Adaptation of the Production to Sustainable Soil Management and Its Natural and Economic Efficiency in Topciderska River Watershed in Rakovica and Vozdovac Communities

Miodrag Zlatić [1]

[1]Faculty of Forestry, Belgrade University, Kneza Višeslava 1, Yugoslavia
E-mail: mizlatic@EUnet.yu

Abstract: Topciderska river watershed is characteristic for occurrence of all the erosion phenomena in the agricultural areas in the Rakovica and Vozdovac communities, which constitutes the part of the hilly region of the wider Belgrade area. The existing structure of agricultural production indicates that erosion processes in this region have narrowed and also decelerated the yield increase rate which would be possible on natural and economic conditions. In this paper the establishment is discussed of the production taking into account the conservation of land resources, the needs of the population and profitability in this watershed. In this sense, agricultural, fruit and forest productions are anticipated from the aspect of soil management for sustainability, and the possibilities are given for the improvements of the production model giving better long-term economic effects. The improvements of the offered production model have been performed by establishment of the bee hiving production.
Keywords: erosion, sustainability, improvement, effects, sensitivity analysis

1 Introduction

The Topciderska river watershed is characteristic for incidence of all the erosion phenomena in the agricultural areas of the Rakovica and Vozdovac communities, which constitute the part of the hilly region of the wider Belgrade area.

On the basis of the detailed terrain reconnaissance it has been established that the main cause of the intensive erosion processes in this region is the inadequate land use. Agricultural land occupies 2484.23 ha. On the arable land, in which due to small surface areas of the land pieces and the impossibility to turn the machinery around, tillage is mainly performed along the slopes. The average soil losses from the agricultural surfaces of this morphological unit, according to USLE method amount to 23.84 $t \cdot ha^{-1}$. Due to the quoted circumstances the yield and income from the agricultural products are not such as they should have been according to the natural and economic conditions of this region, especially considering the vicinity of Belgrade as a large consuming center.

In this paper on the example of the Topciderska river watershed the effects are shown of the established production model from the aspect of preservation of the land resources. Also the effects are presented of the improvement of this model.

2 Research methods

2.1 Method of natural effects of planned models

Some data for this analysis were obtained from the Department of Erosion and Torrent Control of the Faculty of Forestry in Belgrade (1988). On the basis of terrain reconnaissance, at 66 sample plots of the agricultural soil, soil losses have been estimated according to USLE erosion equation for present way of soil utilization, as well as for a perspective one - based upon the soil management for sustainability principles.

2.2 Production models

The basic production model (model I) was developed from the aspect of soil management for sustainability, the needs of the population in this area (production lines most frequently applied in practice) and potential economic effects (Zlatić 1994). Production is primarily planned in a quantitative sense, i.e. the relations are designed bet-ween the groups within arable farming (erosion-control crop rotations) and orchard production (classical orchards, orchards with self-terracing, and orchards with classical terraces), as well as pasture and forest areas. In the qualitative sense, the lines of production as per crop species are designed. Crop rotation includes cereals like wheat and oats, root crops (corn, soya beans and sunflower) and grasses. Orchard species include apple, pear, peach, apricot, cherry, sour cherry, plum, raspberry, blackberry and walnut.

The improvements of the basic production model (models II and III) were performed by the establishment of bee-keeping in two variants: I variant - production of honey as the chief product, and wax, propolys, and flower powder as by-products (model II) and II variant - production of royal jelly as the chief product without by-products (model III). The production of honey within the frames of the existing production can be organised as an additional activity in agricultural areas (sunflower production line), in orchards (apple, pear, cherry, sour cherry, apricot, raspberry, etc.), in forest cultures (black locust and Austrian pine), as well as in meadows. Therefore, models II and III represent an advancement of model I, aimed at the improvement of economic effects, yet preserving the protective character of the basic production model. Thereby a possibility is presented to the local population to improve their income from the existing production lines, thus enabling them to stay in these regions.

2.3 Methods of assessment of economic efficiency

The assessment of the long-term effects of the planned model has been performed in terms of the Internal Rate of Return - IRR, Pay Back Period - PBP, benefit-cost ratio - B/C and net present value - NPV (Gittinger 1982). A period of 15 years has been chosen for the assessment of the economic efficiency according to the average production lifetime of stone-fruit orchard species. The assessment of risk and uncertainty has been performed by sensitivity analysis of IRR and PBP. The prices have been expressed in USD for the period May-June 2001.

3 Results of research

3.1 Changes in land utlizaton

According to eroson processes sanation concept and model of production from soil resources preservation aspect, as well as according to soil utilization tendences, the changes are evident wth respect to the state prior to arrangement (Table 1).

Table 1 Changes in land utilization

Utilization type	Species Grown	Before arrangement	After arrangement
		ha	
Arable Lands	Wheat	726.12	468.8
	Oats	21.42	193.74
	Corn	945.48	468.42
	Sunflower	7.93	84.27
	Soybean		129.33
	Σ	1,700.95	1,344.5
Meadow		279.28	328.55
Pastures			115.83

Continue

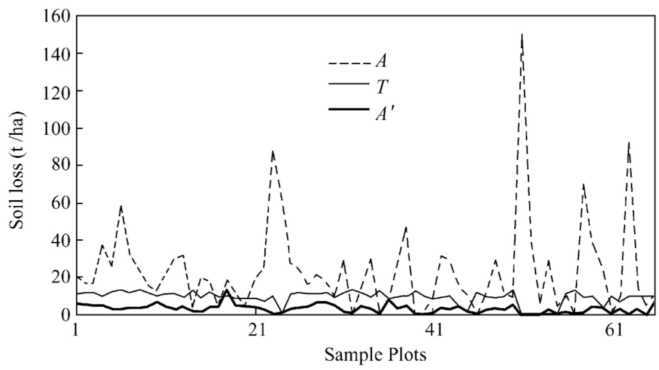
Utilization type		Before arrangement	After arrangement
		ha	
Orchards	Apple	43.55	97.26
	Pear	23.36	44.89
	Peach	9.72	42.27
	Apricot	9.72	20.56
	Sour cherry	10.78	119.88
	Plum	11.3	137.62
	Sweet cherry	3.53	101.27
	Raspberry	6.02	43.16
	Blackberry	6.02	43.16
	Walnut	1.93	3.89
	Σ	125.93	653.96
Afforestation		0.00	41.43
TOTAL		2,484.23	2,484.23

Source: original, 1988 and Zlatić (1994)

It can be seen that major changes are related to reduction of arable fields and increase of orchards, as well as to the mild increase of pastures surface areas. Within the arable areas structure, the surfaces are reduced under wheat and corn, and those with oats and soybeans increased - in particular at higher slope.

3.2 Natural effects of establishing sustainable production

The average soil losses from the agricultural surfaces of this community with the present land use, according to USLE method, amount to 23.84 t·ha^{-1}. The sediment as a product of the erosion processes carries with it the harmful substances both of organic and inorganic origin and this also harmfully affects the environment. Taking into consideration the evident previous tillage down the slope, which causes soil loss of 23.84 t ha^{-1}, by the proposed model of production the values of "C" (factor of land use) and "P" (factor of erosion control) in the USLE equation willl be reduced several times. Thereby, decreasing the soil losses below the limits of tolerance, it would be on average amount to 3.21 t·ha^{-1} for the whole Topciderska river watershed.



Source: original

Legend:

A — Soil Loss According to Present Land Use (t· ha^{-1})

T — Tolerant Soil Loss (t· ha^{-1})

A' — Soil Loss According to Proposed Model of Production (t· ha^{-1})

Fig.1 Soil loss on the sample plots of Topciderska river watershed

3.3 Economic effects of the planned and improved models

Internal rate of return (IRR)

Cost efficiency of the investments is calculated on the basis of the amount of the discount rate, where the present value of all inputs is equal to the present value of all outputs in the same statement of accounts. It can be seen that the IRR for the this watershed amounts to 17.58% for the planned production (model I, Table 2), and 19.30% for the improved production - variant I with honey as the chief product (model II, Table 2), and 25.46% for the improved production - variant II with royal jelly as the chief product (model III, Table 2).

By the comparison of the calculated IRR with the real interest rate, which amounts to 12% for Eastern European countries according to the International Bank for Development, one can conclude that the investment in the soil conservation and in the proposed production variants are cost effective. This statement is based on the fact that, after the credit commitments have been met, a certain percentage for the extended material base results from the increase of the net economic benefit. The accumulation amounts to 5.58% for the planned production (model I), 7.30% for the improved production with honey as the chief product (model II), and 13.46% for the improved production with royal jelly as the chief product (model III).

Pay back period (PBP)

Contrary to the IRR, which shows the interest rate of the invested capital, PBP shows the period in which the invested capital can be returned. The PBP for the planned production model is 10 years (model I, Table 2), and for the iimproved model with honey as a chief product is 9.2 years (model II, Table 2). The improved production model with royal jelly as a chef product gives satisfactory efficiency of PBP (7 years - model III, Table 2). As the credit return period for the majority of Yugoslav banks is 10 years, the method for the first model has to be tested by the sensitivity anlysis of PBP. Model II and model III give satisfactory efficiency.

Benefit-cost ratio

This parameter represents the ratio of the total annual benefit and the total annual costs discounted to the initial instant at a discount rate of 12%. One can see that the Benefit-Cost ratio is 1.17 for the planned production (model I, Table 2), 1.20 for the improved - variant I (model II, Table 2), and 1.36 for the improved - variant II (model III, Table 2) models. Since the value of this parameter is higher than 1, it is cost-effective to invest into any of the models suggested.

It is clear that the accumulation would amount to 0.17 USD for the planned (model I), 0.20 USD for the improved variant I (model II), and 0.36 USD for the improved variant II (model III) production models per 1 USD invested.

Net present value (NPV)

This parameter represents the sum of total annual benefits discounted to the initial instant, reduced by the total costs discounted to the same instant, at the discount rate of 12% (the real interest rate). According to the calculation of NPV, it can be seen that this parameter amounts to 2.536 million USD for the planned production (model I, Table 2) 3.283 million USD for the improved production variant I (model II, Table 2), and 5.825 million USD for the improved production variant II (model III, Table 2) models.

Since NPV is well above 0, one can conclude that it is cost effective to invest in the designed erosion control works and the subsquent production models in the region.

Table 2

Model	Parameters of economic efficiency			
	IRR (%)	PBP (years)	B/C	NPV (million USD)
Model I	17.58	10	1.17	2.536
Model II	19.30	9.2	1.20	3.283

Model III	25.46	7	1.36	5.825

Source: original

3.4 Risk and uncertainty assessment

The long-term economic effects calculted according to the discount methods are based upon the normal circumstances. However, for a multitude of reasons the perturbations relative to the Benefit-Cost ratio are possible, either if the revenues should increase or reduce, or that the same happens to the costs.

Sensitivity analysis is performed when the calculated parameters of economic efficiency are tested in order to observe what happens to these parameters if costs or benefits are modified. In this case the sensitivity analysis has been performed for the IRR and PBP parameters.

Sensitivity analysis of the internal rate of return

The sensitivity of IRR (Table 3) has been measured with respect to the changes of the annual costs and benefits. The examined values of changes of these parameters range from 5% to 30% both positive and negative.

One can see that IRR is most sensitive to the benefit changes. By observation of the negative changes one can see that IRR would be on the rentability limit (at the level of the real discount rate of 12%) if the benefits would be reduced by 14.70% with the planned, by 17% with the improved - variant I and by 26.30% with the improved - variant II production models. In the same sense, cost increases by 17.30%, 20.00% and 35.80% are acceptable for the quoted models, respectively.

In the case of possible changes of the quoted parameters by 20% in the positive sense, IRR in the case of the increased revenue would amount to 24.23 % for the planned, 27.02% for the improved - variant I and 34.77% for the improved - variant II production models; in the case of the decreased costs by the same amount of 20%, IRR would amount to 25.78% for the planned, 28.84% for the improved - variant I and 37.05% for the improved - variant II production models.

Table 3 Sensitivity analysis of IRR

Model		Changes in percent								
		70	73.7	75	80	85	85.3	90	95	100
Model I	Costs	31.04		28.29	25.78	23.49		21.38	19.42	17.58
	Benefits					11.89	12.00	13.88	15.77	17.58
Model II	Costs	35.16		31.83	28.84	26.14		23.68	21.41	19.30
	Benefits					12.85		15.09	17.24	19.30
Model III	Costs	45.17		40.84	37.05	33.69		30.68	27.95	25.46
	Benefits		12.00	12.73	15.46	18.07		20.59	23.05	25.46
Model		105	110	115	117.3	120	125	130	135	135.8
Model I	Costs	15.86	14.23	12.68	12.00					
	Benefits	19.33	21.01	22.65		24.23	25.78	27.30		
Model II	Costs	17.34	15.49	13.74		12.00				
	Benefits	21.30	23.25	25.15		27.02	28.84	30.64		
Model III	Costs	23.17	21.05	19.07		17.21	15.46	13.80	12.21	12.00
	Benefits	27.83	30.16	32.47		34.77	37.05	39.33		

Source: original

Sensitivity analysis of PBP of investments

Sensitivity analysis of PBP (Table 4) has been carried out with respect to the changes of annual benefits and costs of production. By observation of the negative changes, an increase of the production costs by 10% results in PBP of 12.5 years for the planned, 11.5 years for the improved - variant I and 9.0 years for the improved - variant II production models. First and second cases are longer than the credit paying off period (10 years), and shorter than the system lifetime (15 years), but third one is on the limit of paying off period.

With the cost increase by 30%, first two cases are longer than the system life time, only third one is longer than credit paying off but shorter than the system lifetime.

A benefit decrease by 10% results in PBP of 12.6 years for the planned, 11.6 years for the improved-variant I, and 9 years for the improved - variant II production models. The decrease of benefits by 30%, PBP longer than 15 years resuslts for all three models.

For the changes in the positive sense, the cost decrease by 30% results in PBP of 6 years for the planned, 5.5 for the improved - variant I and 4.5 for the improved - variant II production models. The benefit increase by 30% results in PBP of 6.5 years for the first, 6 for the second, and 5 for the third of the models under consideration.

Table 4 Sensitivity analysis of PBP

Model		Changes in percent						
		70	75	80	85	90	95	100
Model I	Costs	6	6.3	7	7.6	8.5	9.3	10
	Benefits				15	12.6	11	10
Model II	Costs	5.5	6.0	6.3	6.7	7.7	8.5	9.2
	Benefits			>15	14	11.6	10.2	9.2
Model III	Costs	4.5	5	5.3	5.7	6	6.5	7
	Benefits	>15	14	11.5	10	9	8	7
Model		105	110	115	120	125	130	135
Model I	Costs	11	12.5	14	15			
	Benefits	9.25	8.8	8	7.3	6.9	6.5	
Model II	Costs	10.4	11.5	13	15			
	Benefits	8.5	7.8	7	6.6	6,2	6	
Model III	Costs	8	9	9.5	10.5	11.5	13.0	15.0
	Benefits	6.5	6	5.8	5.5	5.2	5	

Source: original

4 Conclusions

The planned production model sustains the conservation of soil as one of the most important natural resources, since it reduces soil losses below the permissible limits. The soil losses are estimated to decrease from 23.84 $t\ ha^{-1}$ at present, down to 3.21 $t\ ha^{-1}$ for the conditions following the introduction of the proposed model.

The assessment of the investment efficiency, carried out by the discount methods, proves the satisfactory economic efficiency.

One can see that the efficiency is envyable of all the three models under consideration. The variant with honey as the chief product also gives somewhat better economic efficiency with IRR and benefit-cost ratio than with the planned production model, and considerably higher with NPV. The improved production model with royal jelly as the chief product has given higher efficiency, significant and noteworthy for these areas.

The risk and uncertainty assessments also indicate the significant efficiency of investments into the quoted. The offered model can sustain the negative changes of costs of up to 17.3% and 14.7% for benefits. The improved model - variant I can sustain negative changes of costs of up to 20% and 17% for benefits. Variant II with royal jelly as the chief product is capable of sustaining the benefit decrease of up to 24.2% and cost increase of as much as 35.8%, still remaining within the frames of rentability. Considering the positive reserves of the production models, for the changes by 30% in the positive sense, the economic efficiency is very significant for all the parameters, especially with PBP, where in the improved - variant II model it amounts to 5 years as compared with the improved - variant I model with 6 years and the offered production model value of 6.5 years.

According to the calculated economic efficiency parameters, risk and uncertainty of investments assessments and their unmeasurable effects, it can be concluded that in Topciderska river watershed the investments in soil management for sustainability are cost effective and beneficial for environmental conservation. The offered improvements of the production by introduction of the bee-hiving have considerably increased the economic efficiency, and simultaneously are very acceptable and adaptable for the small farmers, which is the additional reason for people to remain and survive in these areas.

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