Investment Appraisal of Poplar Plantations in Serbia

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Abstract

In conditions of increasing wood consumption and demand in the world, the aim of the majority of national economies is to intensify local resource production. Due to the fact that poplar rotation is one of the shortest in forestry, and as production of poplar wood requires rational and well-planned management, the potentials of sites and species must be maximally utilised. Favourable financial effects of such a production should be realized.

The commercial profitability of poplar cultivation was analysed in an artificial poplar plantation in Serbia. The aim of the study was to validate the invested financial means in artificial poplar plantations, based on the analysis of costs and receipts in different rotation (25-42) years, on different fluvisols (alluvial semigley, humifluvisol, humogley and $\alpha/\beta-\beta$ gley), at different discount rates (4-12%). Methods of analysis of commercial profitability, especially some methods of dynamic investment calculation (net present value – *NPV*, internal rate of return – *IRR*, benefit-cost method – *R* and pay back period – *PBP*) were used. The investigated plantations were established from *Populus* x *euramericana* cl. *I-214,* with planting spacing 6 x 6 m. Thirteen study plots – management units (55 stands), with a total area of 331.05 ha were investigated in the period 2002-2010.

For a discount rate r = 12%, all tested areas had a negative *NPV* of 11 088 to 23 676 €·ha^{-1}, regardless of age and site quality. The discount rate of 6% can be accepted by shorter production cycles in younger stands (to the age of 28 years) on better sites (alluvial semigley). *IRRs* varied in the range 4.32-6.94% (average 5.63%) at a discount rate of 12%. Internal rates were larger for plantations on good quality soil types and for shorter rotations and vice versa. The analysis showed that *PBP* is practically unacceptable for the investor under the discount rate of 6%. The most favourable situation is the discount rate of 2% in younger plantations. The average amount of *R* was 0.36 for all studied plots.

Key words: hybrid poplar plantations, investment, financial appraisal, commercial profitability, costs, revenues, dynamic methods

Introduction

Poplar wood has a lot of comparative benefit and widely applied. Today it is recognized in different ways in the wood processing industry as a very important substitute for wood of other, more valuable, tree species with longer rotation periods. Production processes in forestry last longer than similar processes in other industries. The process of investing in poplar cultivation includes financial investments in the present period aimed at realisation of economic benefits or effects in a future period, of a seasonal character (Keča and Pajić 2010). This implies a significant problem in the process of predicting and determining investments in fixed assets, engagement of human and machine resources, etc. The main characteristics of the procedure of investment in poplar cultivation, is the fact that the conditions for the beginning of production and their exploitation are not created simultaneously. The advantage of plantations over classical forestry is that the production scope and structure can be relatively quickly adapted to market requirements.

Poplar plantations are a category of fixed assets in forestry, i.e. assets with a biological character. They are site related, are cultivated for a relatively long time and they have a relatively long utilisation cycle, with the yield development determined by the plantation growth and age. Plantations transfer their value gradually to the obtained products, during the harvesting period. The means invested in the plantation are reproduced after product realization. The investment period in poplar growth can be relatively long. Therefore, it is important to determine the time needed for the return of the capital invested in these and similar plantations.

The aim of this research was to assess the cost-effectiveness of funds invested in wood production in poplar plantations, based on the analysis of costs and receipts in different periods of plantation age, using: the net present value method (NPV), internal rate of return (IRR), pay back (PBP) and benefit-cost method (R). The NPV calculates the current value of all cash flow associated with an investment: the initial investment outflow and the future cash flow returns. Alternatively, you can work out the discount rate that would give an investment an NPV of zero. This is called the IRR. The key advantage of NPV and IRR is that they take into account the time value of money – the fact that money you expect sooner is worth more to you than money you expect further in the future. Payback period is a simple technique for assessing an investment by the length of time it would take to repay it. Cost-Benefit Analysis (CBA) estimates and totals up the equivalent money value of the benefits and costs to the community of projects to establish whether they are worthwhile. However, the research goal was to validate the justification of funds invested in wood production in poplar plantations, based on revenues and cost analysis at different plantation ages, using the *IRR* method. The objective of the study was also to evaluate the possible pay back period of invested capital in wood production in poplar plantations.

Serbia is situated in southeast Europe in the central part of the Balkan Peninsula. Owing to the great production potential of hybrid poplars and their easy vegetative and generative reproduction, banks of rivers (Danube, Sava, Tisa) have been used for the establishment of plantations of many different poplar clones, especially clone *I-214* (Cagelly and Lefevre 1995) on some of the best sites for poplar establishment in Europe (Herpka 1986). The total area of these poplar plantations is about 48,000 ha, which is about 2.1% of the forest areas in Serbia (Banković et al. 2009). *Populus* x *euramercana* (Dode) Guinier cl. *I-214* dominates (Table 1). Poplar forests are also a significant element of riparian stability, particularly of major rivers. They are composed of species that tolerate extreme and frequent flooding. About 36.000 ha of poplar plantations are situated in Vojvodina, the Northern Province of Serbia (Table 1).

Investigation of the investment appraisal in poplar plantations has been done due to several reasons. First of all, poplars are very significant for forestry in Serbia, and particularly Vojvodina. Second, poplar production is explicitly a capital-intensive one, where the invested funds could have significant, sometimes and a crucial influence on the achieved level of economic effectiveness. Third, the economic effectiveness level of the investment in poplar plantations could be significantly influenced by different biological, climatic, technical and technological factors as well as organisation and economic factors. Their appearance or influence intensity can not be always forecasted in advance neither can their effect be precisely quantitatively identified. Fourth, these investments mostly represent a complex long term investment with a long period for investment construction as well as a proportionally long period of exploitation.

Table 1. Main data on poplars in Serbia and Vojvodina

Legend	Value		Unit	Additional
Area of poplars in Serbia	48.000		*ha*	
Ownership	state	83.3	%	
Plantations	74.2		%	
Semi-natural stands	25.8		%	
Plantation density	289		trees·ha^{-1}	
Average volume	175		$m^3 \cdot ha^{-1}$	6.137.862 m^3
Volume increment	9.5		$m^3 \cdot ha^{-1}$	338.272 m^3
Preservation status	well-preserved	60.9	%	
	insufficiently stocked	28.3	%	
	devastated	10.8	%	
Dominantly clean stands	90		%	43.000 *ha*
Volume structure	small diameter	14.2	%	
	medium-diameter	48.0	%	
	large-diameter	37.8	%	
Area of poplars in Vojvodina	36.000		*ha*	
Ownership	state	51.7	%	
Plantations	28.6		%	
Plantation density	439		trees·ha^{-1}	
Average volume	172		$m^3 \cdot ha^{-1}$	5.511.291 m^3
Volume increment	9.0		$m^3 \cdot ha^{-1}$	299.000 m^3
Preservation status	well-preserved	65.7	%	
	insufficiently stocked	29.1	%	
	devastated	5.2	%	

Yield classes in hybrid poplar plantations (*P.* x *euramericana* cl. *I-214)* are high in Serbia. But, the economic cost-effectiveness of poplar plantations is debatable, due to the high costs encountered at the stage of plantation establishment (chipping of tree stumps, ploughing, planting, protection, etc.) (Table 2). The near non-existence of income until the end of the whole cycle, except for a small profit from thinning after 6-9 years is also very disputable. The largest poplar plantation areas are intended for the production of veneer, peeling and cutting logs, all of which, about 350,000 m^3 round wood year^{-1}, is processed in Serbia. They have been used in the production of: packaging, veneer, pallets, various types of board, and other articles.

Thus, the question of the economic effectiveness of intensive plantations arises. The investment activity undertaking is usually based on the hypothesis that the economically most suitable investment is implemented, one that can contribute to the greatest extent to the profitability increase of an enterprise or some other production subject (Sangster 1993). On the other hand, the economic effectiveness of such investments in poplar plantations may be affected by a large number of different factors (biological, climatic, technical-technological and management) (Pudar 1982, Sredojević and Veličković 2002, Holopainen et al. 2010, Keča 2010/a,b 2011).

The subject of this research has been poplar plantations of clone *I-214* aged 25-42 years in various fluvisols (alluvial semigley, humifluvisol, humogley and $\alpha/\beta-\beta$ gley). Our hypothesis is that the financial results for short rotations and better habitats will be better than those for long rotations and poorer habitats. The main goal of the work reported in this paper was to examine the financial effects of different discount rates on the cost-efficiency values of poplar plantations, based on an analysis of the present value of costs and revenues over a stated time period using different methods of investment appraisal. Ac-

Table 2. Annual costs of a poplar plantation for the rotation period of 26 years on 1 ha in study plot number 2

Total in zero year	euro/ha
Ground preparation for afforestation	1 195.17
Mulching of waste wood	445.21
Chipping of stumps M.L. 250 pieces/ha, d=51-60cm	454.01
Chipping of stumps other species	215.11
Collecting and removal of roots	80.85
Ground preparation for afforestation	300.00
Ground ploughing	219.59
I undermining of ground	48.01
II undermining of ground	32.40
Afforestation with seedlings of clone poplars space 6x6m (peg production, division, boring holes, transport of seedlings, sowing of seedlings)	545.31
Total in first year	209.44
Maintenance and protection of plantation	209.44
Treatment among rows	29.51
Treatment among rows	43.07
Weed control among rows	42.08
Dig up the seedlings	48.70
Pruning	9.22
Sprout removal	8.36
Herb disease protection	11.70
Protection against insects	16.80
Total in second year	177.97
Afforestation with seedlings of cloned poplars with 6x6m spacing (pegs production, divide, bore the holes, transport of seedlings, sowing of seedlings)	51.06
Maintenance and protection of plantation	126.91
Treatment among rows	29.41
Treatment among rows	43.07
Weed control among rows	42.08
Dig up the seedlings	9.22
Sprout removal	4.04
Herb disease protection	11.70
Protection against insects	16.80
Total in third year - Care	111.65
Treatment among rows	29.51
Treatment among rows	21.54
Weeds control among rows	41.80
Pruning	18.80
Total in fourth year - Care:	96.90
Treatment among rows	14.76
Treatment among rows	21.54
Weed control among rows	41.80
Pruning	18.80
Total in fifth year - Care:	96.90
Treatment among rows	14.76
Treatment among rows	21.54
Weed control among rows	41.80
Pruning	18.80
Total in sixth year	423.42
Maintenance of plantation:	18.80
Pruning	18.80
Marking of trunks for schematic thinning	7.80
Schematic thinning (6th – 12th year.) :	415.62
Round wood of small dimensions	**Income**
Pulpwood	**Income**
Compensation for cut wood 3% of	31.93
Cutting and processing	170.72
Dragging	212.97
Total in the last (26) year	6 836.66
Total survey for the main cutting	16.14
Mulching among the rows	
Main cutting – main income	
Assortment structure:	
F class	**Income**
L class	
I class	
II class	
Pulpwood	
Compensation for cut wood 3% of market value paid by the forest enterprise to the Ministry	470.98
Cutting and processing	1 046.08
Dragging	2 074.34

cordingly, the intention was to establish the possibility of improving the economic efficiency of wood production in poplar plantations.

Material and methods

Modern methods of investment valuations and consequently their practical applications in forestry were applied in this research. The investigated plantations were established from *Populus* x *euramericana* cl. *I-214,* with planting spacing 6 x 3 m (555 trees per ha), for technical wood production. After selective thinning in the sixth year, the plantation had 278 trees (6 x 6 m). The study was carried out in plantations of poplar trees in the north-western part of Serbia, in the area of the river Sava, in the period 2002 – 2010. Thirteen study plots id est 55 stands, aged 24-42 years, with a total area of 331.05 ha (Table 3) were investigated. Data were collected from different types of soil belonging to site classes I – V (Table 3).

The data used in this study were collected in two main phases. Data pertaining to costs during years 0-5 (soil preparation, planting, care and protection, etc.) were obtained from the archives of the forest enterprise which managed the studied plantations - Public Forest Enterprise “Vojvodinašume”, according to the plantation age (Table 2). Table 2 shows the annual costs of a plantation in Serbia over the period of 26 years on 1 ha for sample plot no.2, planting density 6x6 m, forest type poplar on fossil hydromorphic black soil (humosemigley) on loess-alluvium. Cash outflow is present in the first 5 years, and cash inflow from

Table 3. Spatial distribution, qualitative and quantitative structure of the studied plantations

Study plot no.	Soil Type	Site Class	Assortment structure ($m^3 ha^{-1}$)			Age (years)	Area (ha)
			Timber	Pulpwood	Ratio		
1.	RC/HGL	IV	268.54	61.20	81/19	24	25.00
2.	AS/ASG	I	318.20	94.49	77/23	26	36.75
3.	AS/ASG	I	266.62	114.43	70/30	26	2.33
4.	AS/ASG	I	336.69	56.50	86/14	26	9.87
5.	AS/ASG	I	259.23	41.66	86/14	26	1.32
6.	AS/ASG	I	332.53	49.28	87/13	28	32.57
7.	AS/ASG	I	262.48	54.08	83/17	29	28.82
8.	LC/HFL	III	252.35	55.35	82/18	29	33.81
9.	LC/HFL	III	269.80	91.78	75/25	29	51.49
10.	LC/HFL	III	309.42	41.76	88/12	31	58.15
11.	ASG	I	490.53	73.58	87/13	37	5.80
12.	ASG	I	331.51	53.15	86/14	42	6.62
13.	α / β-β gley	V	333.16	45.93	88/12	42	38.52
Total							331.05

schematic thinning in year 6 and at the end of rotation (in this case at the age of 26).

In the second phase, data were collected from management and materials books of the forest enterprise. In the sixth year, selective thinning was performed in all plots. All income (the value of F–veneer and L–peeling logs, timber wood class I and II, and pulpwood) and costs (total survey, logging and processing, dragging, compensation for the felled trees paid by the forest enterprise to the Ministry of Agriculture, Trade, Forestry and Water Management) related to the final cutting were collected directly in the field and controlled in the official documentation of the forest enterprise (Keča 2010/b). Costs are expressed per unit area 1 ha at the prices in force in January 2010, converted into euro (€). Since, all studied stands are state-owned and managed by the Public Forest Enterprise "Vojvodinašume", the value (cost) of the land (land rent) did not enter into the calculations (Keča 2011).

Many forest investment appraisal studies have been done over the past years in forestry all around the world (Bann 1997, Gregersen et al. 1995, Gregersen 1996, Kengen 1997) although rigorous quantitative studies (Cavendish 2000, 2002, Campbell et al. 2002, Fisher 2002) are only recent and very rare (Angelsen and Wunder 2003).

Investment Appraisal also known as Capital Budgeting (Lumby 1988, Röhrich 2007, Götze et al. 2008) is used to asses whether capital expenditure on particular poplar plantations will be beneficial for the entity or not. These techniques can be used to evaluate projects both in the private and public sector in forestry. Most commonly used techniques include: Net Present Value (*NPV*), Internal Rate of Return (*IRR*), Payback Period (*PBP*), Benefit-Cost Method (*R*) (Pogue 2010).

Assessment of the cost-effectiveness of production in hybrid poplar plantations was carried out on the basis of net present value *(NPV),* which is used as one of the indicators for project evaluation (Gittinger 1972, Buongiorno et al. 1985, Smith-Daniels et al. 2007). The *NPV* method calculates the present values for all future cash flows (Lumby 1988, Röhrich 2007, Götze et al. 2008). Projects are cost-effective when the $NPV \geq 0$.

$$NPV = \sum_{t=1}^{n} (Rt - Ct) \cdot \left(\frac{1}{1 + \frac{r}{100}} \right)^{t}, \qquad (1)$$

where: R_t is cash inflow in year t, C_t is cash outflow in year t, r is the discount rate, and n is the plantation age.

The value of 12% was chosen for the base discount rate, which is about the average of the range 10-15% recommended (IMF 2005) for the evaluation of economic investments in developing / transition countries (Neumann and Zimmermann 2000). Profitability was also tested for the discount rates of 8%, 6% and 4%.

To determine the value of the discount rate at which a *NPV* investment is zero *(NPV* = 0) – the internal rate of return *(IRR),* the following formula was solved for r:

$$0 = \sum_{t=0}^{n} (Rt - Ct) \cdot \left(\frac{1}{1 + \frac{r}{100}} \right)^{t}, \qquad (2)$$

IRR calculates the rate at which the *NPV* of a project equals zero. According to this method if the cost of capital of a company is more than the *IRR*, the project will be rejected and if it is lower than the cost of capital it is likely to be accepted. *IRR* and *NPV* concepts are correlated (Row et. al. 1981, Klemperer 2003).

Payback period calculates the time taken by a project to recoup the initial investment. A company evaluating projects by this technique would prefer projects with a short payback period rather than those with longer payback periods. It is simple to calculate and easy to understand (Kula 1988, Pogue 2010). Application of the pay back period (*PBP*) calculation can affect greatly the reliability of predicting the degree of economic effectiveness of investments, and also the potential risks for the investor in his decisions. The payback is the time required for the cash inflows from a capital investment project to equal the initial cash outflow(s). Payback is often used as a "first screening method". By this, we mean that when a capital investment project is being subjected to financial appraisal, the first question to ask is: 'How long will it take to pay back its cost?' The organisation might have a target payback (Hoskins and Mumey 1979, Pike 1985, Lefley 1996)), and so it would reject a capital project unless its payback period was less than that target payback period. Application of the pay back period method determines the pay back period of investments, for example identifies the period of amortisation of investments based on the dynamic model of investment calculation. This period can also be defined as a part of the planned period of the asset exploitation of wood in a poplar plantation, in which it is possible to return the invested capital and the appropriate interest under the given interest rate.

$$PBP = \frac{I_p}{A_{cf}}, \tag{3}$$

where: PBP– the payback period, I_p – the cost of the project or initial payment A_{cf} – the annual cash flow.

Benefit – cost ratio (R) is an indicator, used in the formal discipline of cost-benefit analysis that attempts to summarize the overall value for money of a project or proposal. R is the ratio of the benefits of a project or proposal, expressed in monetary terms, relative to its costs, also expressed in monetary terms (Northcott 1992, Bent et al. 2002, 2005, Ferrara 2010). All benefits and costs should be expressed in discounted present values.

$$R = \frac{\sum R_r}{\sum C_r}, \tag{4}$$

where: R – the benefit- cost ratio, C_r – the present values of costs, R_r – the present value of benefits.

These four methods are nowadays used in all countries over the world in the appraisal of investment economics effectiveness. The dynamic methods start with the assumption that money has its time value, id est a certain amount of money does not have the same value today and in a certain future moment of time, which is very interesting particularly in forestry where rotations are very long. So, it is necessary to evaluate future costs and benefits to be deduced at the present moment of time (Gittinger 1972, Röhrich 2007, Götze et al. 2008).

Results

The mean value of plot establishment and management costs between 0 and 6 years is 3 205.07 € ha^{-1}. The income from thinning was 620 € ha^{-1}. At the end of rotation (production cycle), *id est* between 24-42 years, revenues were 11 088, 23 676 and 16 779 € ha^{-1} for 24, 37 and 42 years, respectively. The values for NPV at a discount rate of r=12% were negative in all studied plots, and ranged from –1 585.84 to –2 161.99 € ha^{-1} (Table 3). At the annual level, NPV_s indicated a similar trend of decline with increasing age (Table 4).

The financial effects for the plantations were also estimated using discount rates of 8%, 6% and 4%, under the condition that the costs and revenues are

Table 4. Revenues and costs, net present value (NPV) and the average net present value (NPV_s) at a discount rate r=12% for the 13 studied poplar plantations

Study plot no.	Year	C	R	C_r	R_r	C_{rs}	R_{rs}	$\Sigma R_r - \Sigma C_r = NPV$
					(€·ha^{-1})			
Cash outflow	0	2 040.48	0	2 040.48	0	2 040.48	0	–2 040.48
	1	209.44	0	187.00	0	2 227.48	0	–2 227.48
	2	207.48	0	165.40	0	2 392.88	0	–2 392.88
	3	111.65	0	79.47	0	2 472.35	0	–2 472.35
	4	96.90	0	61.58	0	2 533.93	0	–2 533.93
	5	96.90	0	54.98	0	2 588.92	0	–2 588.92
	6	442.22	1 064.20	224.04	539.16	2 812.96	539.16	–2 273.80
1.	24	3 031.75	11 088.30	199.74	730.52	3 012.70	1 269.68	–1 743.02
	Σ			3 012.70	1 269.68			
2.	26	3 857.77	12 144.08	202.61	637.82	3 015.57	1 176.97	–1 838.60
	Σ			3 015.57	1 176.97			
3.	26	3 688.25	14 157.86	193.71	743.58	2 983.14	1 282.74	–1 700.41
	Σ			2 983.14	1 282.74			
4.	26	3 585.44	16 236.34	188.31	852.75	2 977.74	1 391.90	-1 585.84
	Σ			2 977.74	1 391.90			
5.	26	2 919,61	12 516.98	153.34	657.40	2 942.77	1 196.56	–1 746.22
	Σ			2 942.77	1 196.56			
6.	30	2 996.38	16 094.21	100.01	537.19	2 889.45	1 076.35	–1 813.10
	Σ			2 889.45	1 076.35			
7.	29	2 529.66	12 627.73	94.57	472.07	2 884.00	1 011.22	–1 872.78
	Σ			2 884.00	1 011.22			
8.	29	2 576.24	12 551.97	96,31	469.23	2 885.74	1 008.39	–1 877.35
	Σ			2 885.74	1 008.39			
9.	29	3 644.95	15 919.76	136.26	595.13	2 925.69	1 134.29	–1 791.41
	Σ			2 925.69	1 134.29			
10.	32	2 843.47	14 479.44	75.66	385.28	2 865.10	924.44	–1 940.66
	Σ			2 865.10	924.44			
11.	37	5 513.48	23 676.36	83.25	357.48	2 896.20	896.63	–1 999.57
	Σ			2 896,20	896,63			
12.	42	3 727,64	16 779.22	31.94	143.75	2 844.90	682.91	-2 161.99
	Σ			2 844.90	682.91			
13.	42	3 246.93	16 725.84	27.82	143.29	2 817.25	682.45	–2 134.80
	Σ			2 817.25	682.45			

C – costs; R – revenues, C_r – discounted cost, R_r – discounted revenue, C_{rs} – average relative cost (divided by age of plantation), R_{rs} – average relative revenue, NPV – net present value, NPV_s – average net present value (divided by age of plantation) equal ($C_r = R_r$) (Table 5). For a discount rate of 8%, *NPV* values were negative for all plantations. Positive *NPV* values for r= 6% were observed only for the best site classes for a rotation of 26 years, with a maximum of 580 € ha^{-1} (Table 5). At a discount rate of 4%, *NPV* of all study plots had a positive value, and ranged from 310 to 2 390 € ha^{-1}.

Table 5. Sensitivity of *NPV* (€ · ha^{-1}) compared to relative changes of C_r and R_r (discount rate r = 4-12%)

Study plot no.	Soil Type	Age	r = 12%		r = 8%		r = 6%		r = 4%	
			C_r	R_r	C_r	R_r	C_r	R_r	C_r	R_r
		year	€·10^{-3}							
1.	HGL	24	-1.74	-1.74	-0.98	-0.98	-0.24	-0.24	0.94	0.94
2.		26	-1.84	-1.84	-1.13	-1.13	-0.41	-0.41	0.78	0.78
3.		26	-1.70	-1.70	-0.81	-0.81	0.10	0.10	1.60	1.60
4.	ASG	26	-1.59	-1.59	-0.51	-0.51	0.58	0.58	2.39	2.39
5.		26	-1.75	-1.75	-0.92	-0.92	-0.09	-0.09	1.29	1.29
6.		28	-1.81	-1.81	-0.92	-0.92	0.08	0.08	1.86	1.86
7.		29	-1.87	-1.87	-1.14	-1.14	-0.34	-0.34	1.06	1.06
8.		29	-1.88	-1.88	-1.15	-1.15	-0.36	-0.36	1.02	1.02
9.	HFL	29	-1.79	-1.79	-0.90	-0.90	-0.06	-0.06	1.76	1.76
10.		31	-1.94	-1.94	-1.23	-1.23	-0.40	-0.40	1.14	1.14
11.	ASG	37	-2.00	-2.00	-1.19	-1.19	-0.12	-0.12	2.05	2.05
12.		42	-2.16	-2.16	-1.73	-1.73	-1.10	-1.10	0.31	0.31
13.	α/β–β gley	42	-2.13	-2.13	-1.69	-1.69	-1.03	-1.03	0.42	0.42

HGL – Humogley, ASG – Aluvial semigley, HFL – Humofluvisoil, α/β–β gley

Sensitivity analysis of *NPV* was also carried out for changes in costs and yields within the interval 70–130% around the base values. These changes might be caused by unwanted influences such as abiotic and biotic factors (wind, snow, insects, etc.), for r = 4 – 12%. At r=12%, the NPV_s obtained showed that the project is more sensitive to changes in costs (-986 € ha^{-1} to –2 740 € ha^{-1}) than to changes in income (-2 180 € ha^{-1} to -1 550 € ha^{-1}) (Figure 1). Thus, it seems better to focus efforts on reducing production costs rather than on increasing the income.

By analysing the sensitivity of *NPV* in relation to relative changes of C_r and R_r (at r = 4-12%) for all investigated plantations, it was found that for r = 12% the project was profitable only if it is possible to achieve increased revenues by a multiple of 2.9 (290%) or if costs are reduced by about 65%. For r = 8%, it is necessary to reduce establishment costs or to improve plantation management by about 35%. For existing conditions an alternative is to increase the revenue by about 59%. For r = 6%, with the existing costs and growth rates and income, it is necessary to reduce expenses by about 8% (realising 92% of expenditures made) for investment costs to be viable. It is possible to achieve the same financial effect, for the existing conditions and costs, by increasing revenues by 11%. For r = 4%, it is possible to cover investment costs from income even if costs are increased by about 31%. With costs incurred the under existing conditions, by reducing revenue by 23% (77% of actual), it is possible to achieve the same financial effect (Keča 2010/a).

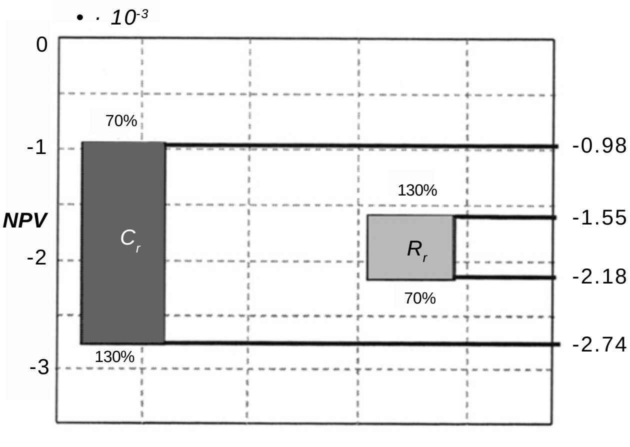

Figure 1. Changes in net present values (*NPV*) in relation to relative changes in cost (C_r) and revenues (R_r) at the discount rate r=12%

The internal rate of return (*IRR*) for the 13 studied plots was found to be in the range 4.32 to 6.94% (Table 6). The highest values were obtained for studies on alluvial semigley, and the worst on humifluvisol and α/β–β gley. The internal rates are larger for plantations on good quality soil types, suitable for poplar plantation (aluvial semigleyic soil), and for shorter rotations and vice versa. *IRR* values higher than 12% were not found in the researched cost-revenue rates.

Table 6. Values of the Internal Rate of Return – *IRR* (at r=12%) for studied plots

Study plot no.	Soil type	Age (*year*)	*IRR* (%)
1.	HGL	24	5.20
2.		26	6.94
3.		26	5.83
4.	ASG	26	6.18
5.		26	6.12
6.		28	5.41
7.		29	5.84
8.		29	4.32
9.	HFL	29	5.36
10.		31	5.35
11.	ASG	37	6.10
12.		42	5.51
13.	α/β–β gley	42	4.43

HGL – Humogley, ASG – Aluvial semigley, HFL – Humofluvisoil, α/β–β gley

The results clearly show an inverse proportion between the discount rate and plantation age, and also a direct proportion with the soil type i. e. discount rates are higher for plantations grown on stands suitable for poplar production (alluvial semigley) and for shorter rotations and *vice versa.* Stands with higher *IRR* have investment priority. In the research they are the younger plantations, referring investors in poplar production to invest in stands with shorter rotations. The *IRR* in all analysed sample plots are less than the calculated discount rate of 12% and a positive financial effect could be realised by decreasing costs or increasing receipts. Stands with higher *IRR*, and shorter rotations have investment priority.

Based on application of the susceptibility analysis, it was concluded that the most unfavourable situation is in study plot 13, when *IRR* amounts higher than 12% are not considered in the observed changes of costs and receipts, and they are realised on the level below 70% of costs or above 130% of realised receipts. It is an over-matured stand, on an unfavourable soil type for poplar production. On the other hand, the most favourable situation is in study plot 4 where there are not considered amounts of *IRR* higher than 12% in observed changes of costs and receipts, and they are realised on the level below 70% of costs or above 130% of realised receipts. Susceptibility analysis leads to the conclusion that the project is susceptible to changes in costs and receipts. In the case of *IRR* amounts higher than 12% they were not observed. They achieved below 70% from realised costs (≤35.8%) or higher than 130% from accomplished receipts (≥288.6%) (Figure 2).

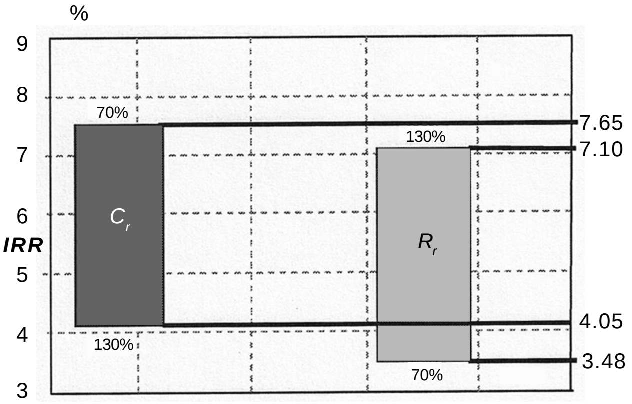

Figure 2. Changes in the internal rate of return (*IRR*) in relation to relative changes in cost (C_r) and revenues (R_r) at the discount rate r=12%

Application of the pay back period (*PBP*) calculation can affect greatly the reliability of predicting the degree of economic effectiveness of investments, and also the potential risks for the investor in his decisions on investments in poplar cultivation. In this procedure, we have not applied the recognized calculation rate of 12%, which is usually applied worldwide, but rates of 6%, 4% and 2%. The analysis shows that *PBP* is practically unacceptable for the investor under the discount rate of 6%. In all studied plots, for r=6% it amounts to 22-80 years. The most favourable situation is the discount rate of 2%, where the period ranges between 12-20 years. If the results for *PBP* are presented collectively for all sample plots (Table 7), it can be concluded that the most favourable situation is for r=2% and, in younger plantations, for r=4%. This fact supports the conclusion that the production cycle period in poplar plantations should be shortened. In younger stands, the situation is more favourable, so under special conditions the potential loan can be repaid.

Table 7. Pay back period (PBP) for studied plots (discount rates r=6%, 4% and 2%)

Study plot no.	1	2	3	4	5	6	7	8	9	10	11	12	13
r(%)	year												
6	29	29	25	22	26	29	36	36	33	40	41	80	75
4	19	19	17	15	18	19	21	21	21	23	22	38	36
2	14	13	13	12	13	13	15	15	15	15	14	20	19

The pay back period for the discount rate of 6% ranges between 22-80 years, which is unacceptable from the economic standpoint. For r=2% this range is fairly shorter, from 12 to 19 years depending on the soil type and age of stands.

The susceptibility of *PBP* in this case was analysed by varying the costs within 10-100%, and the receipts between 100-550%. Based on the analysis of susceptibility for the pay back period method, it can be concluded that the change in receipts and costs in 5% steps can be represented by an exponential function and that *PBP* is between 1.3-4.6 years. For r=2% this ratio is the most favourable both in the case of changes in receipts and changes in costs (Keča 2011).

R varied in the range 0.467 – 0.240 (average 0.36%) at a discount rate of 12% (table 8). That practically means that the costs are 2.8 times higher than receipts for r = 12%. Therefore it can be claimed that it is economically unacceptable to invest in such stands, but just when r= 12%.

Table 8. Values of Cost-Benefit analysis (R) for studied plots at the discount rate r =12%

Study plot no.	R_r (in €)	C_r (in €)	Age year	R
1	1269.68	3012.70	24	0.421
2	1008.39	2885.74	29	0.349
3	1391.90	2977.74	26	0.467
4	1196.56	2942.77	26	0.407
5	1282.74	2983.14	26	0.430
6	1076.35	2889.45	30,25	0.373
7	1011.22	2884.00	29	0.351
8	1134.29	2925.69	29	0.388
9	1176.97	3015.57	26	0.390
10	924.44	2865.10	25,31,32	0.323
11	896.63	2896.20	37	0.310
12	682.91	2844.90	42	0.240
13	682.45	2817.25	42	0.242
Average	**1056.50**	**2918.48**	/	**0.36**

Sensitivity analysis of *R* was also carried out for r = 8–12% in the range of changes of costs and receipts lower than 1. For r = 4–6% there are cases where this ratio is above 1. Thus, it seems better to focus efforts on reducing the discount rate, respectively (Figure 3).

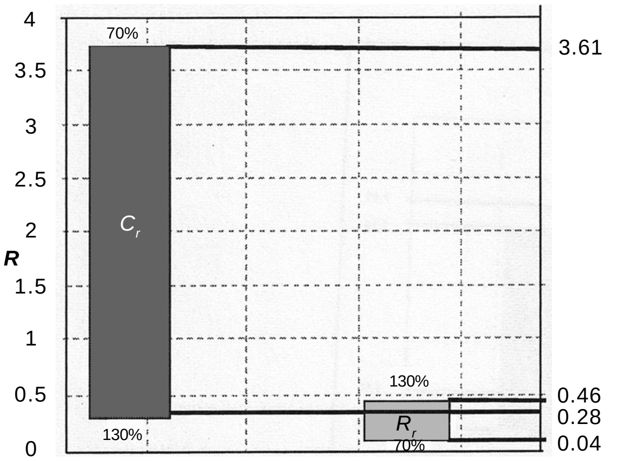

Figure 3. Changes in the benefit-cost index (R) in relation to relative changes in cost (C_r) and revenues (R_r) at the discount rate r=12%

When lower discount rates are applied R reaches 1. For r=8% R=0.71, for r=6% R=0.94. When r=4% poplar plantations are profitable and for 1 invested euro, one can earn 1.22 €.

Changes of R depending on costs follow an exponential function and on the other hand changes of R depending on changes of receipts follow a linear function (Figure 4).

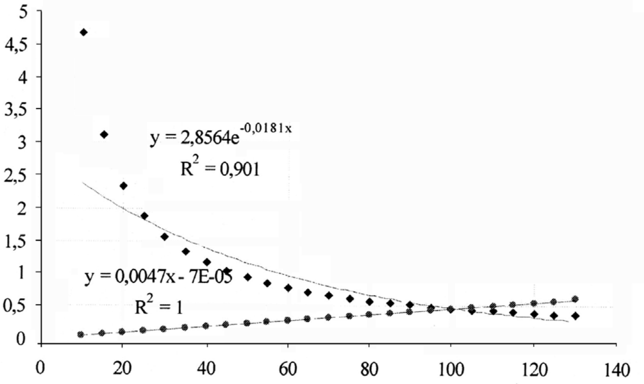

Figure 4. Changes in the benefit-cost index (R) in relation to relative changes in cost (C_r) and revenues (R_r) at the discount rate r=12% for the studied plot No. 4

Discussion

Although poplar plantations have a high productivity and, in terms of forestry, short rotations (10-25 years), their economic profitability is far less than that found in industry and agriculture (Easton et al. 2002, Gittinger 1972) due to high investments necessary during their establishment (Blatner et. al. 2001, Isebrands 2007).

Serbia produces around 350,000 m^3 of poplar wood, which is much less than the world greatest producers like China, France, India, Italy and Turkey that produce more than 1 million m^3 from specialised plantations (Spinneli and Magagnotti 2011). Productivity of plantations on best sites ranges between 350-550 m^3 in year 20, with an annual increment between 15 and 25 m^3, which can be compared with the most productive sites in Italy (Spinneli et al. 2011). Most plantations are established with the aim of production of high value veneer logs that can participate up to 65% of wood volume (Lj. Keča, unpublished). Such a high share results in length of rotation (25-35), which is much longer than in other countries such as Italy, France and India (Spinneli et al. 2011, Dhillon et al. 2001). Long production cycles, provide low values for *NPV*, even for the discount rate of r=4%. Based on the above, it is clear that, in practice, it is necessary to improve the position of production in getting the deficient financial means for investments in poplar cultivation, in order to stimulate establishment of artificial poplar plantations, especially in the private sector (on private lands, which are unattractive for agricultural production) (Brown 2000, James and Del Lungo 2005). The costs of logging and assortment production make a significant expense item, so it is necessary to reduce costs in the felling and preparation of assortments and in the first phase of transport (Cremer et. al. 1982, Eriksson et. al. 2002, Zhu et al. 1998).

Investments can be directed in cost reduction for: soil preparation (stump chipping, deep ploughing, etc.), improvement of inter-row tilling, better plant protection against insect pests and phyto-pathogenic fungi (Keča 2008). On sites unsuitable for poplar planting, it is recommended to apply fertilisers, branch pruning to heights as high as 6 to 8 *m*. All the above technical and technological measures, although classified as direct costs, contribute to improvement of project efficiency, because they directly reflect on the quality of assortments and their value at the end of the production cycle. Reduction of costs, in the future, can be also obtained by mechanization instead of use of manual production of assortments with a chain saw (Spinelli et al. 2011). World economic crisis also makes labour very cheap in Serbia, but on the other hand there is a constant labour shortage which can be overcome with the use of harvesters (Spinelli et al. 2001).

Additional income and cost reduction can be obtained by using remaining poplar wood for biomass (Spinelli et al. 2005), which is in line with the Common Agricultural Policy of the European Union and endeavours of the Government of the Republic of Serbia to develop the bioenergy sector. A lot of data show the potential for conversion of tree tops, branches and stumps into chipped biomass products (Spinelli and Magagnotti 2011).

The *NPV* analyses and the calculated values can be guidelines for the distribution of costs and receipts; however, they are not sufficient for estimation of poplar plantation cost-effectiveness. For this reason, it is necessary to analyse the internal rate of return, terms of return, and the benefit-cost ratio.

However, it is clear that the results have practical application, as they show in which interval poplar plantations are profitable. Global crisis made land, especially land susceptible to flooding, very cheep and reduced rents to less than 200 € ha^{-1} year^{-1}, so involvement of that factor wouldn't change much final calculations of financial parameters. In the future, this situation can change and involvement of this factor may change the calculated indicator values. Commercial banks in Serbia, give loans with an interest rate of 5%. Private owners can be advised to invest in such a production of poplar wood. On the other hand, the state has an interest regarding poplar plantations. Plantations are very efficient in consuming CO_2, as shelterbelts, flood control, etc. Therefore, the state can stimulate future investments of forest owners in poplar production on riverbanks. Plantations grown on better quality soil types such as alluvial semigley are more profitable.

Regarding *IRR*, the results clearly show an inverse proportion between the discount rate and plantation age, and a direct proportion with the soil type. For example discount rates are higher for plantations which are grown on stands suitable for poplar production (alluvial semigley) and for shorter rotations and *vice versa.* Stands with higher *IRR*, have investment priority. In the research, they are the younger plantations, referring investors in poplar production to invest in stands with shorter rotations. Performed susceptibility analysis leads to the conclusion that the project is susceptible to changes in cost and receipts. The financial performance measures used, net present value (*NPV*) and internal rate of return (*IRR*) were found to complement each other. It is also very important to mention that poplar plantations cannot be profitable at discount rates in the range 10-15%, as used in assessing funding opportunities in the economies of developing and transition countries (IMF, 2005). The values of *IRR* in the work of various authors range from 4.3% (Anderson and Luckert 2006) through 6-10% (Tankersley 2006) up to 12-15% (Tabbush and Beaton 1998, Jain and Singn 2000) for poplar plantations.

PBP in forestry is very high, so comparison with agriculture is not very reasonable. For example, *PBP* in agriculture (plantations of apple, walnut) are 5-10 years, however for a complete appraisal it is necessary to have in mind the plantation exploitation period as well (Vasiljević 1998). Different authors analyse different *PBP* for poplar plantations depending on the soil type, age of stand, plant density and climate. In India Dhillon et. al. mention *PBP* of 7 years, Chandra about 10 years (Chandra 1986), McKenney in the range 10-22 years (McKenney et.al. 2011) and Latif et.al. mentions 15 years for poplar plantations in Malaysia.

Lust (1998) mentions that in Flandria the poplar plantations average „benefit-cost" value is in the range (0.4-2.8), in Turkey (1.5-2.0) (Erkan 2002, Birler 1986) and in Pakistan it is (0.56-1.22) (Siddiqui et. al. 1991).

Only application of all four methods gives solutions to investment issues in poplar plantations in general. The observed characteristics, such as soil type and age, are the directions for the establishment of intensive poplar plantations in the future, which will be cost-effective even under an interest rate, which is the upper limit of cost-effectiveness of investments in poplar cultivation (about 6%).

This paper shows that hybrid poplar plantations can be profitable if financed at interest rates in the range 4-7%. In order these highly productive plantations might be cost-effective it is necessary to raise them on adequate sites/habitats (Fluvisol and semigley) and that the rotation, depending on the purpose of plantations and market conditions, must be shortened, to 15-20 years. The current prescribed period is 25 years.

Conclusions

Based on of the analysis performed using the *NPV* method, it can be concluded that the project for the period of 24-42 years was unprofitable, because the loss was about 1,586-2,162 €·ha^{-1}. For the project to be acceptable by the investors, this ratio must be positive and in these cases it is negative. The receipts were in the range 12.144 to 23.676 €·ha^{-1} for the observed stands at the end of rotation. Investments in the plantations of these rotations are acceptable only if the discount rate is 4%. The best ratio is in the youngest stands. The discount rate of 6% can be accepted in shorter rotations in younger stands. Investment under the calculation rate of 4% is financially justified in all study cases. It should be emphasised that production on alluvial semigley is most profitable at the age of 26 years (2,300 €·ha^{-1}), and it is least profitable on the same soil at the age of 42 years (310 €·ha^{-1}). Based on application of the susceptibility analysis, it was concluded that positive financial effects can be realized by decreasing costs, or by increasing receipts. Such projects are more sensitive to changes in receipts and recommendations are directed to: encourage work control in forests, create efficient incomes in all production phases, and decrease the costs of soil preparation, while production of seedlings should be directed to production by clients.

The research showed that the *IRR* for 13 sample plots varied in the interval 4.32-6.94% with an average rate of 5.63%. The internal rates are larger for plantations on good quality soil types, suitable for poplar plantation (aluvial semigleyic soil), and for shorter rotations and vice versa. *IRR* values higher than 12% were not found in the researched cost-revenues rates. The sensitivity analysis proved that the project is very easily affected by cost-revenues changes.

The analysis shows that *PBP* is practically unacceptable for the investor under the discount rate of 6%. In all sample plots, for *r*=6% it amounts to 22-80 years. The most favourable situation is the discount rate of 2%, where the period ranges between 12-20 years. It can be concluded that the most favourable situation is for *r*=2% and, in younger plantations, for *r*=4%.

R varied in the range 0.467 – 0.240 (average 0.36%) at a discount rate of 12%, therefore it can be claimed that it is economically unacceptable to invest in such stands. It seems better to focus efforts on reducing the discount rate, respectively.

Based on of the analysis done on poplar plantation production and economic investment models, we have tested assumptions and constraints of the established poplar investment appraisal model. Possibilities have been examined and conclusions made on the adequacy of the selected methods for investment economic effectiveness appraisal in poplar plantations.

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ОЦЕНКА ИНВЕСТИЦИЙ В ПЛАНТАЦИЯХ ТОПОЛЕЙ В СЕРБИИ

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Резюме

В условиях возрастающего спроса на дерево и его потребления, во всем мире и в нашей стране, многие национальные экономики стремятся увеличить производство, используя отечественные ресурсы. Сложности производства тополя требуют рациональной и плановой организации в целях максимального использования потенциалов всех насаждений и самой породы. Положительные эффекты такого производства можно ожидать и в будущем.

В настоящей статье проанализированны элементы коммерческой выгоды выращивания тополя в плантажах на территории Сербии. Цель исследования: на основе анализа текущих расходов и доходов в период 25 лет-42 года, путем применения динамических методов экономических исследований, исследовать финансовые эффекты в рассматриваемых насаждениях тополя и уточнить их реакцию на возможные изменения в соотношении расходов и доходов, на различных типах почвы – флювисоль (аллювиальный семиглей, гумусный флювисоль, чернозем и α/β–β глей), применяя различные учетные ставки (4-12)%. Использованы методы анализа коммерческой выгоды, в первую очередь динамические методы, такие как метод (нетто текущая стоимость, внутренняя ставка дохода, срок возврата денег и метод „польза-расход“). Исследованные плантажи: *Populus* x *euramericana* cl. *I-214, расстояние между насаждениями* 6 x 6 м. Проанализированно всего 13 экспериментальных лесных баз – хозяйственных единиц (55 насаждений), общей площадью в 331.05 ha, в период 2002-2010.

При учетной ставке r=12%, на всех исследованных лесных базах обнаружена отрицательная внутренняя ставка дохода с 11 088 до 23 676 €·ha^{-1}, не смотря на тип почвы и старость насаждения. Более короткий производственный цикл в молодых насаждениях (до 28 лет) на лучшей почве (аллювиальный семиглей) может привести даже к учетной ставке, составляющей 6%. Исследования показали, что стоимость внутренней ставкиы дохода в 13 исследованных единиц составляла с 4,32 до 6,94%, вcреднем 5,63%, при учетной ставке, 12%. Внутренние ставки более высокие в насаждениях на качественной почве, в аспекте выращивания тополя (аллювиальный семиглей), а также в более коротких оборотах и наоборот. Анализ показал, что срок возврата денег неприемлемый для инвесторов, даже при учетной ставке, составляющей 6%. Самая выгодная обстановка в этом смысле наблюдается при учетных ставках, составляющих 2% в более молодых насаждениях. Соотношение ‘’польза/расход вcреднем составляет“0.36 для всех экспериментальных лесных баз.

Ключевые слова: плантажи тополя, инвестиции, финансовая оценка, коммерческая выгода, расходы, доходы, динамические методы