil fertility of 36 units increases by 220 EUR/ha; at the 30 units

by 183 EUR/ha; at the 25 units – by 153 EUR/ha. The transportation factor is highly significant in selecting the sites for the perennial plantations.

In order to increase economic benefits from SRC and to reduce dependency on subsidies or other kind of financial support, the following potential solutions can be used:

1) Location of the SCR plantations closer to the consumers of woodchips as well as location the plantations closer to sewage water treatment plants or similar sources of organic fertiliser (if the plantations are planned to be fertilised); thereby in the Vidzeme region the most profitable territories would be the ones around the towns and / or large villages;
2) Use of the positive scale effect - developing of larger plantation areas (blocks of areas), which will reduce site arrangement and cultivation related costs;
3) Significant increase of yield of the SRC crops by developing and implementing more productive species and crops;
4) To create innovative technological solutions in which the resource investments (labour force, equipment / hardware) and expenditure for soil preparation and cultivation of the plantations would be lower. Considering the existing technological schemes the expenses on soil preparation, weed control and other expenses are relatively high, which is also a highly significant reason for the negative economic profitability.

By now in Latvia, just like in other European countries relatively little information is available regarding the long term studies related to further agricultural use of land after removal of the SRC plantations. Thereby there is no convincing argumentation for the fact that in 20 and more years of using the areas for perennial woody plantations they will be efficiently used for other agricultural activities without additional investments.

In general SRC plantations are not widely used in Latvia; therefore SRC related aspects are little covered or not described at all in the legislation related to the management of AL (Law on the Protective Zones, the environment protection legislation) as well as during the planning of territorial development. In future in the strategies and territorial plannings developed by the local authorities in the Vidzeme region solutions should be prospected for use of unmanaged and low quality agricultural land areas including for arrangement of the SRC plantations.