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Review

Valuating Natural Resources and Ecosystem Services: Systematic Review of Methods in Use

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Abstract: The relevance of an ecosystem approach, which involves addressing ecosystems as an object of research, economically evaluating ecosystem services, and including the existing variety of evaluation methods and their classifications for the estimation of nature's value, was the focus of this study. So, the aim of the current research is to develop an evaluation theory by refining approaches and methods for the economic evaluation of natural resources and ecosystem services. The research object was the evaluation practice of the former USSR, Russia, and countries outside Russia. Employing research methods of systematization and content analysis with evolutionary and ecosystem approaches, about three hundred scientific papers have been the subject of this review. The study (1) reveals the evolutionary changes in economic evaluation approaches and methods of natural resources and ecosystem services; (2) discloses the features of the existing classifications of economic evaluation methods; and (3) offers the author's classification, which is based on the five classification criteria: evaluation type, evaluation approaches, evaluation character (nature), evaluation methods, and market discourse. We believe that understanding the development of scientific thought about evaluation methods and their classifications will make it possible to increase the reliability of the estimation results in natural resource and environmental economics.

Keywords: economic valuation; evaluation ((e)valuating process); ecosystem services; natural resources; evaluation method; evaluation approach; classifications

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1. Introduction

In 1667, W. Petty wrote that land and labor act as the father and mother of "value", reflecting the main idea of the pre-classical stage (start of the 16th C.–17th C.) in economic science in general and in natural resource and environmental economics (ecological economics) in particular ([1], p. 1210). The classical stage (early 18th C.–early 19th C.) is characterized by the works of such titans of economic science as A. Smith, D. Ricardo, T. Malthus, and K. Marx, who addressed the question of the land's value and methods of its (value) assessment. The neoclassical stage, which began in the 19th century with works of K. Menger, S. Jevons, A. Marshall, R. Coase, and others, continues to this day by the elaboration of the evaluation theory and value theory of natural resources [2], employing and improving such concepts as ecosystem services [3–13], total economic value [14–19], natural capital [20–22], and a range of biophysical approaches presented in the study [23]. However, despite the almost four-century history of evaluation theory's and value theory's elaboration, evaluation methods are still the subject of scientific disputes and research [23–26]. Moreover, there is still a problem with the understanding of what is "valuation" and "evaluation"; different studies have used these terms as synonyms or as different terms [27–34]. Many classifications of methods have been developed and certain approaches have been discussed [35–112], but there is a lack of classification models of economic evaluation methods of natural resources and ecosystem services, which includes

more than one criterion, based on international experience of evaluation methods' classification, and which considers the essence of each evaluation approach. In addition, the variety of existing classification models based on different criteria contributes to both misunderstanding and confusion in practice. Hence, the aim of this paper is to elaborate evaluation theory by refining the approaches and methods of economic evaluation of natural resources and ecosystem services. Therefore, the core objectives of the study are: (1) to make an evolutionary analysis of the economic evaluation approaches and methods and (2) to create the author's version of the methods' classification. The research hypothesis, which has both practical and theoretical significance, is that the elaboration of the evaluation theory increases the reliability of economic value of natural resources and ecosystem services. It ultimately helps to improve the state regulation of environmental management, mainly via inclusion valuations in national accounting systems as the main users of valuation data of natural resources and ecosystem services.

2. Materials and Methods

Research methods are systematization and content analysis with evolutionary and ecosystem approaches. About three hundred scientific papers have been the subject of this review. The information base of the research consists of scientific studies in sustainable development economics, evaluation theory, value theory, theory of state regulation and law, ecosystem services' theory, total economic value's concept, and natural capital theory. These scientific studies are presented by monographs, articles of periodicals, international databases (Scopus and WoS), and an eLibrary portal. In addition, the paper includes the information from international projects and from the authors' own research.

The review of evaluation methods was conducted in Scopus and WoS, using search strings containing either "Ecosystem* Service*" or "Natural* Resources*", with and without keywords "evaluation theory", "value theory", "ecosystem services", "total economic value concept", "evaluation tools", "methods", "natural resources", "natural resource economics", and "ecological economics". We also searched for well-known researchers in the evaluation theory of natural goods, such as D. Pearce, R. Turner, R. Costanza, R. de Groot, U. Pascual, G. Daily, J. Krutilla, and E. Barbier. Russian sources were identified in a similar way on the eLibrary portal. Employing content analysis of titles, keywords, and abstracts based on the criteria "any information about the evaluation methods of natural resources and ecosystem services", about 100 studies were selected for further detailed study. Later, these studies were supplemented with information from international projects on the estimation of nature's value, such as Earth Economics, Marine Ecosystem Services Partnership (MESP), Operationalisation of Natural Capital and Ecosystem Services (OpenNESS), A Community on Ecosystem Services (ACES), The Economics of Ecosystems and Biodiversity (TEEB), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), ALTER-Net: A Long-Term Biodiversity, Ecosystem and Awareness Research Network, Europe's ecosystem research network, Biodiversity Knowledge, Natural Capital Initiative, Ecosystems Knowledge Network, The Sub-Global Assessment Network (SGAN), BIOdiversity and Economics for CONservation, Environmental Valuation Reference Inventory (EVRI), The National Ocean Economics Program (NOEP), and the New Zealand Non-Market Valuation Database. Next, we selected all this information according to subject and evolution steps in the evaluation methods used. The subject criterion was included if the paper was about the essence of terms "valuation" and "evaluation" or about the evaluation approaches and certain methods. The evolution criteria divided the information to three blocks: (1) within the model/concept for (e)valuating the used natural resources and "kind of" ecosystem services, but before the emergence of ecosystem services' theory; (2) after the emergence of ecosystem services' theory; and (3) after the emergence of ecosystem services' theory and within the concept of total economic value. These evolution criteria reflect the main changes in evaluation practice. Firstly, it was due to the shift from the valuation of the used resources to the valuation of total economic value of nature. Secondly, the paramount reason in evolutionary changes of evaluation

theory of natural resources was the appearance of ecosystem services theory. This way, it helps to elaborate evaluation methods of natural resources and ecosystem services, as well as to create the author's classification leveling the duplication of the essential content of existing methods.

3. Results and Discussion

3.1. "Valuation" vs. "Evaluation" or These Are Synonyms?

The concept of natural resources has been used in social relations for a long time and initially characterized only the natural aspect.

The performed analysis of the term "(e)valuation" demonstrates that it is understood either as a process (evaluation—"the making of a judgement about the amount, number, or value of something; assessment" [27]) or as a result of assessment (valuation—"an estimation of the worth of something, especially one carried out by a professional valuer" [28]) [29–33]. If the subject of evaluation and the methods used are directly related to the evaluating process, then obtaining the value's assessment characterizes the result—valuation. So, the reliability of (e)valuation largely depends on the acceptability of the methods used [34]. It should be mentioned that, in this study, we use the term "evaluation" to signify a process of making judgements about the value of natural resources and ecosystem services and "valuation" to signify the result of the evaluation. The spelling "(e)valuation" demonstrates both meaning (process and result).

3.2. Traditional Approaches for (e)Valuating Natural Resources and Ecosystem Services in Russian and International Research within the Model/Concept for (e)Valuating the Used Natural Resources and "Kind of" Ecosystem Services: Before the Emergence of Ecosystem Services' Theory

Returning to the works of W. Petty, A. Smith, D. Ricardo, T. Malthus, and others, the first proposals on methods for the economic evaluation of specific functions of forest ecosystems appeared quite a long time ago, dating back to the 1970s. However, the issues of economic (e)valuation of natural resources (mineral and land) had a fairly detailed coverage in the scientific literature in the 1950s–1960s [35–41]. It demonstrated a model/concept for (e)valuating used natural resources. According to the study by A. Dushin [42], the first resource to be evaluated was mineral resources. These were evaluated in order to rank deposits for economic purposes. Russian studies on the (e)valuation of mineral deposits dated back to the beginning of the 20th century, and possibly to an earlier period. The sale of land in the Russian Empire also involved the valuation of land. In the USSR, when state ownership appeared to all natural resources, the (e)valuation issue for a long time remained unclaimed. However, occasionally, questions about the need to valuate natural goods were raised by individual researchers within their (natural goods) free-of-charge concept. The high importance of mineral raw materials for countries' economies, including for the USSR, led to a huge surge in scientific interest in the topic of economic (e)valuation of mineral deposits. In general, these studies were based on an income approach, which had been used in countries outside the former USSR too, when the valuation of a deposit was equal to the amount of income from mining for the entire period of operation. Until the mid-1960s, the income approach was the most widespread.

In the 1960s–1970s, an understanding of the limits of natural resources and their depletion led to the appearance of a cost approach. The cost approach involves the evaluation of natural objects in terms of their use and maintenance costs, as well as the cost of making this object suitable for operation. According to the Russian tradition, its founder is S. Strumilin. Referring to "already used or being used" natural resources, he believed that resources' usage had a price. The cost approach did not receive much support among the majority of researchers; its exhaustive criticism is given in studies by V. Nemchinov [43] and N. Fedorenko [44].

It is impossible to ignore (e)valuations that are obtained with cost indicators and have been approved by law. For instance, there are taxes and fines for the illegal extraction and destruction of resources of fauna and flora, standing timber fees, indicators of the normative price of land, indicators of the cadastral value of land plots, etc. This approach of

(e)valuation is called the normative (approach). It implies the mandatory use of established constants in the calculations.

Despite the fact of the income approach's existence, the majority of researchers supported the point of view of N. Fedorenko, who was the Academician of the Russian Academy of Sciences. He believed that "each resource should be evaluated in terms of the economic effect, which it brings" ([44], p. 96). So, valuation is equal to the obtained profit, by deducting current costs from income. An effective approach for the (e)valuation of natural resources emerged.

There were also more extravagant proposals, such as to summarize the effect with the costs of usage [45,46]. However, the largest number of followers acquired the rental approach, which appeared almost simultaneously with the cost one. The golden age for the rental approach is from the beginning of the 1970s till the 1990s. According to V. Novozhilov ([47], p. 9), the rental approach is "an evaluation of resources, which is based on measuring the results of their use; it relies on labor costs and represents their (labor costs) different manifestations". Conceptual discussions devoted to the rental approach for mineral resources ultimately resulted in the appearance of the temporary standard methodology for the economic evaluation of mineral deposits (1980) [48].

$$P = \sum_{t=1}^{T} (Zt - 3t)/(1 + E)t \quad (1)$$

P—economic (e)valuation of a deposit; Zt—value of annual production, calculated in replacement costs in the t-th year; $3t$—the sum of capital and operating costs (without depreciation) in the t-th year; T—settlement period; t—current period; E—standard for multi-temporal costs.

Land resources also have special feathers in methods of economic (e)valuation. The 1950s brought a qualitative (e)valuation of land resources (point estimation approach (scoring) and expert approach) [49–51], which took into account natural conditions. The selection of characteristics for classification according to quality was linked to local specifics. The main criteria for the transition from local scales to broader ones was the yield. The majority of researchers consider the qualitative evaluation of lands as the first stage in economic (e)valuation by using point estimates. According to Academician N. Fedorenko, it should only have an auxiliary value in economic (e)valuation.

For the first time, specific recommendations for the economic (e)valuation of land resources were published in the 1960s as a result of S. Cheremushkin's research activities. Like his followers, he considered that it was necessary to use two indicators: gross production (in value form) and net income [39]. This way, the work on economic (e)valuation included two stages: the creation of rating scales for taking into account different types of soils, and the evaluation itself.

A number of researchers offered their own approaches to economic valuation, the variety of which is illustrated in the scientific journal "Voprosy Economiki" (Scopus, Q2) [52]. Among the evaluation indicators, the following were considered: the amount of compensation for the alienated agricultural land, the cost of reclamation during the restoration of disturbed lands, differential rent, net income and differential rent, the labor costs for converting land into a means of production and improving its quality, output per unit area, and costs for its production. The rental approach in the economic (e)valuation of land did not receive general recognition, whereas in international evaluation practice, the price of land was determined based on the annual rent received by the owner of the resource and the interest rate that the bank paid for long-term deposits ([53], p. 68). Later, this approach (rental) became the main one in the cadastral (e)valuation of land. So, for the economic (e)valuation of mineral deposits, the rental approach has become the main one; for land resources, differential rent and a substitute/replacement method for producing products from the (e)valuated land plot. Studies (e)valuating forest and water resources were few in number.

So, by the beginning of the 21st century, traditional (e)valuation approaches were used. These approaches could be combined into the following groups:

- cost approach;
- income approach;
- rental approach;
- mix of the cost and rental approach;
- point estimation approach (scoring) and expert approach; and
- normative approach.

We consider this grouping to be insufficiently substantiated. Firstly, the economic (e)valuation involves monetary calculation. That is why the point estimation approach and a mix of the rental and point estimation approaches should not be included in the list under consideration. The point estimation approach plays only an auxiliary role in economic (e)valuation. The normative approach is different from the usual, generally accepted evaluation procedures. The latter (conventional (e)valuating), includes the cognition of the subject of evaluation and valuation itself. With the normative method, there is no valuation, since the cost indicators, which had been approved by law, are the subject to use. So, in the grouping, there are cost and rental approaches and their mixed modifications. Certain remarks could be made regarding the rental approach, so that, like the income one, it is included in the effective approach. The final grouping is:

- cost approach and its modifications;
- effective approach, including rental and income; and
- mix of the cost and rental approaches.

One more famous approach is the market (comparative) approach, which was quite popular in developed countries. The core of this approach is the idea that we can use the price of a comparable resource to estimate a natural resource without any evaluation procedures. However, in the former USSR, this approach was hardly used due to the absence of natural resources' markets. It was used only for non-timber forest products (mushrooms, berries) when their sale prices were used for the evaluation of comparable products, in addition to the expert approach. The worldwide flourishing of the use of this approach is linked with the theory of ecosystem services' emergence. It happened after the 1970s, and even more precisely, after the 1990s, when the economic valuation of ecosystem services was closely tackled.

The cost approach consisted of the methods that were used till the 1970s, such as:

- The evaluation of the costs for developing new resources instead of the withdrawn ones. This method was mainly used to substantiate the standards for compensation for agricultural production losses associated with the withdrawal of agricultural land for non-agricultural needs [54]. This method has not been used in international practice. In Russia, this method has ceased to be used since the 1990s.
- The evaluation of the costs of restoration (restoration cost); the method of restoration cost. The idea is the reconstruction of the estimated object, if it disappears in the same volume, with the same set of consumer properties. We are talking about a conditional reconstruction, since it is not possible to achieve full identity. The subjects of the evaluation were rare and endangered plants and animals, while justifying the corresponding rates. Today, examples of the use of this method to valuate ecosystem services, such as pedogenesis and soil erosion management, can be found in studies [55–58].
- The evaluation of the costs of replacement/substitute (replacement/substitute cost). When implementing this method, the (e)valuation is based on the costs of employing the option that allows us to replace the natural benefits that have been provided by the (e)valuated object. For example, "replacement/substitute costs" are for building a reservoir to meet water demand in an economic valuation of water resources. Later, in relation to ecosystem services, this method was used to assess the forest ecosystems of Norway (Oslo). The analysis showed that, in 2017, the value of 700 thousand trees was 3.5 billion euros.

- The evaluation of the costs of preventing damage, which is caused by the absence of the object being evaluated (damage cost avoided). The initial condition is the assumption that the value of a natural resource is equal to the amount of economic damage, which is caused by its loss. So, the economic damage for the population, that is caused by the lack of drinking water can be considered as an economic valuation of the water resources. For example, in modern practice, the eco-efficiency of agriculture in the Amazon region in Brazil was assessed using the damage cost avoided method [59].

The effective approach consisted of the mentioned approaches, such as:

- income approach, which is related to the calculation of the profit, that can be obtained by using the evaluated resource [60];
- rental approach, which is based on the evaluation of a part of the profit (differential rent I), formed due to the best natural characteristics and conditions (for instance, high content of useful components, close location to the surface of ore bodies, high soil fertility, etc.), and does not require labor [61].

A mix of the cost and rental approaches is rarely used. An example is proposals to include social costs of reproduction and differential rent in standing timber fees [62,63]. However, the practice showed that only differential rent was the subject for evaluation, which explains its insignificant value.

3.3. Evolution of Traditional Approaches for (e)Valuating Natural Resources and Ecosystem Services in Russian and International Research: After the Emergence of Ecosystem Services' Theory

The 1970s became pivotal in the economic valuation of natural goods. The concept of "ecosystem services" emerged and gained increasing recognition in the following decades. This theory was set up by W. Westman [64] and R. De Groot [65] research, where the useful functions of ecosystems had been presented as services in order to increase public interest in the conservation of biodiversity. The 1990s demonstrates relevance of issues of economic (e)valuation of ecosystem services in the works of R. Costanza, R. D'Arge, R. De Groot, S. Farber, M. Grasso, B. Hannon, M. Van Den Belt, etc. [3], as well as in the works of Russian scientists S. Bobylev and V. Zakharov M. [6,7], A. Tishkov, N. Lukyanchikov, R. Perelet [9], I. Potravny, O. Medvedeva [66], etc. Subsequently, specialized communities were created to assess the value of ecosystem services. Examples include Ecosystem Services Partnership [67], Natural Capital Coalition [68] and ACES: A Community on Ecosystem Services [69], Earth Economics [70], Marine Ecosystem Services Partnership (MESP) [71], Operationalisation of Natural Capital and Ecosystem Services (OpenNESS) [72], A Community on Ecosystem Services (ACES) [73], Millennium Ecosystem Assessment (2005), The Economics of Ecosystems and Biodiversity (TEEB) [74], Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) [75], ALTER-Net: A Long-Term Biodiversity, Ecosystem and Awareness Research Network, Europe's ecosystem research network [76], Biodiversity Knowledge [77], Natural Capital Initiative [78], Ecosystems Knowledge Network [79], The Sub-Global Assessment Network (SGAN) [80], BIOdiversity and Economics for CONservation [81], Environmental Valuation Reference Inventory (EVRI) [82], The National Ocean Economics Program (NOEP) [83], the New Zealand Non-Market Valuation Database [84], etc.; even the UN's system of environmental and economic accounting appeared. In research and projects, the indirect nature of the use of natural goods was the reason for the emergence of new evaluation methods within different approaches, such as the market (comparative) approach, effective approach, and cost approach, and new ones such as the sociological approach.

The sociological approach includes the following methods:

- The travel cost method, which evaluates the willingness to pay for environmental benefits based on the cost of visiting their locations. It is widely used in determining the economic value of recreational services and the tourist value of natural sites. The study [85] provides an assessment of an ecosystem service such as recreational fishing in New Zealand. The value of this ecosystem service was estimated, using the travel cost method. It was USD 48–60 per trip in 2008.

- The hedonic pricing method is designed to evaluate the natural goods at the prices of the real estate market or the labor market. It uses real estate prices, depending on environmental factors (for example, noise level, air purity, beauty of the landscape). Utilizing this method, regions of Spain and Portugal [86], as well as China [87], have been evaluated in a number of recent studies.
- The contingent valuation method is widely used. It is implemented by directly asking consumers about their willingness to pay or receive compensation for changes in the provision of natural goods in a hypothetical natural resource market. Polls can take the form of telephone interviews, face-to-face interviews, mail-order surveys, etc. The (e)valuation of the aquatic ecosystem, which is located near the Marlborough Winery, was carried out by using this method in the research [88]. Ecosystem service water regulation was estimated at USD 1.253 million in 2010.
- The preventive expenditure method, which allows us to estimate costs that the population agrees to incur to mitigate or prevent damage, which are usually associated with pollution, for example, water. The study [89] presents the evaluation results of the Louisiana wetlands, using modifications of various methods, including the preventive expenditure method. The value estimates range from USD 8437 to USD 15,763 per acre of wetland in 1996.

As far as an effective approach is concerned, there are other new methods, such as:

- The factor income method. This is where the ecosystem service is estimated by the value of the increase in income that has been obtained due to its presence outside the evaluated object. For example, improved water quality can increase the income of commercial fisheries by increasing the catch and improving the quality of fish. Some examples of the method's application can be found in the research [90,91].
- The shadow pricing method. This method uses market prices that are adjusted for transfers, market failures, and policies. Shadow prices are calculated for products that do not have a market. In essence, this method is an evaluation of an investment project, in which regional specificity is usually taken into account and expressed in adjustments. This method could be found in the Russian research [92]. In international practice, modifications of this method are also used, but in the pollution sphere. One of the innovations was the abatement cost approach, to which Elsevier devoted a separate link with a selection of various journals and monographs on the subject. "Abatement cost is defined as total discounted cost of temperature-target scenarios compared to unconstrained "business-as-usual" reference case" [93]. Examples of this method's application within an emission reduction approach are found in [94,95].

One more method within the effective approach is the market price. An example of its implementation is [96], where the following ecosystem services of the forest ecosystem are evaluated: water regulation, preventing soil erosion, and regulating local climate and air quality. Using the market price method, the valuation of these ecosystem services is from USD 17.016 billion to USD 17.671 billion per hectare or from USD 1.427 billion to USD 1.482 billion, according to the estimates of the entire reserve in 2013.

Cost methods are added by the production function method [97]. In this method, an ecosystem service is evaluated in a dynamic modeling process, using a production function to estimate changes in the value of a product as a result of changes in the costs that are associated with the service being valued. The usage of this method is described in a study [98] of the evaluation of mangrove ecosystems in Thailand, as well as in the works of A. Freeman [99] and E. Barbier [100] et al.

The market (comparative) approach was supplemented by the possibility of using the available estimates of the economic value of analogue, which was called the analogy method (including the basic benefit transfer method). For instance, the economic evaluation of such ecosystem service as the preventing soil erosion in the coastal region of the Bristol River, Avon, Wiltshire, Great Britain [101] was made by the basic benefit transfer method. The value of this ecosystem service was estimated at GBP 1600 (or USD 2100). Various modifications of the basic benefit transfer method were also used in the famous study of

R. Costanza and co-authors [3] and were presented in a subsequent study, which compares global estimates of the value of ecosystems in 1997, 2007, and 2011 [34].

Subsequently, after the emergence of the basic benefit transfer method, the new modification of the replacement/substitute method (barter method) was added, which is based on a direct substitute for a product that does not have a market for a product that has a market. When speaking about the evaluation of pollution and ecosystem productivity in relation to the service of regulating local climate and air quality, a striking example is the evaluation of greenhouse gas emissions, for the total determination of which all greenhouse gases are converted into CO_2 equivalent, the market for emissions of which (CO_2) has already been formed.

The separate market (comparative) approach's method is the opportunity/option value. This method relies on the comparison of the possible profit from various options for using the evaluated object. The method of opportunity/option value is partially used in the research [102]. According to the source ([103], p. 561), the opportunity/option value is such a value that allows one to evaluate a natural object (resource) "through the lost income and benefits that could be obtained by using this object or resource for other purposes".

3.4. Classifications of Economic (e)Valuation Methods of Natural Resources and Ecosystem Services in Russian and International Research within the Concept of Total Economic Value

The most complete valuation of natural goods and ecosystem services required a change in the evaluation model—the model/concept for (e)valuating the used natural resources was replaced by the concept of total economic value. This concept includes the evaluation of the use value and non-use value by utilizing the variety of (e)valuation methods [6,14,16–19,104]. It should be noted that the set of (e)valuation methods in modern academic papers is far from identical. Moreover, in a number of cases, the contents of these methods and their names are presented in different ways.

The analysis demonstrates that traditional (e)valuation methods are most often combined into three aggregated groups (evaluation approaches): cost, rental, and a mix of the cost and rental. The classification criterion is the character (content) of (e)valuation: cost, rental, and a mixed approach (Table 1).

Table 1. Classification of economic evaluation methods.

Evaluation Approaches	Classification Criteria	
	Character (Content) of (e)Valuation	**The Method of Evaluation**
Cost	+	Value-based approach
Rental	+	
Mix of the cost and rental	+	
Point estimation (scoring)		Scoring-based approach
Normative		Normative

"+"—it means the precence of the character (content) of (e)valuation.

The emergence of new methods of economic (e)valuation has expanded different classifications and entailed the creation of new classification criteria. For instance, the research performed by A. Gusev and E. Almykina [106] offers two groups of methods, such as "economic" and "sociological" (later, the same two groups are distinguished in the study by V. Yurak [17]). These groups of methods demonstrate how the results have been obtained: using economic calculations or by employing sociological polls and questionnaires. When detailing the list of each group, methods are classified according only to the character (content) of (e)valuation (Table 2).

Table 2. Classification of economic evaluation methods.

Groups of Methods	The Character (Content) of (e)Valuation
Economic	1. Effective approach - market price method - shadow pricing method - rental method - cadastral value method - production function 2. Cost approach - replacement/substitute cost method - restoration cost method - transfer cost method - preventive expenditure method - damage cost avoided method 3. Market (comparative) approach - analogy method - substituted goods method
Sociological	- contingent valuation method (willingness to pay) - travel cost method - hedonic pricing method

The classification under consideration does not include the opportunity/option value method, which is widely used, and the factor income method. The content of the transfer cost method is not entirely clear. We also believe that the cadastral value method is included in the rental one but with a more detailed consideration of factors that affect the value of a resource, which serves primarily for tax purposes.

One more classification of economic (e)valuation methods of natural resources and economic services could be found in a modern study that was undertaken by S. Bobylev [107], where international and Russian experience were researched. It includes the following approaches for (e)valuation methods of natural goods:

- total economic value approach;
- market (comparative) approach;
- rental approach;
- cost approach;
- opportunity/option value approach;
- stated preference approach;
- basic benefit transfer approach; and
- surrogate market approach.

Like in most classifications, there is a combination of several classification criteria. Approaches include a valuation model for total economic value. The explanations of the (e)valuation approaches are given in an extremely concise manner, without the necessary information, for example, asking what is the surrogate market approach?

The UN also created recommendations for the classification of economic (e)valuation methods of natural resources and economic services. The UN's classification combines the methods into three groups using the criteria of the preference character and value transfer. The first group of revealed preferences includes the travel cost method and the hedonic pricing method. The second group of stated preference consists of the contingent valuation method. The last third group is represented by value transfer methods. The uneven distribution of methods among groups and the lack of a target orientation of the UN's classification has led to the fact that it is in little demand.

At the beginning of the 21st century, guidelines appeared that adapted the UN's environmental and economic accounting for Russia [108,109]. These guidelines combine all methods into three groups: market, direct non-market, and indirect non-market. The mar-

ket valuation methods' group employs the actual market prices of biological resources; the current present value, assuming net profit and net prices, multiplied by the corresponding amount of reserves of natural assets (including biological). This market valuation methods group is almost equal to the market price method with constant and changing rates of resource exploitation, as well as the rental approach for renewable resources. Methods for assessing reserve depletion are used for non-renewable resources, such as the user cost method, the net price method, and the present value method; this group also includes the substituted goods method. The non-market direct (subjective methods) group of methods includes the contingent valuation method, travel cost method, hedonic pricing method, and preventive expenditure method. Almost all the cost approach's methods are classified as non-market indirect valuation methods, such as damage cost avoided method, production function method, and restoration cost method. This classification focuses on the market criterion. The same market criterion has been used in the modern study undertaken by researchers from Switzerland [110]. Underdeveloped natural resource markets and environmental and economic accounting in Russia limit the use of classifications based on market criteria. The international practice of (e)valuation demonstrates a similar trend but with some variations in the classification of economic (e)valuation methods of natural resources and ecosystem services [23–26]. However, the key tendency is that the international studies focus on the elaboration of the market (comparative) approach's methods and sociological approach's methods (methods of revealed and stated preference) [111,112].

3.5. The Author's Classification of Economic (e)Valuation Methods of Natural Resources and Ecosystem Services

The generalization and analysis of the information described above allow us to create the author's classification, which is based on five classification criteria: evaluation type, evaluation approaches, evaluation character (nature), evaluation methods, and market discourse (Figure 1). This classification provides methods that are relevant to the economic (e)valuation of natural resources and ecosystem services, excluding those that are aimed at changes in pollution. Criteria of "Evaluation type" subdivide methods into quantitative, with monetary terms of indicators, and qualitative, involving the use of a point estimation (scoring). Criteria of "Evaluation approach" include the following (e)valuation approaches: value-based, cost, sociological (survey methods, questionnaires, etc.), market (comparative), normative (the mandatory use of established constants in the calculations), expert (expert polls), and scoring-based approaches. Criteria of "Evaluation approach" involve the subdivision of methods based on the specifics of the evaluation activity. With value-based and scoring-based approaches, the evaluation process involves the knowledge of the evaluation object and the valuation itself. So, the calculation of the final integral indicator characterizes the evaluation result. The sociological approach has the specific process of collecting information through surveys and questionnaires of the population about the (e)valuation object. Its processing and obtaining the final result are carried out by evaluators. In the process of cognizing an (e)valuation object (its comparability with an analogue is established), the market (comparative) approach has no evaluation at all, because already available economic valuations are used. The normative approach, as well as the market (comparative) one, does not have the process of evaluation itself because the normative approach employs the ready-made cost standards. The expert approach is unique by the selection of participants (experts) for conducting an expert survey. These experts carry out cognition and an initial valuation of the object. The final (e)valuation is carried out by the professional evaluators.

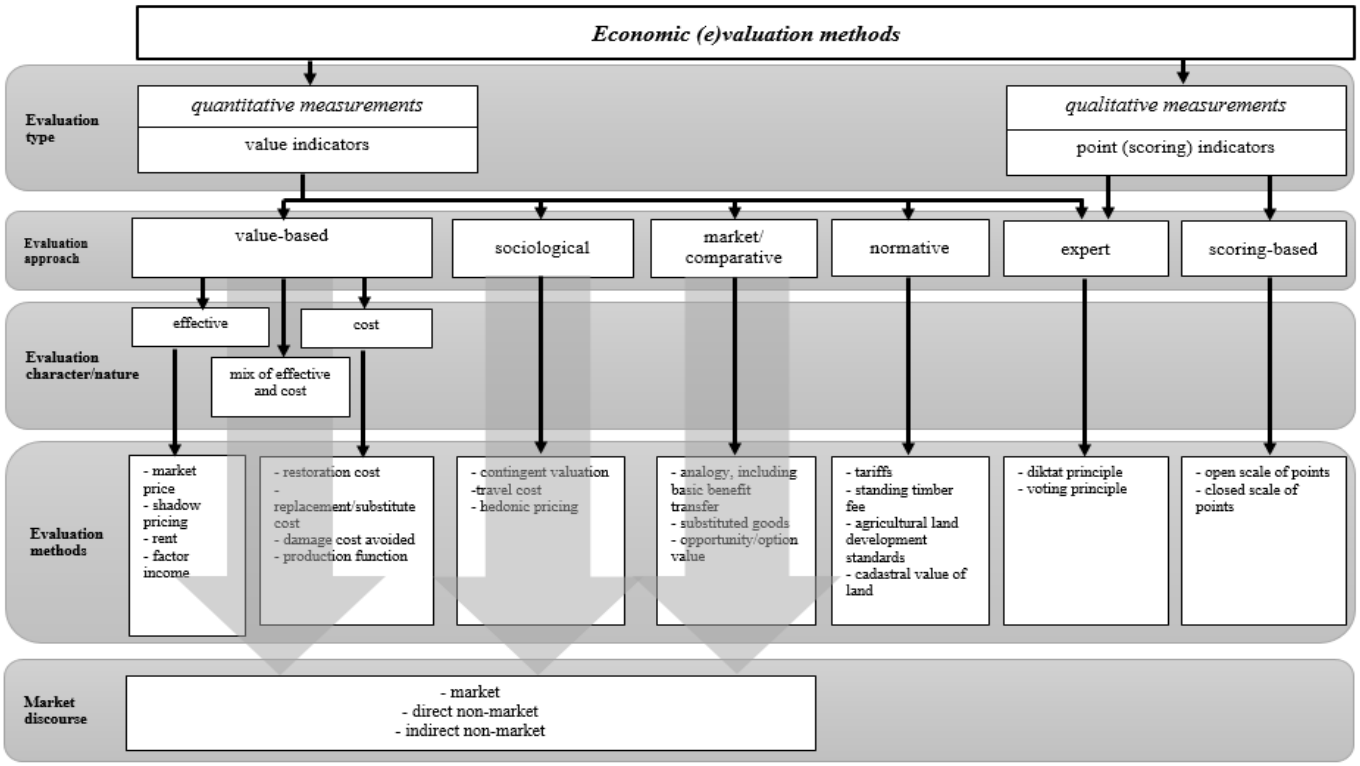

Figure 1. The author's classification of economic (e)valuation methods of natural resources and ecosystem services.

The reason for distinguishing the expert approach, despite its rarity in use, is determined, firstly, by the exclusivity in the evaluation of unique objects, and secondly, by the widespread implementation of project management practices in all areas and the use of this approach when determining the project value in IPMA ICB 4. In practice, there are three methods of expert approach, such as (1) the diktat principle, when the group preference coincides with the preference of one main expert of the group, usually the one that has the greatest degree of importance; (2) the voting principle, in which the decision corresponds to the coalition of the group of experts with the largest number of votes; and (3) non-systemic principles of choice, when the motive of choice is customs, ideological considerations, etc. [113]. In the author's classification, the third method is not presented, since it partly and essentially duplicates the diktat principle. The scoring-based approach is comparable to the value-based approach, i.e., the cognition of the object and the full evaluation with result valuation are carried out by the evaluators. The scoring-based approach is divided on two methods, such as with an open scale of points and a closed scale of points. The difference between them is that the closed one has a consistent ranking of quality characteristics, without gaps; the open scale of points has gaps between ranks of quality characteristics. Evaluation character/nature exists only for a value-based approach. There are effective, cost, and mix of effective and cost sub-approaches. The evaluation methods have the largest list, detailing the evaluation approaches. Lastly, classification criteria (market discourse) are not widely used due to the insignificance of natural resource markets in Russia.

Additionally, one fundamental work is the research of U. Pascual et al. [23]. This is a thorough study of approaches and methods for the (e)valuation of natural resources and ecosystem services, taking into account the research of their predecessors [114–116], and to which modern international studies refer. U. Pascual et al. [23] have three blocks of methods: a block of market valuation (price-based method is market price method; cost-based methods—damage cost avoided method, replacement/substitute cost method, restoration cost method; and production-based methods, such as production function

method and factor income method), a block of revealed preference (travel cost method and hedonic pricing method), and a block of stated preference, which includes the subjective evaluation methods, such as the contingent valuation and ranking methods, choice modeling method, and the deliberative group valuation method ([23], p. 207). If the block of market valuation is equal in international evaluation practice (in the author's classification, U. Pascual et al.'s [23] market block is represented by the value-based and market/comparative approaches), then in the blocks of revealed and stated preferences (the sociological approach in the author's classification), there is a peculiar specificity of scientific thought.

An interesting fact is that European researchers do not distinguish the expert approach at all; it seems to dissolve into revealed and stated preference approaches (sociological approach), while in essence, both the choice modeling method and the deliberative group valuation method are special cases of the contingent valuation method. With a choice modeling method, respondents usually choose on the basis of a set of criteria what they are willing to pay [117] or receive compensation. A deliberative group valuation method is a mix of the contingent valuation method followed by a kind of "public hearings", which result in a final evaluation of the value of natural resources and ecosystem services.

In addition to the sociological approach, the authors' classification has the normative approach as a kind of tribute to the USSR's evaluation tradition, as well as the expert approach, which is based on the specialists' valuations, and the scoring-based approach, that was historically the first one in natural resource and environmental economics. There is no connection between normative, expert, and scoring-based evaluation approaches with the evaluation criterion "market discourse", since the origins of this criterion are western and European studies, and they do not isolate either normative, expert, or scoring-based approaches.

4. Conclusions

The study reveals the evolutionary changes in economic evaluation approaches and methods of natural resources and ecosystem services, discloses the features of the existing classifications of economic evaluation methods, and offers the author's classification, which is based on the five classification criteria: evaluation type, evaluation approaches, evaluation character (nature), evaluation methods, and market discourse.

The essence of evolutionary changes in economic evaluation approaches and methods of natural resources and ecosystem services is in the expansion of the list of evaluation methods and in the complication of evaluation due to the need to take into account environmental and social constraints.

The main reasons for the change in (e)valuation theory and practice are:

- the ecosystem approach's development updates the economic (e)valuation of ecosystem services;
- the emergence of a new (e)valuation object (natural capital) and a new (e)valuation model (total economic value, which has replaced the model/concept for (e)valuating the used natural resources and "kind of" ecosystem services);
- the evaluation methods elaboration of value-based approach shifts to market/comparative and sociological ones;
- the transition to a market economy (specifically for Russia).

The analysis of the existing classifications of economic evaluation methods shows the different traditions in international and Russian evaluation research. However, both practices demonstrate that classification models of economic evaluation methods of natural resources and ecosystem services include one or two criteria and do not embrace all existing evaluation approaches and methods.

The proposed author's classification provides a clear structuring of almost all existing evaluation approaches and methods in the international experience (including the Russian tradition), which considers the essence of each evaluation approach. It (the authors' classification) helps to model evaluation depending on the valuation purpose, external and

internal factors, and value characteristics determined by the evaluators. We believe that this classification model helps to minimize misunderstanding and confusion in evaluation practice.

Moreover, the analysis of international experience in the economic (e)valuation of natural resources and ecosystem services revealed a number of trends, such as:

- quite often, the natural capital of regions (districts), protected areas or ecosystem service of carbon sequestration are (e)valuated at different levels of management;
- the main (e)valuation object is terrestrial ecosystems, including forest ecosystems and the flow of natural goods and services supplied by them;
- among natural resources (providing ecosystem services), the following are the subject of consideration: timber, non-timber forest resources, hunting resources (including recreational ones), fish resources (including recreational benefit), and medicinal plants. All of them are usually valued using the market price method. In the absence of market prices, the substituted goods method is used. Rarely enough, fresh water is the subject to (e)valuation employing the market price method and contingent valuation;
- among the regulating ecosystem services, the following are the subject of consideration: carbon sequestration by forests, carbon sequestration by swamps/wetlands, water purification and waste treatment by swamps/wetlands, and erosion regulation by forests, recreation, and tourism;
- if the carbon market is considered to be valid, the market price method is used for the economic (e)valuation of carbon sequestration. Some researchers define the economic equivalent as surrogate prices;
- water purification and waste treatment by swamps/wetlands is (e)valuated employing the replacement/substitute method, as well as for the (e)valuation of the ecosystem services called air quality regulation and water purification made by forests;
- erosion regulation by forests involves the use of the substituted goods method, replacement/substituted cost method, factor income method, and market price method, depending on the chosen tactic of (e)valuation;
- recreation and tourism (including ecotourism) are (e)valuated by the travel cost method and market price method, and much less often, by contingent valuation;
- in all cases with a lack of information, the analogy method (including basic benefit transfer method) is used. It is a common practice to use basic benefit transfer method for evaluation of cultural, educational, aesthetic, and spiritual ecosystem services based on the international experience.

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