: Water - the future source of forestry income?

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ABSTRACT

The increasing competition for nature resources usage emerges the highest pressure on ensuring forest ecosystem services. The goal of the paper is to demonstrate that the quality of the water is the forest's positive external effect and the value of this service. The paper points to possibilities for valuation methods based on costs for drinking water treatment in forested water catchments near three water reservoirs in Slovakia. The value of this service in the case of analysed water reservoirs in Slovakia is in the range of 1.67 to 8.90 € ha^{-1} $year^{-1}$. With the alternative payment of a water cent for each m^3 of drinking water consumed, the calculated value per ha of forest in water reservoir catchment is in the range of 3.82 - 12.19 € ha^{-1} $year^{-1}$. The valuation of water quality and quantity regulation enables to compensate forest enterprises for ensuring these services and is also the base for implementing effective forest policy instruments.

KEYWORDS

Water quality, forestry, forest ecosystem services, valuation of forest ecosystem services

1 INTRODUCTION

As a result of limited resources, water is gradually becoming an important capital and strategic natural source. In the Slovak Republic, underground water sources (82.2%) and surface water sources (17.8%) are used to collect drinking water. Almost all drinking water from surface sources is tied to forest ecosystems. This reflects that most water reservoirs used for the "production" of drinking water and drinking water abstraction points are located in forested areas. Although water-related ecosystem services are included among the key forest ecosystem services (Hamilton et al., 2008; Čaboun et al., 2010; Robinson and Cosandey, 2011) and almost all surface water sources are formed in forests, forest managers in the Slovak Republic are excluded from the "water trade chain".

The increment in water prices is related to the increasing costs of its treatment. The operating costs depend on the water source distance from the point of abstraction, the character of the source (surface/underground), investments of water management utility into the distribution network, the number of abstraction points and costs of water treatment. The alternative of decreasing total costs is to take advantage of the positive external effects of forests ecosystem to water quality and quantity. The sustainable and superior water sources descend from forest ecosystems (Šišák et al., 2002; Neary et al., 2009; Sukhdev et al., 2010). Conversely, agriculture and urbanisation are the main source of nutrients and xenobiotics that decrease water quality (Bennett et al., 2001). Forest ecosystems play an important role in water cycling. They increase vertical and horizontal water flows, such as condensation, retain precipitation and reduce surface effluent retention (Papánek, 1978). The existence of the forest as such excludes or significantly eliminates the use of fertilisers and chemical substances that affect water quality (Trenčiansky et al., 2021). In areas with agricultural production transition to ecological farming combined with the exclusion of fertilisers and chemical preservatives improve water quality indicators (Trenčiansky et al., 2022a).

The goal of the paper is to demonstrate the valuation methods of water-related forest ecosystem services on the example of the prior national study (Trenčiansky et al., 2022b). The results of the alternative costs method and „water cent" payment mechanism are presented.

2 METHODS

2.1 Valuation method of water-related ecosystem services

The Water-related ecosystem services are not objects of the market. Therefore, it is essential to make conditions for these services analogically. The valuation principles based on revenues arise from two basic approaches i.e., the producer´s and consumer´s perspectives (Bergen et al., 2002). The valuation from the producer's perspective is based on the fact that for each unit of forest ecosystem service, the producers demand a minimum compensation in the amount of the costs they have to spend on its production in the required quantity. We interpret the valuation from the consumer´s perspective of the forest ecosystem services as his maximum willingness to pay for the amount of the given service.

From a methodological point of view, we demonstrate an example of quantifying a water protection ecosystem service based on the Alternative cost method. An alternative to ensuring the water protection ecosystem service is the cost of drinking water treatment, formed by the costs of chemical substances for drinking water treatment. We will define a regression equitation formula based on the analysis of water treatment costs in the years 2011-2015 in three water reservoirs (Málinec, Klenovec, Turček) and the analysis of forest cover. Next, we will calculate the difference between the average costs for water treatment of individual water reservoirs in the observed period and the model costs determined by the linear regression equation at 0% level of afforestation. The difference will represent a cost saving in the average cost of water treatment and the contribution of forest stands to the water protection ecosystem service.

We calculated the value of water protection ecosystem service for each catchment using formula:

$$VWS = \frac{DC \cdot W}{FC}$$

where:
VWS - annual value of water protection service (€ ha^{-1} $year^{-1}$)

DC - difference of real average costs of water treatment at the current forest cover and modelled costs in case of 0% forest cover (€ m^{-3})

W - average volume of treated water (m^{-3})

FC - forest cover in catchment area (ha)

We will compare the calculated value of the water protection service with the alternative payment scheme water cent. With this payment scheme, water consumers would pay a fee of 0.01 € m^{-3} $year^{-1}$ to forest owners per each consumed volume of drinking water.

2.2 Study area

The study was made on three water reservoirs (WR) and its catchments located in central Slovakia region: WR Málinec, WR Klenovec and WR Turček (Figure 1). The basic parameters of the reservoirs are shown in the Table 1.

Figure 1. Analysed water reservoirs (source Google Earth)

The input data of the research are average costs of water treatment took from water management utilities and catchment forest cover ratio (Table 1) and qualitative water indices before its treatment.

Table 1. The basic parameters of chosen WR

Water reservoir	Málinec	Klenovec	Turček
Forest cover (%)	56,11	70,80	100,00
Catchment area (km²)	78,7	92,12	28,96
Water area (km²)	1,38	0,71	0,54
Capacity (mil. m³)	26,70	8,43	10,60
Average annual volume of drinking water (mil. m³)	2,6	2,5	3,5
Average costs for drinking water treatment (€ m^{-3} $year^{-1}$)	0,01227	0,01232	0,00940

The lowest costs of water treatment in observed period and highest water quality before treatment was spotted in water reservoir Turček (managed by „Stredoslovenská vodárenská spoločnosť, inc., Banská Bystrica"). Turček catchment has highest forest cover. The costs of water treatment represent costs of used chemical substances, e.g. sodium chlorite, hydrochloric acid, ferric sulphate, potassium permanganate and calcium aluminate.

3 RESULTS

We defined a regression relation based on the results on average costs for drinking water treatment and forest cover of the catchments (Figure 2).

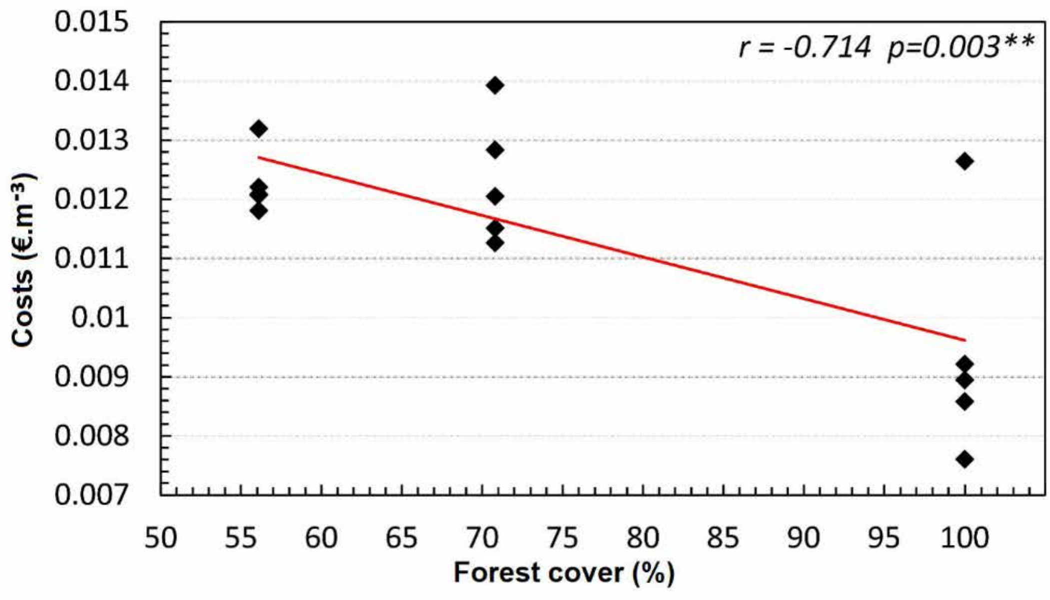

Figure 2. Dependence of average water treatment costs on forest cover of water catchments

Defined regression equitation confirmed relations between costs of drinking water treatment with decreasing forest cover. In case of no forest cover (0 %), the modelled costs are 0,0167 € m^{-3}. The difference between modelled costs in case of no forest cover and real costs of water treatment in each catchment around water reservoirs, represents potential costs saving of water treatment for water management utility. This is caused by the forest and its influence on water quality (Table 2).

Table 2. Saving of average costs for water treatment in individual catchments of water reservoirs

Water reservoirs	Forest cover (%)	Average costs for water treatment (€.m^{-3})	Model costs for water treatment at forest cover 0 % (€.m^{-3})	Saving of average costs for water treatment (€.m^{-3})
Málinec	56.11	0.01227	0.0167	0.00443
Klenovec	70.80	0.01232	0.0167	0.00438
Turček	100.00	0.00940	0.0167	0.00730

The alternative to reduction of the costs of water treatment is increasement of forest cover of catchment. The annual costs savings of water treatment through using positive external effects of forests on water quality represents annual value of water protection service. The annual value of water protection per year and hectare is based on average annual volume of treated water of each catchment (Table 3). The highest costs savings of water treatment for water management utility is in WR Turček. Average value of water protection service falls within 1,67–8,90 € ha^{-1} $year^{-1}$.

Table 3. The value of the water protection function of forests in individual catchments of water reservoirs

Water reservoirs	Forest area (ha)	Average annual volume of treated water (m^3)	The value of the water protection function of the forest (€ $year^{-1}$)	Average value of water protection function (€ $ha^{-1}year^{-1}$)
Málinec	4,417	2,601,392	11,515	2.61
Klenovec	6,522	2,490,399	10,911	1.67
Turček	2,896	3,529,540	25,767	8.90

Table 4 shows the calculation of alternative payment "water cent". The payment is derived from the volume of water treated and consumed by consumers per year. The average annual value of the payment figured per ha of forest is in the range of 3.82 - 12.19 € ha^{-1} $year^{-1}$. The annual value of the water cent payment per 1 consumer reach to 0.35 € $year^{-1}$, with the average annual water consumption 35 m^3 $year^{-1}$ per consumer.

Table 4. Water cent as payment for water protection ecosystem service

Water reservoirs	Average annual volume of treated water (m^3)	"Water cent" (€ $year^{-1}$)	Water cent -average value for forest area (€ $ha^{-1}year^{-1}$)
Málinec	2,601,392	26,013	5.89
Klenovec	2,490,399	24,904	3.82
Turček	3,529,540	35,295	12.19

4 DISCUSSION AND CONCLUSION

Forested water catchments contribute to improvement of water quality and decrement of water costs treatment (Biba et al., 2007). The results of USA study (Ernst et al., 2004) confirmed that costs on water treatment in water utilities that used surface water sources, has varied in relation of the forest cover. Moreover, the operating costs of water treatment had decreasing trend in relation to a higher forest area ratio. Each 10% of higher forest cover decreases water costs treatment by approximately 20%. In our case, the analysis showed that with an average increase in forest coverage by 10%, the average cost of water treatment decreased by approximately 5%. The deviation of costs may be caused by the influence of other factors that may affect water quality. Payments for ecosystem services (PES) are one of appropriate optimal mechanisms for ensuring water-related ecosystem services near water reservoirs. The side of the supply is represented by forest owners or enterprises who manage the forests around the reservoirs. The beneficiaries are water management utilities, municipalities, and residents. The costs related to ensuring water-related ecosystem services defray forest owners without additional compensation. The private PES scheme should compensate management practices focused on water quality and quantity support. The alternative costs method valuated ensuring of water quality protection near water reservoirs as 1.67 – 8.90 € ha^{-1} $year^{-1}$. The "water cent" method assessed value of this services as 3.82 – 12.19 € ha^{-1} $year^{-1}$. The PES focused on water-related ecosystem services are still considered as innovative approach in Slovakia. In case of its successful development, the provision of water-related ecosystem services will increase. It is important to prepare PES schemes consistently and with the support of involved stakeholders.

5 REFERENCES

// Bennett E.M., Carpenter S.R., Caraco N.F. 2001. Human impact on erodable phosphorus and eutrophication: a global perspective: increasing accumulation of phosphorus in soil threatens rivers, lakes, and coastal oceans with eutrophication. BioScience, 51, 3: 227–234. https://doi.org/10.1641/0006-3568(2001)051[0227:HIOEPA]2.0.CO;2

// Bergen V., Löwenstein W., Olschewski R. 2002. Forstökonomie, Volkswirtschaftliche Grundlagen, Vahlen.

// Čaboun V., Tutka J., Moravčík M., Kovalčík M., Sarvašová Z., Schwarz M., Zemko M. 2010. Uplatňovanie funkcií lesa v krajine [Application of forest functions in the landscape], Národné lesnícke centrum vo Zvolene.

// Ernst C., Gullick R., Nixon K. 2004. Conserving forests to protect water. Opflow, 30, 5: 1–7. https://doi.org/10.1002/j.1551-8701.2004.tb01752.x

// Hamilton L.S., Dudley N., Greminger G., Hassan N., Lamb D., Stolton S., Tognetti S. 2008. Forests and water: a thematic study prepared in the framework of the Global forests resources assessment 2005. Roma, FAO.

// Neary D.G., Ice G. G., Jackson C.R. 2009. Linkages between forest soils and water quality and quantity. Forest Ecology and Management, 258, 10: 2269–2281. https://doi.org/10.1016/j.foreco.2009.05.027

// Papánek F. 1978. Teória a prax funkčne integrovaného lesného hospodárstva [Theory and practice of function integrated forestry management], Príroda. Bratislava, Lesnícke štúdie, Volume 29.

// Robinson M., and Cosandey C. 2011. Water Resources Depend on Vegetation Cover and land use, European Forest Institute: 59–64.

// Simmons B. 2010. The economics of ecosystems and biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB. Ginebra, UNEP.

// Šišák L., Švihla V., Šach F. 2002. Oceňování společenské sociálně-ekonomické významnosti základních mimoprodukčních funkcí lesa. [Appreciation of the social socio-economic significance of the basic non-production functions of the forest], Praha, Ministerstvo zemědělství ČR.

// Sukhdev P., Wittmer H., Schröter-Schlaack C., Nesshöver C., Bishop J., Brink P., Gundimeda H., Kumar P., Trenčiansky M., Štěrbová M., Výbošťok J., Lieskovský M. 2021. Impacts of Forest Cover on Surface Runoff Quality in Small Catchments. BioResources, 16: 7830–7845. https://doi.org/10.15376/biores.16.4.7830-7845.

// Trenčiansky M., Štěrbová M., Výbošťok J. 2022. The Influence of the Transition to Ecological Farming on the Quality of Runoff Water. Sustainability, 14, 22: 15412. https://doi.org/10.3390/su142215412

// Trenčiansky M., Štěrbová M., Výbošťok J. 2022. Oceňovanie vodoochrannej ekosystémovej služby lesa metódou alternatívnych nákladov na príklade vybraných vodárenských nádrží Slovenska. [Valuation of water protection ecosystem service of the forest by the alternative costs method on the example of water reservoirs in Slovakia]. Reports of Forestry Research, 67, 1.

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