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RESEARCH ARTICLE

Valuation of the Water Protection Function of Forest Territories and Income Allocation: a Case Study of Bulgaria

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Abstract

The owners of forests with water protection functions in Bulgaria do not receive compensation for their limited right to use wood and non-wood forest products from the forest areas they own. At the same time, the contribution derived from forests with water protection functions is received by water users and water consumers, whereas the costs of managing the forests are borne by their owners. The problem thus defined is not a forestry one, but an economic one, and the purpose of this paper ensues therefrom, namely to propose and test a methodology for valuating the production function of forest areas with water protection function in Bulgaria, allowing a fair distribution of income between the forest owner and the user of forest ecosystem services. The methodology is based on the form of forest management and the analytical expression of the economic relationship between a forest owner and a user of forest ecosystem services, constructed using Schenrock's formula. It has been tested with actual data from forest areas with water protection functions falling within the administrative and territorial scope of Velingrad municipality. The obtained results are as follows: as regards the forest territories falling into Sanitary protection zone (SPZ) I of the forests with water protection functions, the economic gains from the property should be 100% realized from water consumption and the owner should receive about EUR 49.83 /ha per year; in SPZ II of the forests with water protection functions, the economic gains from the property should be realized by prioritizing the water protection over the wood production function in a 75:25 ratio, i.e. the owner should receive about EUR 37.37 /ha/year; in SPZ III of the forests with water protection functions, the economic gains from the property should be realized equally in a 50:50 ratio through both production functions, i.e. about EUR 12.22 /ha/year.

Keywords

forest ecosystem services, rental income, wood production function of forests, water protection and regulation function of forests.

Introduction

The forests with water protection functions in Bulgaria occupy an area of 576,117 ha, which accounts for 7.8% of the country's forest areas. Of these, 72.64% are state owned, 11.41% - municipality owned, 9.89% - privately owned, and 6.06% under other ownership. The forests with water protection functions accumulate, annually, between 1-1.5 billion m^3 of water. These forests, by nature, serve as multi-annual equalizers, generating a steady flow of clean water all year round, which reaches water consumers and water users through the water-supplying infrastructure (Ministry of Environment and Water, https://eea.government.bg/bg/soer/2020/forest/gorskite-resursi-i-tehniya-prinos-kam-globalnite-tsikli-na-vaglerod-1; Ministry of Agriculture, 2022, 53 (project)).

In order to obtain this product, forest owners are obliged to manage them under a special regime. Under the water protection regime, the goal is not to obtain wood from the forest, but to manage it in such a way as to maintain and even increase the natural water protection and regulation properties of forest ecosystems. Forest owners would choose to manage their forests as water protection ones as long as they have the opportunity to generate income from this property. However, this type of management is only possible if the water protection properties of forest ecosystems acquire a production function for the forest owner. The funds advanced for the realization of this production function must be protected by institutions in such a way as to allow each forest owner to generate their future income along the water use and water consumption chain. These problems are not forestry, but economic in nature, where the main question associated with every production function should be answered – the question of production efficiency and how the income should be distributed between the owners of the factors of production. In other words, what fair income the forest owner should receive from the water protection function, calculated as a portion of the gross value added created for the country's water sector. The current tying of their income to wood production and wood processing transfers the contributions generated by these forests to the account of water users and water consumers, and the costs associated with these forests remain at the expense of forest owners and organizations that manage them. In relation to the problem thus defined, this study argues that water protection forests should be recognized as capital, and their owners should have the right to generate income from them by recognizing the water protection properties of forests as having a production function. This is precisely what this study aims to address, namely: to propose and test a methodology for valuating the production function of forest areas with water protection functions in Bulgaria, allowing a rational distribution of income between the forest owner and the user of forest ecosystem services.

In specialized literature there is enough research concerning economic valuation of the water protection function of forests based on different approaches. M. Krey, D. Adams and F. Escobedo (2014) assessed the economic value of conserving forests for water quality protection by means of a meta-analysis of willingness-to pay for fully preserved water resources. At the same time, the authors verified a multiple regression model with regressors, which predetermine the dependent variable – willingness to pay (Kreye et al., 2014). The willingness-to-pay for restoration of out of the country forested watersheds was valuated by E. Obeng and F. Aguilar. Using the bivariate probit model, the scholars estimated the drivers influencing the willingness to pay (Obeng et al., 2021). To some extent the willingness-to-pay approach is not so precise for the economic valuation of the water protection function of forests. A more accurate method is applied by Z. Mashayekhi, M. Panahi, M. Karami, S. Khalighu and A. Malekian (2010). The scientific team assessed the water storage function of Zagros forests in Iran using Replacement Cost Method and four simulation models. On these grounds the authors established that the water retention value of each hectare of Zagros forests amounts to 43 USD (Mashayekhi et al., 2010). Similar research has been done by A. Keogh and W. Vasquez (2019), M. Islam, R. Akter and M. Haider (2022), C. Wilson et al. (2020) and T. Kim et al. (2021) (Islam et al., 2022; Keogh et al., 2020; Kim et al., 2021; Wilson et al., 2021). An original approach for the economic valuation of the water supplying function of a mountain-forest in Turkey has been proposed by G. Uzel, S. Gurluk and F. Karaer (2020). Based on the Faustman and Hartman approaches the scholars integrated the natural resources economic valuation with the forest rotation system. On this ground they have developed three models for valuation of the water protection function of the forests in Uladag National Park. According to the first and second models, the forests must be subjected to rotation at intervals of 44 years and their net value is 956 USD/year per hectare and 976 USD/year per hectare respectively. At the same time, in the third model the water quality increases by 10%, the rotation age is 107 years and the stand value per hectare is 1,470 USD (Uzel et al., 2020). Interesting approaches for water protection function valuation of forests have been studied by P. Golos (2009) who compared results from the Contingent Valuation Method (CVM) and the Relative Utility Method (RUM). As of 2009 the water protection function of forests estimated by both methods amounts to 109.5 PLN/ha/year and 805 PLN/ha/year respectively. The variation in the results is due to differences in the theoretical assumptions of the methods. For example, the CVM creates a quasi-market to evaluate the water protection function of forests while the RUM relies on the base function which is the timber production function, which is assessed based on the timber sales income per hectare for a year (Golos et al., 2009).

Forest investments are usually analyzed using the Faustmann model (Faustmann 1849, Samuelson 1976). This method was mainly discussed by Conrad and Clark (1987) and Comolli (1981), and later revised by Yin and Newman (1997) (Comolli, 1981; Conrad et al., 1987; Faustmann, 1995; Samuelson, 1976; Yin et al., 1997).

In Bulgaria, the issue of forest valuation has also been considered. Prof. Temelko Ivanchev (1940) was the first to lay the theoretical and methodological foundations of forest valuation. For this purpose, he used German textbooks on the subject, published at the beginning of the 20th century (1912, 1919, 1921) (Ivanchev, 1940).

I. Yovkov, I. Paligorov and Y. Poryazov, using the theory of contribution, developed a solution to the economic problem of optimal duration of the cutting cycle in order to achieve the maximum financial contribution from the use of the clear-cutting form of forest management (Yovkov et al., 1992). I. Yovkov, I. Paligorov and I. Dobrichov (1992) undertook the task to determine the optimal volume at which the maximum financial contribution would be achieved from the use of the cutting form of forest management (Yovkov et al., 1992).

D. Georgieva (2005) perfected the approach for economic valuation of selectively cut forests in structural balance by using net present value in perpetuity. She proposed an approach for choosing the optimal target diameter of selectively cut forests under conditions of uncertainty by means of the marginal analysis method (Georgieva, 2005).

It should be noted that the Bulgarian authors listed so far have succeeded in valuating forests with timber production functions. However, both the theory and practice is not enough for an economic valuation of the other functions (Andréassian, 2004; Tsoklinova et al., 2019; Kolev et al., 2020). On the other hand, the methods and valuations turn to the ecological functions of forests (Boggs et al., 2015; Clément et al., 2017; Duan, 2018; Ellison et al., 2017; Oishi, 2018).

Despite having a significant contribution to the management of forest ecosystems, the silvicultural ecological approach in Bulgaria leaves a certain gap in the theory and practice of forest management. The water protection functions of forests, their recreational and tourist functions, their field protective functions, etc., remain undervalued. The main commodity produced by forests with such functions is not wood, but water, tourist products and services, agricultural products, etc. In the present study, it is therefore justified to make a valuation of the water protection function. Its economic aspect is missing both in the economic theory of forestry and in the well-established practical market approach to forest management. The reason for this is that forests in general, including water protection forests, are still viewed as a fund and not as capital. If forests are viewed as capital, then they constitute an investment and should be valued as such. This is precisely what is missing in the existing research in Bulgaria Unlike us, a scientific team led by Constanza et al. (1997) estimated that the value of the world's ecosystem services and natural capital was in the range of 16 to 54 trillion USD per year (Constanza et al., 1997).

Materials and Methods

Study Area

The methodology for valuating the water protection function of forest areas in Bulgaria has been tested using actual data on the forest areas with water protection functions falling within the scope of Velingrad municipality, taken from the forest management plans of the territorial division of State forestry unit (SFU) "Alabak" and the territorial division of State hunting unit (SHU) "Chepino". It should be specified that according to the legislation in force in Bulgaria, sanitary protection zones (SPZ) are designed around water sources and facilities for drinking and domestic water supply from surface and underground water. Each SPZ has 3 belts, which are outlined according to an accepted methodology. In belt I of the water sources and facilities for drinking and domestic water supply from surface and spring waters, the permitted activities include anti-erosion, afforestation and thinning activities. In belt II, cutting activities are limited to thinning, and in belt III, these activities are restricted if proven necessary (Sirakov, 1982). The area distribution of sanitary protection zones by forest type on the territory of Velingrad municipality is presented in Table 1. It shows that the area of coniferous forests falling within the three sanitary protection zones on the territory of Velingrad municipality is 89.28% of the total area of the municipality's water protection forest territories. Therefore, the valuation of the water protection function in this paper focuses on the coniferous forests falling within the first, second and third belts of SPZs in Velingrad municipality. The wooded area of the coniferous water protection forests is 98% of their total area, their tree species composition consists of 70% spruce and 30% white pine, and their total timber volume amounts to 951,527 m^3 or 346 m^3/ha with an average increment per hectare of 4.60 m^3/ ha (Forest management plans of the territorial division of SFU "Alabak", 2018; Forest management plan of the territorial division of SFU "Rakitovo", 2019).

Methodology for valuating the productive function of forests with water protection functions

The silvicultural systems that are currently used in Bulgaria are mainly even-aged forest management systems. These systems employ regenerative cutting methods, which result in even-aged, and uniform in structure and density stands over large areas. For this reason, the methodology for economic valuation of the water protection function of forest territories is limited to this type of cutting, and its silvicultural technical characteristics have been briefly presented.

The size of the cutting area in shelterwood cutting is up to 2 ha, and the period of regeneration is a minimum of 15 years and a maximum of 20 years. Cutting is carried out evenly over the cutting area in 3 or 4 phases (preparatory, seeding, secondary and final). Each phase is characterized by a different cutting intensity and canopy density. In the preparatory phase, canopy density is reduced to 0.7 - 0.8, and the cutting intensity is up to 25%. This phase can be skipped if regular thinning has been carried out. The seeding phase is carried out no earlier than 5 years after the preparatory phase, where the cutting intensity is up to 30%, and the canopy density is reduced to 0.5 - 0.6. During the secondary phase, the cutting intensity is up to 30%, and the canopy density is reduced to 0.3 - 0.4. It is carried out no sooner than 5 years after the seeding phase. Finally, when the canopy density of tree stands in the cutting area is not greater than 0.4 and more than 80% of the area is covered with undergrowth, the final cutting phase is carried out (Kostov et al., 1996).

In accordance with the silvicultural and technical characteristics of the shelterwood cutting presented above, the methodology for valuating the water protection functions of even-aged forests is based on the following algorithm:

Table 1. Distribution of area of sanitary protection zones on the territory of Velingrad municipality by forest type and age classes, ha

Age classes, years	**0-10**	**11-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**	**71-80**	**81-90**	**91-100**	**101-110**	**111-120**	**121-130**	**131-140**	**141-150**	**151-160**	**TOTAL**
Area of SPZ, ha	36.9	33.9	127.8	280.8	553.2	555.3	91.8	145.8	182.9	310.7	451.7	266.2	61.8	3.8	16.1		3118.8
Belt I of SPZ , ha			0.4	0.3	0.4	0.1			0.4	2.2	0.2	0.3	0.1	0.2			4.6
Coniferous, ha			0.4	0.1	0.4	0.1			0.1	1.8	0.1	0.3	0.0	0.2			3.6
Broadleaved High stem, ha			0.0	0.1					0.3	0.4	0.1	0.0	0.0				1.0
Belt II of SPZ , ha	5.2	22.7	94.4	177.2	290.7	309.1	64.5	120.7	126.7	284.2	224.6	154.8	61.0	0.7			1936.4
Coniferous, ha	4.9	21.5	88.3	164.7	264.2	302.3	58.3	107.9	74.1	191.0	193.3	132.1	50.4	0.7			1653.6
Coppice, ha	0.2		0.2	4.0	1.1	1.8	0.8	0.3									8.5
Broadleaved High stem, ha	0.2	1.2	6.0	8.4	25.3	4.9	5.5	12.4	52.7	93.2	31.3	22.7	10.6				274.3
Belt III of SPZ , ha	31.7	11.2	32.9	103.4	262.1	246.1	27.3	25.1	55.8	24.3	227.0	111.1	0.7	3.0	16.1		1177.8
Coniferous, ha	31.3	10.5	30.7	101.4	261.0	244.4	23.6	25.1	43.0	22.3	210.2	105.4	0.7	3.0	14.8		1127.4
Coppice, ha	0.4	0.7	2.2	0.9	0.2	1.5	3.3										9.3
Broadleaved High stem, ha			0.0	1.1	0.9	0.2	0.5		12.8	2.0	16.7	5.7			1.3		41.2

Source: Forest management plan of the territorial division of SFU “Alabak” and forest management plan of the territorial division of SHU “Chepino”

Determining the volume of standing timber(V)

The **volume of standing timber** - It depends on the natural conditions of growth and development of the plantation and on the economic activity carried out in them. The volume (V) of the **standing timber** is calculated using several methods: the mean sample stem method, mensuration methods by girth and class, and mensuration table methods.

Determining the monetary value of wood from shelterwood cutting

Based on the silvicultural technical characteristics of shelterwood cutting described above, it is clear that income from regenerative cutting (W_u) does not come all at once, but at different times during the regeneration period. In this case, a certain year is chosen, which is taken as the u cutting age. This year or age is the year in which the final phase of regenerative cutting occurs. It is clear that a portion of the income from regenerative cutting (W_u) is received in the u year of final cutting. Another part of this income (W_{u-m}) from preparatory cutting is received before reaching the u age, for example in year m, and therefore this income is extended for the period from its receipt to year u, equal to (u - m) years (Kolev, 2018).

Capitalized monetary value of wood from the preparatory, seeding and secondary phases of cutting:

$$W_{u-m} = \sum_{i=1}^{4} Q_i \cdot P_i \cdot (1+r)^{u-m}, \qquad (1)$$

where W_{u-m} is the capitalized value of wood from the preparatory, seeding and secondary phases of cutting;

Q_i – volume of wood from the ith category, m^3;

P_i– the warehouse price of $1m^3$ of wood from the ith category EUR/m^3, where m is the year of cutting;

r – the rate of return on alternative investments for the period, percentage expressed as a fraction of 1.0.

The current methodology has adopted the use of the so-called forest interest rate r = 4% [30].

Monetary value of wood from the final phase of cutting (W_u):

$$W_u = \sum_{i=1}^{4} Q_i \cdot P_i, \qquad (2)$$

Finally, the monetary value of wood from regenerative cutting (W_{reg}) is determined using the formula (3):

$$W_{reg} = W_{u-m} + W_u, \qquad (3)$$

Determining the present monetary value of wood from thinning (W_{clear})

When calculating income from thinning, first of all, it should be examined and determined whether such income can be actually generated or not. Oftentimes such revenues cannot be generated either due to the limited market conditions for the sale of wood harvested from thinning, or due to a lack of convenient and cost-effective freight transport. It is clear that given these unfavorable conditions, this intermittent income should be left out of the calculations.

There are also cases when, due to inefficient management, thinnings are not carried out, but they are perfectly possible, and then the income generated from them will have to be determined and included in the calculations. Data on the amount, receipt, etc. of the income from thinnings can be obtained from other neighboring state forestry offices working under approximately the same conditions, which carry out regular thinning activities and receive a corresponding income generated from them.

It goes without saying that, if thinning activities are carried out properly, in addition to being of great silvicultural importance, they are also sources of significant income for state forestry offices.

The monetary value of wood from thinning activities in year a (W_a) is calculated using the following formula:

$$W_a = \sum_{i=1}^{4} Q_i . P_i, \tag{4}$$

In order to add the income from thinning to the income from regenerative cutting, the former must be expressed in a comparable form, i.e. should receive a present value at the end of each plantation age.

The cash income from intermittent cutting must be capitalized in year u when the income from the regenerative cutting is received.

The total revenue from all thinning activities (W_{clear}) is calculated as follows:

$$W_{clear} = W_a(1+r)^{u-a} + W_b(1+r)^{u-b} + \cdots + W_q(1+r)^{u-q}, \tag{5}$$

where W_a, W_b,... and W_q are the monetary values of wood from thinning, EUR;
a, b... and q are the years in which thinning activities are carried out in the plantation.

Determining the costs of creating woodland and their future value at plantation age (FV_c)

The costs of establishing a forest plantation include the costs incurred until the establishment of the plantation: clearing the cutting area, soil preparation, delivery of planting material, tree planting, fertilization, replacement, cultivation, fencing. The costs of establishing the plantation depend on the tree species, its origin and the difficulty of the terrain during planting. This investment is one-off and is capitalized for the entire period of the adopted cutting cycle.

The costs incurred initially to establish the forest plantation and capitalized at plantation age are calculated using the formula (6):

$$FV_c = c.(1+r)^u, \quad (6)$$

where FV_c is the future value of the costs of establishing the forest plantation at plantation age, EUR;

c – the costs of establishing the forest plantation, EUR.

Determining the fixed costs and their future value at plantation age (FV_v)

During the life of the plantation, usually every year until its regenerative cutting, fixed costs amounting to EUR v are incurred (Kim et al., 2021). These costs have the characteristics of an annuity, whose future value is calculated using the formula (7) (Clément et al., 2017):

$$FV_v = v.\frac{(1+r)^u - 1}{r}, \quad (7)$$

where FV_v is the present value of fixed costs, EUR.

v – average annual fixed costs, EUR;

Determining the net financial contribution at different plantation ages (NFC_u)

The net financial contribution (NFC_u) is calculated as the difference between the total updated income generated from thinning activities (W_{clear}) and regenerative cutting (W_{reg}) and the total present costs of establishing the forest plantation (F_{vc}) and the average annual administrative costs (FV_v).

Based on the above formulas for calculating the income and costs, the net financial contribution at the end of year u will equal (Kim et al., 2021; Kostov et al., 1996):

$$NFC_u = W_u + W_a(1+r)^{u-a} + W_b(1+r)^{u-b} + \dots + W_q(1+r)^{u-q} - FV_c - FV_v, \quad (8)$$

The above formula (8) gives us the net financial contribution of the plantation over its lifetime of u years. With its help, the production possibility frontier can be defined. At the same time, the economic choice is limited to alternative options. The criterion for this choice is the value of use (max NFC_u) of forest ecosystems for different target functions or a combination of several functions.

Determining the forest rent and the distribution of the income between the forest owner and the user of forest ecosystem services

The resulting net financial contribution (NFC) has to serve the interests of the owners of the three types of capital: forestry, labor and entrepreneurial capital, i.e. the individual owners of the factors of production must obtain an economic benefit from their property. The factor of production – timber fund (standing timber) – has the characteristics of a natural resource. The economic benefit from any natural resource is the rent. Forest rent is an income generated from the property rights over forest resources. This income is acquired by the owners by means of two mechanisms. The first involves leasing the right of use, where the so-called "natural fruits"[1] are acquired by the "user of the forest ecosystem services", and the "civil fruits"[2] by the "forest owners". Historically, the institutional environment has been created in such a way as to support forest owners, protect their property rights (the forest) and improve the forest for future generations. A resource to help carry out this function is the rent (R). It is the economic benefit of ownership of forest territories. The user of the forest ecosystem services is the bearer of the property rights on the capital advanced for the forest business. The user is the entity that has a monopoly on the management of forest territories. The economic benefit from their property is the profit. The mechanism that reflects the nature of the transactions between the two entities and by means of which they acquire the rights to the property is expressed by Schenrock's formula (Glushkov et al., 2006; Kolev, 2008; Kolev, 2021; Markov, 2021; Sirakov, 1982):

$$R = \frac{P}{1+g} - (e + d), \quad (9)$$

where: R is the forest rent (income from the right of use of forest property) for forest owners, EUR/m^3, EUR/kg, etc.;

P – the market price per forest product, EUR /m^3, EUR/kg, etc.;

g – profitability based on production costs per user of forest ecosystem services, as a fraction of 1.0;

e – costs for harvesting forest products, EUR/m^3, EUR/kg, etc.;

d – costs for transporting forest products EXW to the nearest location where the user of forest ecosystem services can receive them, EUR/m^3, EUR/kg, etc.

The transactions under this mechanism are of such a nature that the two entities, guided by their interests and protecting them in the negotiation process, receive a fair value of the income from the invested capital. The meaning of fair here extends to the degree in which the institutions set up to regulate the market equally protect both types of property – that of forest owners and that of the user of forest ecosystem services. Under this mechanism, if the forest ecosystem has a wood production function, the rent (R) as an income for the forest owner will be generated based on the market price reached by wood resources.

According to this mechanism, the profit generated by a user of forest ecosystem services is the result of the amount of wood resources used and the rate of profit (g) of the market price per unit of wood resource. This norm reflects the following exchange relation: the price that the respective buyer has agreed to pay and the seller has agreed to accept under the circumstances existing at the time of each transaction. Therefore, it is fair insofar as the institutions provide conditions for the protection of the prop-

[1] Natural fruits – movable things that are periodically separated from forests as natural ecosystems without affecting their integrity (Yovkov et al., 2007).

[2] Civil fruits - the income that the forest owner receives from its forest estate through transfer of property rights to another person on the grounds of contracts between them (Yovkov et al., 2007).

erty rights of a user of forest ecosystem services. Finally, the operating costs (e+d) incurred by a user of forest ecosystem services will obviously depend on the price of the factors of production. These factors are territorially differentiated and obviously have an impact on the final income – rent and profit.

Now, we can ask the question: What should the owner of forests with water protection functions receive if the nature of the transactions is of the type reflected in formula (9) in the case of an even-aged forest (under a clear cutting form of forest management)? According to economic logic, this would be the opportunity cost of the loss of rental income from unrealized gains from timber use rights. These unrealized gains can be:

Full – when the forests are used only for their water protection function and the income from wood is zero. Here the loss from unrealized gains from forest use rights is 100% and should be 100% covered along the water consumption or wood production pricing chain;

Partially limited – when forests are used equally for both wood production and water protection. The fair allocation here requires that 50% of the income be at the expense of wood production, and the other 50% - at the expense of the water protection and water regulation function;

Limited – when the wood production function is given priority over the water protection function or vice versa. Here, it is reasonable that 75% of the income should be covered by the wood production function and 25% - by the water protection and regulation function or vice versa.

The second question that arises is what income the forest owner loses from unrealized gains from timber use rights over even-aged forests?

When a forest owner grants the timber use rights to a user of forest ecosystem services, their net financial contribution (NFC) will obviously acquire the characteristics of a rent. In order for it to be determined, the economic balance between the forest owner and the user of forest ecosystem services must also take into account the current costs of the user of forest ecosystem services. In this case, formula (9) calculating this balance takes the form of an annual balance between the two entities, i.e.:

$$R_{year} = \frac{NFC_{year}}{1+q} - (e+d).Q_{year}, \qquad (10)$$

where R_{year} is the annual forest rent, EUR/ha/year;

NFC_{year} – mean annual contribution per 1 year, EUR/ha/year. It is calculated using formula (11):

$$NFC_{year} = \frac{NFC}{u}, \qquad (11)$$

Q_{year} – the average volume of wood harvested per 1 year from thinning and regenerative cutting under a clear cutting form of forest management, m^3/ha/year.

Table 2. Economic valuation of the net financial contribution from 1 ha even-aged coniferous forest from SPZ1

Age classes, years	**0-10**	**11-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**	**71-80**	**81-90**
1.Volume of standing timber (m^3/ha) (V)	22	92	204	310	419	512	481	515	511
2. Monetary value of 1m^3 of round timber, (W_{vumean}), EUR/m^3	14.11	14.11	16.36	16.36	21.21	41.5	21.21	21.21	21.21
3. Monetary value of wood harvested from regenerative cutting, BGN/ha (W_{reg})	-	1 298	3 338	5 073	8 886	21 238	10 201	10 922	10 838
4. Future (present) value of income from regenerative cutting at cutting age in year **u** (W_{reg}), EUR/ha		127	499	1 066	2 214	8 068	7 146	11 659	18 361
5. Present value of all income (W_{reg} + W_{clear}), EUR/ha	-	1425	3 837	6 138	11 100	29 306	17 347	22 581	29 198
6. Future (present) value of costs at cutting age in year u (FVc), EUR/ha	498	737	1090	1614	2389	6917	5235	7749	11 470
7. Future (present) value at cutting age in year **u** (FV_v), EUR/ha	364	551	827	1236	1842	5379	4065	6029	8937
8. Net financial contribution (NFC) for the whole economic life, BGN/ha	-861	138	1920	3288	6870	17 010	8047	8804	8792
9. Net financial contribution (NFC) for 1 year, BGN/ha	-172	9	77	94	153	309	124	117	103

Source: Forest management plans of the territorial division of SFU "Alabak" and the territorial division of SHU "Chepino" and authors' own calculations

Table 3. Economic valuation of the net financial contribution from 1 ha of even-aged coniferous forest from SPZ2

Age classes, years	**0-10**	**11-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**	**71-80**	**81-90**
1.Volume of standing timber (m^3/ha) (V)	27	101	206	308	415	509	486	523	514
2. Monetary value of 1m^3 of round timber, (W_{vumean}), EUR/m^3	14.11	14.11	16.36	21.21	21.21	21.21	21.21	21.21	21.21
3. Monetary value of wood harvested from regenerative cutting, BGN/ha (W_{reg})	-	1 428	3 374	5 045	8 083	10 791	10 310	11 083	10 897
4. Future (present) value of income from regenerative cutting at cutting age in year **u** (W_{reg}), EUR/ha	-	141	520	1 097	2 259	4 172	7 236	11 792	18 558
5. Present value of all income (W_{reg} + W_{clear}), EUR/ha	-	1 570	3 894	6 141	11 062	14 963	17 545	22 875	29 455
6. Future (present) value of costs at cutting age in year u (FVc), EUR/ha	498	737	1090	1614	2389	3536	5235	7749	11 470
7. Future (present) value at cutting age in year **u** (FV_v), EUR/ha	364	551	827	1236	1842	2738	4065	6029	8937
8. Net financial contribution (NFC) for the whole economic life, BGN/ha	-861	282	1977	3291	6832	8688	8246	9097	9048
9. Net financial contribution (NFC) for 1 year, BGN/ha	-172	19	79	94	152	158	127	121	106

Source: Forest management plans of the territorial division of SFU "Alabak" and the territorial division of SHU "Chepino" and authors' own calculations

Historically, in Bulgaria, a profit margin of g=20”%” has been found to ensure a relatively good distribution of income between entities (Glushkov et al., 2006; Markov, 2021). This balance again places the two entities on an equal footing, each of them having the right to receive income from the property they own. This income must be used by them to satisfy their needs, as well as to improve this property for future generations.

Results and discussion

Prices from 2020 were used for the economic valuation of the coniferous forests with water protection functions on the territory of Velingrad municipality, and the main results of the application of the methodology described in section 2 of this paper have been summarized in Table 2, Table 3 and Table 4 for SPZ 1, SPZ 2 and SPZ 3, respectively.

The general trend observed for coniferous forests with water protection functions in each SPZ is that the net financial contribution (NFC) increases with age, reaches a maximum value and then starts to decline. It is most economically advantageous to maintain plantations at an age when the financial contribution is the highest (Yovkov, 1994). This age is between 50 and 60 years for the coniferous forests with water protection functions in all three sanitary protection zones on the territory of Velingrad municipality. The average age of the coniferous forests with water protection functions is 51 years, which means that they have reached their most economically advantageous age. Concerning the latter, similar results have been obtained by G. Uzel, S. Gurluk and F. Karaer (2020). According to some of their models to maintain the water supplying function of the forests in Uladag National Park, the forests must be subjected to rotation at intervals of 44 years (Uzel et al., 2020). As seen in Table 2, Table 3 and Table 4, the maximum net financial contribution for 1 year from 1 ha of coniferous forests with water protection functions on the territory of Velingrad for SPZ 1, SPZ 2 and SPZ 3 is EUR 158 /ha/year, EUR 158 /ha/year, and EUR 128 /ha/year, respectively. This income is for the forest owner, which they receive as an economic gain from the property if they use the wood themselves.

If the forest is used by a user of forest ecosystem services, the economic balance between the forest owner and the user of forest ecosystem services, where the current costs of a user of forest ecosystem services are also taken into account, is calculated using formula (9).

The profit margin of a user of forest ecosystem services (r), as already stated in the methodology, is 20%. At the same time, the average costs associated with cutting, primary processing and transportation to the nearest forest inspection post (e+d) for Velingrad municipality are EUR 10.23 20/m^3, and the average annual quantity of wood harvested from thinning and regenerative cutting for 1 year from 1 ha is about 7–8 m^3/ha/year (Forest management plans of the territorial division of SFU “Alabak”, 2018, Forest management plan of the territorial division of SFU “Rakitovo”, 2019).

Table 4. Economic valuation of the net financial contribution from 1 ha even-aged coniferous forest from SPZ3

Age classes, years	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90
1.Volume of standing timber (m^3/ha) (V)	25	97	201	293	378	472	455	499	499
2. Monetary value of 1m^3 of round timber, (W_{vumean}), EUR/m^3	14.11	14.11	16.36	16.36	21.21	21.21	21.21	21.21	21.21
3. Monetary value of wood harvested from regenerative cutting, BGN/ha (W_{reg})	-	1 369	3 288	4 794	8 017	10 018	9 647	10 575	10 591
4. Future (present) value of income from regenerative cutting at cutting age in year **u** (W_{reg}), EUR/ha	-	127	278	1 730	1 730	3 282	5 813	9 665	15 388
5. Present value of all income (W_{reg} + W_{clear}), EUR/ha	-	1 496	3 566	6 524	9 747	13 301	15 460	20 240	25 979
6. Future (present) value of costs at cutting age in year u (FVc), EUR/ha	498	737	1090	1614	2389	3536	5235	7749	11470
7. Future (present) value at cutting age in year **u** (FV_v), EUR/ha	364	551	827	1236	1842	2738	4065	6029	8937
8. Net financial contribution (NFC) for the whole economic life, BGN/ha	-861	209	1648	3674	5516	7026	6161	6462	5573
9. Net financial contribution (NFC) for 1 year, BGN/ha	-172	14	66	105	123	128	95	86	66

Source: Forest management plans of the territorial division of SFU "Alabak" and the territorial division of SHU "Chepino" and authors' own calculations

Under these conditions, the annual forest rent (R) from forests with water protection functions is:

for SPZ 1:

$$R_{year} = \frac{158}{1+0.2} - 10.23x8 = 49.83 \text{ EUR/ha/year}$$

for SPZ 2:

$$R_{year} = \frac{158}{1+0.2} - 10.23x8 = 49.83 \text{ EUR/ha/year}$$

for SPZ 3:

$$R_{year} = \frac{128}{1+0.2} - 10.23x8 = 24.65 \text{ EUR/ha/year}$$

Table 5 provides information on the income that must be received by the forest owner and the user of forest ecosystem services under different rights of use of the forests with water protection functions on the territory of Velingrad municipality.

In relation to the forest territories falling into Sanitary protection zone (SPZ) I of the forests with water protection functions, the economic gains from the property

Table 5. Distribution of income from water protection forests, even-aged plantations

	Income distribution EUR/ha		Area of SPZ ha	Distribution of income from the whole area EUR/year	
	Forest owner	Forest user		Forest owner	Forest user
Belt I of SPZ (100:0)	49.83	0.00	3.6	179.39	0.00
Belt II of SPZ (75:25)	37.37	12.46	1,653.6	61,799.17	20,599.72
Belt III of SPZ (50:50)	12.33	12.33	1,127.4	13,896.64	13,896.64

Source: Authors' own calculations

should be 100% realized from water consumption and the owner should receive about EUR 49.83 ./ha per year. In SPZ II of the forests with water protection functions, the economic gains from the property should be realized by prioritizing the water protection over the wood production function in a 75:25 ratio, i.e. the owner should receive about EUR 37.37 ./ha/year. Finally, in SPZ III of the forests with water protection functions, the economic gains from the property should be realized equally in a 50:50 ratio through both production functions, i.e. about EUR 12.22 /ha/year. The results of Golos (2009), who evaluated the water protection function through the application of CVM, do not differ significantly from those obtained in the present study and amount to EUR 23.98/ha/year (Golos, 2009). The obtained results confirm our main scientific hypothesis, namely that forests with water protection functions should be recognized as capital, and their owners should have the right to gain income from them by attributing production functions to the water protection properties of forests. In this regard, by means of the Forest Act and the Water Act and the relevant institutional departments and officials, a system of rules (Behera et al., 2006) working in favor of the owners of forests with water protection functions should be constituted. This protection itself is aimed at providing opportunities to generate income from the ownership of forest ecosystems (Asquith et al., 2008), including in cases where they are only used for water protection purposes. Since every forest ecosystem has both a wood production and a water protection function, all future actions should obviously be directed at including forests in transactions not as a fund (accumulation), but as capital, whose profitability is functionally dependent on the relative prices of the commodities along the respective pricing chains.

Only by clarifying and recognizing the production function of forests through market mechanisms along all pricing chains will they acquire capital value as a multifunctional resource. This right in relation to their water protection function is currently not being realized. In addition, there are no direct economic gains from the ownership of forests with recreational and tourist functions, field protection functions, anti-erosion functions, etc. (FAO, IUFRO, USDA, 2021). The main reason for this is the lack of an economic approach to the valuation of the multipurpose production functions of forests in general and of forests with water protection functions in particular. Here it should be underlined that the different valuation methods used generate different results, which raises some doubts. Because of that, the implementation of the methods for assessment of the water protection function of forests has to be done with prudence at national level as a political decision (Golos, 2009).

The tasks associated with the economic approach to the problem of the economic valuation of forests with water protection functions boil down to an alternative choice. The criterion for this choice is the value of using forest ecosystems for different target functions or a combination of several functions. The alternative to the wood production function, which has become dominant in the course of the historical development of the country's forestry sector and as a result of the market mechanism for generating more than 95% of the forest income through wood production, is the economic valuation of the water protection function. This is necessary because the wood production function of forests is no longer able to generate sufficient income (Yovkov et al., 1992). There is a conflict of interest between those who manage the forests for free in compliance with environmental criteria (Martynova et al., 2021) and those who generate income along the water use and water consumption pricing chain.

Overcoming this conflict obviously requires a new institutional environment that would grant forest owners and forest management organizations the right to generate income from the water protection function of forests. This income, as an alternative to the income generated from the wood production function, can also be awarded in the form of a rent. In relation to the wood production function, under the current model of forest management, the rent as an economic gain from the ownership of forest ecosystems is ensured by any single transaction according to formula (9). In relation to the water protection function, the alternative to this rental income will obviously be of equal value, but this value will already have been created along the water consumption pricing chain. This will of course be valid if the forest ecosystem fully participates as an agent of production along this pricing chain. In this case, this value shall be equal to the loss that the forest owner would make from income foregone resulting from the unrealized wood production function, which is the same as if the forest ecosystem was established solely with water protection functions.

Conclusions

Forests with water protection functions must be recognized as capital, and their owners must have the right to derive income from them by attributing production functions to the water protection properties of forests. Consequently, the following question arises: How much should the owner of forests with water protection functions receive if the economic relations between the two main entities – the forest owner and the user of forest ecosystem services – are expressed in analytic form using Schenrock's formula (see formula (9))? Economic logic shows that this will be the opportunity cost of the loss of rental income from unrealized timber use rights, which currently accounts for 95% of the revenues generated from forests in Bulgaria. The fair distribution of the contribution of forest ecosystems between the two main economic entities requires that the Forest Act and the Water Act, which set the rules for the protection of property rights over forests and their functional purpose, should allow for the following alternatives: forests with 100% wood production functions should generate 100% of the economic gains from forest ownership through the use of wood; forest territories falling into the first SPZ belt should generate 100% of their economic gains from the property through water consumption; forest territories falling into the second SPZ belt should generate their economic gains from the property by prioritizing the water protection function over the wood production function in a 75:25 ratio; forest territories falling into the third SPZ belt should generate their economic gains from the property equally in a 50:50 ratio through the two production functions; all forest territories in the country, which are managed by prioritizing the wood production function over the water protection function, should generate their economic gains from the property in a 75:25 ratio, taking this prioritization into account.

The alternatives described above are essentially forms of economic realization of the real contribution of forest ecosystems in the process of their multifunctional management (wood production and water protection functions). The owner of the forest ecosystem has the right to this contribution and they must be protected by the relevant legal instruments. This right, of course, can be economically realized only if the natural water protection and water regulation properties of the forests acquire a production function for forest owners. This new production function is at present as socially significant as wood production and requires institutional protection by means of the mechanisms for natural resource management. In this regard it should be pointed out that the Forest Act (2011) (chapter 17 'Public ecosystem benefits from forest areas') already provides a legal basis for forest owners to derive income not only from timber production, but also from other beneficial characteristics of forests (Forest Act, 2011). The problem is that at the present moment there is not an accepted methodology for the economic valuation of the non-timber production functions of forests. Due to this, our future research should be directed towards the development of reliable methodologies for the assessment of different functions of forests. The results from these methodologies are crucial for the development of national ecosystem accounts and for assessing the costs and benefits associated with national and regional strategies and plans.

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