BALTIC FORESTRY

http://www.balticforestry.mi.lt
ISSN 1392-1355
eISSN 2029-9230

Baltic Forestry 2020 26(1): 296
Category: research article
https://doi.org/10.46490/BF296

Assessment of the socio-economic factors affecting the development of willow energy plantations in Lithuania

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Konstantinavičienė, J., Varnagirytė-Kabašinskienė, I., Škėma, M. and Aleinikovas, M. 2020. Assessment of the socio-economic factors affecting the development of willow energy plantations in Lithuania. *Baltic Forestry* 26(1), article id 296. https://doi.org/10.46490/BF296.

Received 19 July 2019 **Revised** 19 March 2020 **Accepted** 23 March 2020

Abstract

The study was designed to determine whether cultivation of willow (*Salix* sp.) energy plantations (hereinafter WEP) is economically efficient and to identify the main factors that influence development of such plantations in Lithuania. The economic efficiency of the cultivation of WEP was estimated based on cash flow analysis, discounted cash flow net present value and decomposition analysis methods. The survey of the willow plantation growers identified the motives, incentives, problems and intentions of local willow growers. The study revealed that cultivation of WEP was mostly hindered by economic factors, including low selling price of willow biomass for fuel and high cost of harvesting. Willow cultivation in Lithuania was least hindered by social and ecological factors. The results suggest that European Union (EU) subsidies are currently the main incentive to cultivate willow plantations. However, financial support alone did not guarantee the success of willow biomass harvesting and market access of the final biofuel production. The findings of this study provide information for decision makers on the opportunities and challenges of the development of willow plantations in Lithuania.

Keywords: *Salix* sp., short-rotation plantations, social and economic factors, economic incentives

Introduction

The use of renewable energy is one of the key elements of European energy policy (EC 1997, EU Directive 2009, EP 2017). Use of short-rotation woody crops for energy purposes, such as fast growing species *Populus*, *Salix*, is expected to expand in the future. Willow (*Salix* sp.), which tends to produce many shoots when coppiced and exhibits rapid growth, is an alternative to produce biomass in an arable soil with short harvesting cycles. Scientific interest in growing willow for bioenergy occurred more than 30–40 years ago in Canada, the United States and Europe (Volk et al. 2004, Guidi et al. 2013, Pilar et al. 2014, Volk et al. 2016). Previous studies have highlighted multiple social, economic and ecological benefits of growing willow. It was concluded that one hectare of willow plantation could sequester about 5–8 tons of carbon dioxide annually (Baral and Guha 2004, Bennick et al. 2008). Using willow biomass for fuel emits relatively low levels of carbon dioxide compared to other biofuels (Styles and Jones 2007, Evans et al. 2010). This activity could revitalize rural economies (Abolina et al. 2014). Generally, willow growing is regulated by issues such as relatively high initial costs, uncertain profitability and long-term capital commitments (Hauk et al. 2014ab). Nonetheless, several studies have identified the cultivation of willow for energy as a long-term investment (Ledin and Willebrand 1996, Nordh 2005).

Determination of biomass and its growth in commercial plantations allows predicting the yield and is usually carried out to determine the optimal harvesting time (Nordh and Verwijst 2004). For this purpose, measurements of tree diameter, height and mass are performed. Willow diameter is measured at 55 cm height above the ground (Telenius and Verwijst 1995, Verwijst and Telenius 1999, Heinsoo et al. 2002, Nordh and Verwijst 2004). The measurements at this level are assumed to accurately assess aboveground biomass by developing a non-destructive biomass assessment method (Verwijst and Nordh 1992, Nordh and Verwijst 2004). The productivity of willows in experimental plots can be 4–7 times higher than in commercial plantations (Hansen 1991). However, actual productivity in experimental plots is overestimated due to artificial conditions: better maintenance of willow plantations and reduced harvest losses (Larsson and Rosenqvist 1996).

In Lithuania, the experience of willow biomass growing for fuel is rather recent and scientifically based economic indicators of this activity are still lacking. The pilot study on willow plantations in Lithuania showed that such plantations are mainly grown on soils with medium concentrations of nutrients (80 percent) and only up to 10 percent of plantations are grown on more fertile soils (Konstantinavičienė et al. 2017). With the growing demand for biofuels in the market, it is important to analyze the problems that willow farmers encounter, and to identify the factors that facilitate or hinder this activity.

One of the outcomes of our previous study on the willow aboveground biomass in Lithuania (Konstantinavičienė et al. 2017) suggested improving our understanding of the economic indicators and socio-economic factors that are most important for the development of WEP in the region.

Methods and materials

Estimation of economic efficiency of growing willow plantations for energy

For the estimation of the economic efficiency of WEP, the following methods were used: cash flow analysis, discounted cash flow method, net present value (NPV) method (Ericsson et al. 2006, SUNY–ESF 2008, Buchholz and Volk 2011, Makovskis et al. 2012) and decomposition analysis method (Litchfield 1999, Vitunskienė and Baltušienė 2014, Vitunskienė 2014).

Cash flow calculations were based on an economic model Ecowillow (SUNY–ESF, 2008), which allows changing the variables and calculating cash flows and profit over the entire production chain, from the preparation for the WEP growing until willow biomass delivery to the end user (Buchholz et al. 2010). The Ecowillow model suggests the standards for planting, harvesting, transporting, equipment capacity and working time productivity, which have already been used in other countries for the calculation of economic production of willow plantations (Buchholz and Volk 2011, Makovskis et al. 2012). Modifiable variables allowed the costs of labor, fuel, equipment rental, planting, also plant density, and biomass increment adapt for Lithuanian conditions (Table 1).

The calculations were performed for conditional 10-hectare plantation. The revenue was calculated for the lowest annual dry aboveground biomass yield per 1 ha after the first cutting, the average annual dry aboveground biomass yield per 1 ha at the time of the next cutting and the average purchase price of biomass (by market prices

Table 1. Data for the economic model EcoWillow. Values in gray are given as EcoWillow model standards, other values were adapted to Lithuanian conditions

Data	Units	Values
Project size	ha	10
Headlands	% of acreage	8
Project duration	yrs	22
Rotation length	yrs	4
Biomass increment per first rotation	odt*/ha/yr	2
Average biomass increment	odt*/ha/yr	6
Establishment and maintenance	Eur	6306
Planting		
Hectare to be planted (headlands subtracted from total project size)	ha	9
Planter speed	hrs/ha	1.5
Total planting time	hrs	13.5
Planting labour	Eur	272.19
Planting equipment	Eur	926.60
Planting density	cuttings/ha	13000
Planting stock	Eur/cutting	0.04
Stock delivery	Eur	0
Total planting	Eur	6346.79
	Eur/ha	**634.68**
Harvesting		
Area to be harvested (headlands subtracted from total project size)	ha	9
Biomass to be harvested	odt*/ha	24
Harvester speed	km/hr	6.5
Harvesting labour	Eur	248.43
Harvesting equipment	Eur	2155.52
	Eur	2403.95
Total harvesting	Eur/ha	240.39
	Eur/odt*	10.02
First harvesting	Eur	80.13
Total harvesting per all fife rotations	**Eur/ha**	**1071.71**
Transportation		
Wet** tons shipped	t	465
Wet**chip density	m^3/t	3.4
Loading time	min	5
Dumping time	min	15
Total time per trip	hrs	1.68
Transportation equipment maximum capacity	t	35
Load weight	t	31.76
Total trips		14.63
Total time	hrs	24.63
Transportation equipment	Eur	1683.14
Transportation labour	Eur	254.32
	Eur	1937.46
Total transportation	Eur/ha	193.75
	Eur/km	2.57
	Eur/odt*	8.77
Transportation per first harvesting	Eur/ha	70.20
Total transportation per all five harvestings	**Eur/ha**	**845.18**
TOTAL COSTS (excluding costs for administration and land tax)	**Eur/ha**	**3153**

* odt: oven-dried ton, containing 0% moisture;
** wet tons shipped: assuming 50% moisture content in weight.

for 2014–2015 years). The assumption here is, that the harvest takes place every fourth year (SUNY–ESF 2008, Makovskis et al. 2012). Cash flow was calculated with and without EU subsidies.

Assessing future cash flow, the macro-economic analysis and statistical data were used as external sources of information, and it was also based on reasonable limitations. The main limitations were: willow planting material is purchased in Lithuania based on the sales price of 2016; planting density – 13 thousand units per 1 ha; fertilizer expense is calculated on the basis of the recommended method of fertilizer use for growing willows (Lazdina 2016) prices of mechanized agricultural services in Lithuania in 2015 and prices of mechanized agricultural services in Lithuania in 2015; an agricultural tractor with planting equipment was used for planting willows, and a harvester New Holland, which collects and crushes biomass, and a tractor with a trailer, was used for harvesting. All equipment is leased, so depreciation is not calculated, but maintenance costs are included in cash flows; harvesting takes place every four years (SUNY–ESF 2008, Makovskis et al. 2012). Biomass increment was calculated on the basis of the study of willow biomass determination in commercial plantations in Lithuania conducted in 2013–2015 (Konstantinavičienė et al. 2017). For the economic calculations, an average annual increment of dry willow biomass was taken as 6 tones per ha; however, the biomass increment after the first rotation was used as lower value of 2 tones per ha based on the need to develop the root system during the first year (Konstantinavičienė et al. 2017); willow plantation life cycle is 22 years (Abrahamson et al. 2002, SUNY–ESF 2008, Makovskis et al. 2012); transportation costs were calculated at a distance of 50 km (SUNY–ESF 2008, Makovskis et al. 2012, Schweier and Becker 2013); all the work is hired; the cost of working time was calculated on the basis of working hours according to the Ecowillow model (SUNY–ESF 2008) and average wages of workers and craftsmen in 2016; land lease costs were not included in the calculations because only 2 percent of the owners (Konstantinavičienė et al. 2017) lease their land for willow energy plantations in Lithuania; the average purchase price of biomass was 122 EUR/tne (Baltpool 2016).

The discounted cash flow method shows the value of money, taking into account the time factor (Brigham and Ehrhardt 2007). To research the economic efficiency of willow growing and for the cash flow calculations was applied usually 6 percent discount rate in the United States (SUNY–ESF 2008), Sweden, Poland (Ericsson et al. 2006), and Latvia (Makovskis et al. 2012). Therefore, in this study, the basic calculations were based on 6 percent discount rate. Therefore, the revenue-cost flow for WEP was calculated per one hectare of willows for 22 years. Separate analyses of the cash flows with EU subsidies and without them were conducted, to assess the impact of EU subsidies on the profitability of willow production.

Net present value (*NPV*) method was used to evaluate the attractiveness of investments. The aim of this method is to determine the current value of all future cash flow generated by a project, including the initial capital investment, using the discounted cash flow method. The formula for the net present value was:

$$NPV = \sum_{t=0}^{T} \frac{(P_t - I_t)}{(1+k)^t} \quad (1),$$

where NPV – net present value, P_t – net cash inflow during a single period t (EUR/ha), I_t – net cash outflow during a single period t (EUR/ha), k – discount rate, T – number of time periods (years).

Net present value and payback time of investments were calculated with and without EU subsidies.

Decomposition analysis method is often applied to assess the influence of agricultural subsidies upon revenue inequality (Vitunskienė and Baltušienė 2014). Decomposition analysis method was used in this study to: (1) measure inequalities of revenue according to revenue sources (Litchfield 1999); and (2) to evaluate the impact of the European Union (EU) subsidies on the profitability of willow growing. To measure the impact of the payments on the income, the nominal rate of direct support, expressed as a ratio between the income 'with subsidies' and 'without subsidies' was used (Vitunskienė 2014):

$$NRDS = \frac{CF}{CF - \sum S} \quad (2),$$

where $NRDS$ – nominal rate of direct support, CF – cash flow, calculated after received subsidies, $\sum S$ – received subsidies.

The rate shows how many times the support payments (the subsidies) increase the income earned independently by the farm in the market (Vitunskienė 2014).

Operating costs of WEP along with the planting materials, equipment (such as rental and transportation, maintenance and biomass consumption rate) and the workforce (number of employees, number of working hours, hourly rate, indirect labor costs) covered six main cost units: 1) preparation – land preparation before planting (ploughing, disking and paring), and weed annihilation using herbicides; 2) planting – material and work; 3) maintenance – weed control procedures during the first and second years, the primary cutting, and fertilization; 4) harvesting; 5) transportation; and 6) other costs (administrative and taxes).

Assessment of social factors influencing the development of WEP

A questionnaire (consisting of 36 questions) was formulated to reflect the current situation of WEP growers in Lithuania. It aimed to obtain the basic data on WEP such as land area and year of the plantation; how well the activity was organized and its effectiveness (including the facilitating or hindering factors); socio-demographic data of WEP growers, their motivations and future plans. The questionnaire was distributed by e-mail including the information about anonymous participation in the survey.

All the WEP plantations that were subject to this survey were classified according to their size: small (below 10 ha), average (between 10 and 30 ha) and large (above 30 ha). The mean area of large plantations was estimated at 239 ha, and for average-size and small plantations was 16 and 4 ha, respectively. All of the 70 WEP growers had declared their plantations in 2014 (NPA 2015). The sample size of 50 respondents was used in the survey, and it ensured 90% of the study's reliability. Total WEP area of the respondents was 1,814 ha in 2014, while the actual area of willow plantations comprised 2,320 ha. The data were analyzed using Statistical Analysis (SPSS) software.

Results

The economic efficiency of growing WEP

The cash flow diagram of WEP was modeled over the entire 22-year life cycle, which provided the data on the prime cost of 1 ha of work and revenue. Separate analyses of the cash flows with EU subsidies and without them were conducted. The results obtained from the cash flow analyses showed if applying 6 percent of discount rate in a case of no EU subsidies, net present value of willow growing is 458 EUR. Meanwhile, in a case when EU subsidies are used, net present value of willow growing is 1800 EUR in the 22nd year. In both cases, the project of willow growing is effective because the net present value is higher than zero. Similar calculations conducted in Poland showed that the costs incurred after each harvest were calculated, excluding establishment costs, because those costs were incurred regardless of whether the farmer continues to grow willows (Ericsson et al. 2006). The investment payback time (based on the current macro-economic indicators), in the absence of EU subsidies, comes only in the 17th year, but using the current EU subsidies, this project would pay off in the 9th year (after the second harvest), assuming that all the harvest would be sold. Similar calculations conducted in Poland showed that the costs incurred after each harvest were calculated, excluding establishment costs, because those costs were incurred regardless of whether the farmer continues to grow willows or not (Ericsson et al. 2006). The results showed that the revenue of willow growers (excluding subsidies) more than two times exceeded the costs after each harvest (excluding establishment costs). Therefore, the grower can decide whether he or she wishes to continue willow growing after each harvest. Furthermore, the growing of WEP has several advantages. If during the time of harvest it turns out that there is no buyer or that the biomass purchase price is too low, it is possible to delay the harvest until the next year (Lazdina 2016), extending the period of the plantation rotation, which would be impossible when cultivating agricultural crops. Generally, the economic benefit of willow growing depends mostly on the harvest size and the purchase price of the biomass. The price of biomass, however, has a greater impact on the economic efficiency of willow growing than the willow harvest, because when the price raises, only revenue increases, while when the yield increases, harvesting and transportation costs increase as well (Ericsson et al. 2006).

Not discounted costs of willow plantations per hectare in the each year are given in Table 2. It should be noted that no costs were found for the 3rd and 4th year after the plantation establishment, also 3 years after each harvest. The data excluded administration and land taxes. The results obtained from cash flow calculations, based on an economic model Ecowillow, showed that willow biomass production costs over 22 years (five growing rotations) in Lithuania were 3173 Euros per hectare. The establishment costs account for 25% of total costs, maintenance costs are 13%, harvesting costs are 31 percent, transportation costs are 25% and other costs account for 6% in the overall cost structure.

That percentage is comparable with those of other Baltic countries: these costs amount to about half of the total cost in Poland (Ericsson et al. 2006) and 55% in Latvia (Makovskis et al. 2012). However, it is assumed that raising costs also have a significant effect, since the first revenue, excluding subsidies, is not available until the fifth year (Ericsson et al. 2006). It is estimated that the cost of willow plantation management in Poland is lower compared to costs of wheat and barley, while transportation costs for willow biomass are significantly higher (Ericsson et al. 2006). The relative economic efficiency of willow production is higher in soils with medium concentrations of nutrients than the profitability of wheat production in the most fertile soils. Profit is highly dependent on biomass market price, but willow production is cost effective if productivity is high (Ericsson et al. 2006).

Table 2. Annual undiscounted expense of willow plantations for 10 ha (administrative and land tax costs were excluded)

Time for the entire 22-year long rotation	Site preparation	Planting/ establishment	Maintenance	Harvesting, transporting	Total
Years*	Eur				
0	1895				1895
1		6347	1440		7787
2			746		746
5			407	1503	1910
9			407	4342	4749
13			407	4342	4749
17			407	4342	4749
21				4342	4342
22	599				599
				Total, Eur	31526
				Relative annual average cost, Eur/ha	143

Social and economic aspects of WEP production

The survey results revealed the main incentives behind WEP cultivation in Lithuania, such as the opportunity to develop a new business and to receive additional income, including EU support. Twenty two percent of WEP growers indicated another important incentive – willow growing as an opportunity to achieve energy security and independence by generating one's own fuel. WEP also required less work and care when compared to agriculture (Figure 1).

All the respondents indicated that they prepared the land and cultivated it before planting the willow seedlings, over 80% of them used weed control but only some respondents provided protection against diseases and pests (12%) and fertilized the soil (15%). Only 34% of the respondents indicated that they harvested the willow biomass for fuel. Willow biomass was not harvested by 66% of surveyed WEP growers (Figure 2). Of these, 70% did not harvest the plantations because the plantations had not yet reached the harvestable age. The rest of the respondents (7.5%) indicated that biomass harvesting was financially unreasonable because the selling price was not high. Part of the owners of WEP (7.5%) did not harvest the plantations because did not have special harvesting equipment. Poor or bad condition of the willow plantations was also listed as reasons for the not harvesting (7.5%). One-third of the respondents indicated other reasons (of these, 75% of the respondents mentioned that the harvesting machinery could not enter plantations due to bad weather conditions).

When harvesting at least part of the plantations, the owners of small and average WEP used the willow biomass for personal needs and for sale. Whereas, the owners of large WEP used it for commercial purposes only. Part of the willow biomass owners store on their premises (Figure 2). However, it was impossible to indicate the plantation area from which the biomass was collected as most of the respondents indicated that they harvested the plantations only partially. It was also complicated to assess the exact use of biomass. This did not allow us to conclude how the respondents managed to achieve their goals, when 22% of them planned to grow willow biomass for personal needs and 68% for sale.

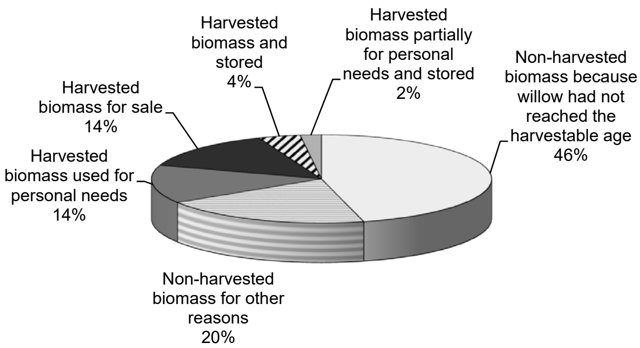

Figure 2. Distribution of biomass harvesting or not harvesting (survey data, $n = 50$)

Factors influencing the development of willow plantations

When analyzing the reasons for the relatively slow WEP development in Lithuania, it was found that the low selling price of biomass and competition between large energy companies mainly hinder the business development (50–58% of respondents agreed with these points) (Figure 3). The lack of harvesting techniques (40% of respondents) and high biomass harvesting costs (36% of respondents) were also highlighted. WEP development was negatively influenced by high cost of harvesting techniques and because the purchase of techniques was not supported by EU subsidies.

When analyzing the reasons for the relatively slow WEP development in Lithuania, it was found that the low selling price of biomass and competition with large bioenergy companies (large companies that produce and centrally supply heat from biofuel; mainly owned by municipalities) hinder the business development (50–58% of respondents agreed with these points) (Figure 3). The lack of harvesting equipment (40% of respondents) along with high biomass harvesting costs (36% of respondents) was also highlighted. WEP development was negatively influenced by high cost of harvesting techniques and because the purchase of techniques was not supported by EU subsidies.

In all, 44% of the respondents indicated that harvest costs were not a hindering factor, although 16% had not yet harvested willow biomass and did not know the real situation (Figure 3). However, 20% of the respondents who had harvested biomass believed that the costs incurred were not a hindrance. This opinion could be explained by the fact that they have harvested the willow biomass using their own technique. Another 12% of the respondents indicated that the cost of the willow plantation establishment was high, but 70% indicated that these costs were acceptable (Figure 3).

Transportation costs were considered as a non-hindering factor by 46% of all the respondents, whereas 30% considered that an issue. Only 2% of respondents lacked information on transportation costs. The economic analysis of WEP also indicated that the costs of such plantation establishment were the same as the transportation costs. Harvesting (31%) and transportation costs (25%) comprised the main part of all costs and could be termed

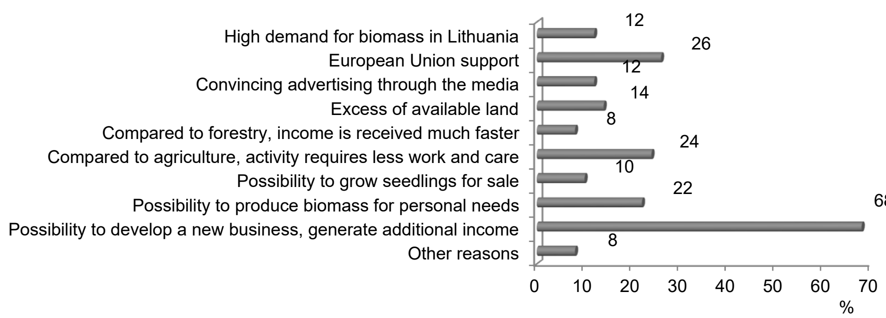

Figure 1. Reasons induced the respondents to start growing WEP (survey data, $n = 50$)

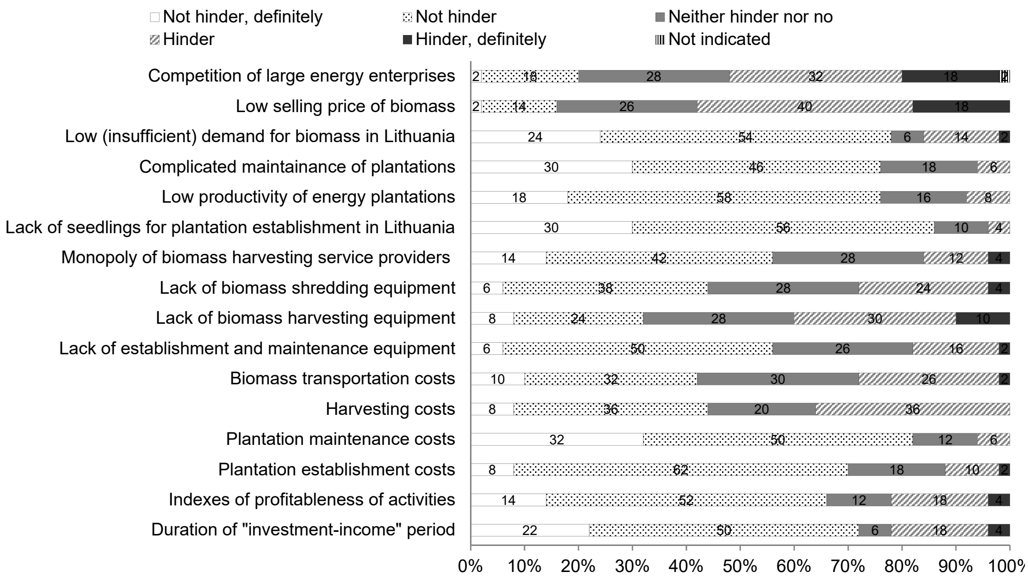

Figure 3. The influence of economic factors on WEP development in Lithuania (survey data, *n* = 50)

hindering economic factors. Only 8% of the respondents pointed out that the low productivity of WEP hindered their development in Lithuania. Almost a quarter of respondents indicated that the investment-income period was too long and that the level of profitability of an enterprise hindered development (Figure 3). In all, 22% of the respondents considered profitability indicators low, but 66% of the respondents did not think that this was a hindering factor. The profitability ratio was higher than one both with and without EU support, although the first profit was obtained only a few years later. The duration of the investment-income period, as shown by the economic analysis, is quite long, but still, 72% of the respondents indicated that this did not hinder their activities. This could be explained by the optimistic expectations of WEP growers or the fact that the growers were willing to wait for deferred profit.

Assessing the social factors that hinder WEP development in Lithuania, the respondents pointed out the lack of public awareness and education as well as negative attitudes about short rotation energy plantations in Lithuania. The lack of knowledge and experience were not identified as hindering factors by most of the respondents. More than one-third pointed out that EU support should be higher and 40 percent indicated that the risk of termination of subsidies hindered WEP development in Lithuania.

The results of a similar survey carried out in Latvia showed that willow biomass producers were faced with the uncertainty of profitability and considered that higher government support was needed (Abolina et al. 2014). Such opinions, however, were formed mainly due to willow growing being a relatively new and scarce practice in Latvia (Abolina et al. 2014). Most farmers who participated in the Latvian survey believed they will be able to decide to continue or stop willow production in a few years after establishing their willow plantations (Abolina et al. 2014). Other studies also showed that subsidies to encourage the development of energy plantations were necessary. For example, in Sweden, the development of energy plantations declined when subsidies were stopped in 1996 (Johansson et al. 2002, Mola-Yudego and Pelkonen 2008). It is thought that subsidies could neutralize negative liquidity in the first year of willow production and ensure higher profitability (Johansson et al. 2002). According to the results of our study, support for willow farmers in Lithuania was not sufficient, and the lack of clarity about future payments raised doubts as to whether it would be possible to ensure successful operations in the future.

The majority of respondents stated that the development of WEP in Lithuania is a positive phenomenon because it promotes rural development, creates additional jobs, reduces the import of fossil fuels and reduces climate change and forest harvesting (Figure 4).

The analysis of the respondents' future intentions revealed that 62% plan to continue to grow the willow plantations. Of these, 13% pointed out that when they started this activity, they thought that they would later expand the plantation areas, but now they had abandoned these intentions because of unsecured financial gain. This suggested similar results to the study in Latvia, regarding financial uncertainty among the willow plantation owners (Abolina et al. 2014).

This study found that the main factors inducing WEP development were the need for increased EU subsidies and the higher selling price of willow biomass. The respondents also were concerned about more effective logistics, constructive attitudes of the government to have large independent energy resources and examples of best practice. This study has identified other factors that could induce WEP development in Lithuania: the increased quantity and capacity of biomass boiler-houses; centralized harvesting of willow plantations; purchase points; and imposition of monetary sanctions and increased taxes for unused and abandoned land.

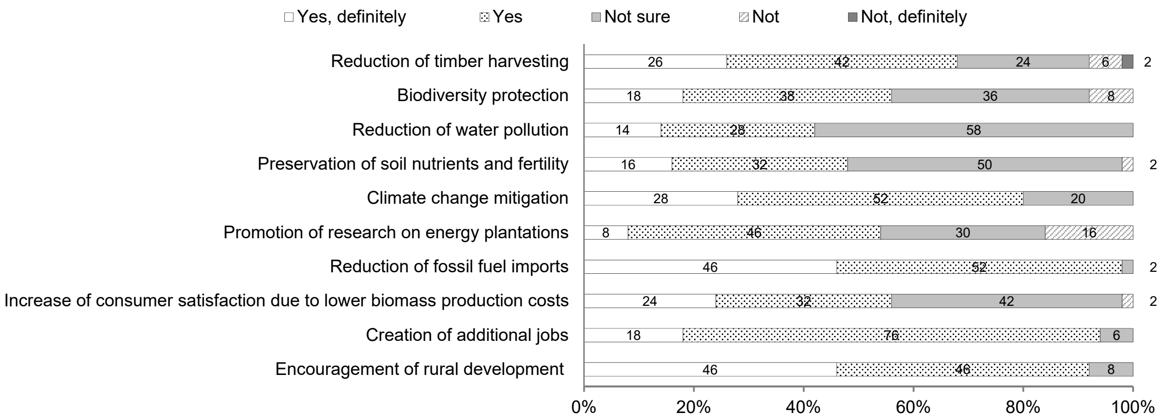

Figure 4. Consequences of WEP development in Lithuania (survey data, *n* = 50; "yes" – positive evaluation; "no" – negative evaluation)

Summarizing the main issues identified in this study, the key priorities of willow plantation growers include the priority to develop new business and obtain additional income, including EU support. The analysis of the inducing and hindering factors lead us to conclude that most of the willow growers were hampered by economic factors, i.e. low selling price of biomass, competition between large energy companies, lack of harvesting technique and high costs of biomass harvesting. Other problems that the growers faced were also revealed: due to weather conditions, the equipment could not do enter the field, preventing harvesting biomass in time; a low purchase price of biomass, so that the harvested biomass is stored or left in the field. Based on the study results, it could be also implied that some willow growers only benefited from the subsidies and lacked the internal responsibility to successfully maintain willow plantations. Summarizing the data of the previous study based on the willow biomass measurements in Lithuania (Konstantinavičienė et al. 2017) and this socio-economic study, we can assume that first of all the land owner should be motivated to cultivate willow plantations by the country's general policies, i.e. price regulation and financial support. These findings could contribute to perceiving the specifics of willow energy plantations grown both locally and in the Baltic region. Furthermore, it could help to recognize the main challenges that arise with the pressure to develop new activities to increase biomass production.

Conclusions

The economic benefit of willow cultivation mainly depends on willow productivity and the purchasing price of biomass. The increase in willow yield, labor productivity and transport lorries as well as the reduction of planting material costs and other prices, as labor and fuel prices, have a positive impact on net cash flow throughout the life cycle of a plantation and increase the profitability of willow production. Under the current macro-economic conditions in Lithuania, willow cultivation can be cost effective with the payback period of 9 years after the second rotation. Therefore, willow biomass growing for fuel can be economically promising even without subsidies.

Compared to the economic study, the willow grower's survey showed that willow growing is mostly hindered by economic factors: the low purchase price of biomass, high cost of collecting biomass, lack of harvesting equipment and competition with major energy-producing companies. While EU subsidies are currently promoting willow growing in Lithuania, they however, do not guarantee a successful harvesting and market access for the final product. We hope that the results of this study will provide vital information for policy developers, decision makers and the investors on the opportunities and challenges facing willow growing in Lithuania along with some practical information for farmers.

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