Problems of environmental and economic sustainability assessments of specially protected natural areas

N A Fokina, E F Yachmenev, V A Ivanova
Institute of Economics and Management, V I Vernadsky Crimea Federal University, Simferopol, 10 Railway Street, 295026, Republic of Crimea, Russian Federation

*Corresponding email: fokina@kafmen.ru

Abstract. We discuss the key factors affecting the environmental and economic sustainability of specially protected natural areas (SPNA). Those are: regulatory and legislative; managerial; economic; environmental; and scientific and educational factors. We carried out an analysis of the factors to establish the main prerequisites and problems of assessing the environmental and economic sustainability of protected areas. We established that the factors can have both positive and negative effects on the development of protected areas. The negative influence of the factors can result in various threats to environmental and economic sustainability. A system of indicators for assessing the environmental and economic sustainability of protected areas has been proposed, consisting of two blocks: economic and environmental. The economic component of sustainability is characterized by the following indicators: the importance of environmental services, cost-effectiveness of recreational services, and the level of recreational development of protected areas. The environmental component is characterized by the following indicators: the level of compliance with the norms of the recreational load, the level of compliance with the rules and norms of hunting (fishing), the level of threat of anthropogenic impact, and the level of negative impact of natural factors. Criteria for evaluating the relevant indicators have been proposed.

1. Introduction
In the modern world, the problem of choosing the most important development priorities for the society has acquired particular importance. This is due to the on-going transformation of the global economy and environment, leading to the depletion of natural resources, deterioration of human health, and a decrease in life expectancy. The importance of solving this problem has been recognized by the UN conferences on environment and development. In particular, an alternative to extensive socio-economic growth has been proposed, the concept of "sustainable development" [1]. This is a unified approach to the evolution of the economic, social and environmental aspects of social relations. The main place in the system of sustainable development issues is given to the issues of regional development management. Within the framework of sustainable development and solutions to environmental problems, specially protected natural areas (SPNA) are of particular value. The Durban Agreement adopted at the Fifth World Congress of Protected Areas identified a number of difficulties faced by protected areas, including those that are especially relevant for the Russian Federation [2]. Among them are: contradictions that arise between the goals of economic development and the rational use of natural resources; lack of state financing of protected areas, which leads to a decrease in performance or inability to effectively perform pressing environmental tasks; lack of informed ecological thinking in the overwhelming majority of the population, etc. Thus, ensuring the
environmental and economic sustainability of protected areas is an urgent task. One of the steps towards the solution should be the development of a system of indicators for assessing the environmental and economic sustainability of specially protected natural areas. Such an assessment will assist in making informed decisions aimed at improving the mechanism for ensuring the environmental and economic sustainability of protected areas.

The purpose of the present research is to form a system of indicators for assessing the environmental and economic sustainability of specially protected natural areas.

2. Methods and Materials
The methodology of the research presented was adopted from the available national and international publications in the field of specially protected natural areas management, sustainable development, systems theory and system analysis, as well as the assessment of complex socio-economic objects. The information used in our research was obtained from official publications of the State Statistics Committee of the Russian Federation, the Ministry of Natural Resources and Ecology of the Russian Federation, reports of international organizations, periodicals and Internet resources, as well as the results of our own research.

We used the systemic and integrated approaches, as well as the following methods: synthesis, generalization and comparison, and methods of statistical and structural-logical analysis.

3. Results and Discussion
The development of regional practices of nature conservation in the Russian Federation has its own specifics. It is due to the following factors [3]:

- a large area of the country, a significant part of which is not influenced by human activities;
- a relatively low average population density (with high regional differences);
- historically established scientific traditions, in accordance with which the emphasis has been placed on the organization of nature reserves in the form of specially protected natural territories.

According to various estimates, for the biosphere to remain stable, from 5 to 50% of the territory should have the status of protected areas [2]. According to N F Reimers and F R Shtilmark, the ecosystems of the forest-steppe zone should account for 35–40% of the territory of protected areas. Target 11 of the Convention on Biological Diversity (CBD) stated: "By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape" [4]. The regional values of this indicator — the share of the area of an administrative entity of the Russian Federation occupied by protected areas — have been formed over several years. They are determined both by the geographic location and the level of economic development of administrative entities, and by the national environmental policy adopted by the regional governments over different periods of time.

In 2017, the area of the network of protected areas of the Federal, regional and local significance of the Russian Federation amounted to 232.7 million hectares, or 11.7% of the total area of the country [5, 6]. This is less than in many other countries (Germany, 42.3%; Great Britain, 18.06%; USA, 13.6%), however approximately half of the Russia's territory is practically unaffected by economic activity [3].

In Russia, the density and distribution of protected areas within the subjects of the Federation are very uneven. For example, in Adygea, Kabardino-Balkaria and Kamchatka, the total area of protected areas at all levels is approximately 30% of the region’s area, while in the Tambov Region and Stavropol Territory this value is 0.4%.

The analysis of the available literature [3–9] revealed the main factors affecting the environmental and economic sustainability of protected areas (table 1).
Table 1. Factors affecting the environmental and economic sustainability of protected areas.

| Factor                        | Characteristic                                                                 |
|-------------------------------|-------------------------------------------------------------------------------|
| Regulatory                   | - forms the regulatory framework in the field of environmental protection;     |
|                               | - defines the approach to the establishment of protected areas (isolationary or integrative); |
|                               | - defines the forms of planning and creation of protected areas (separate protected areas or networks) |
| Administrative                | - forms the management structure of the system of protected areas;             |
|                               | - forms a network and determines the strength of inter-agency interaction of environmental management entities; |
|                               | - regulates the issues of economic use of ecosystems;                         |
|                               | - determines the conceptual development of sectoral regional programs and decisions made in the field of regional development; |
|                               | - stimulates the use of innovative approaches to solving environmental problems; |
|                               | - forms support systems for protected areas both from public authorities and from the general public (public engagement and environmental education) |
| Economic                      | - determines the intensity and directions of economic activity on the territory of protected areas and adjacent territories; |
|                               | - affects the quality of the environment of adjacent territories and protected areas; |
|                               | - determines the financial support options for environmental activities |
| Environmental and ecological | - determines the ecological state of the ecosystems of protected areas;       |
|                               | - affects the change in the natural species composition (for example, as a result of climate change); |
|                               | - negative hydrological, meteorological phenomena and processes can lead to the loss of or damage to protected areas; |
|                               | - geological processes affect the integrity of objects and the stability of the boundaries of protected areas |
| Scientific and educational    | - scientific and social traditions predetermine conditions and types of protected areas; |
|                               | - educational activities determine the attitude of the general public towards environmental protection and compliance with the prescribed rules |

The analysis of the factors made it possible establish the main prerequisites for assessing the environmental and economic sustainability of protected areas:

- deterioration of the environment in many regions of the Russian Federation (reduction of the area of natural landscapes, increased pollution of the atmosphere and coastal waters, increased number of unauthorized landfills, etc.);
- reduction of the natural diversity of regions (reduction in the number of Red Book listed animals and plants);
- imperfection of legislative solutions concerned with the definition and change of the boundaries of protected areas, the procedure for the establishment of protected areas, and with the authority to identify and suppress environmental crimes in the protected areas;
- insufficient financing of the activities of protected areas;
weak conceptual elaboration of regional development programs and the absence of an analytical, forecasting and economic-environmental block;

- insufficiency and low implementability of innovative approaches to environmental problems;
- nationwide reorientation of the approach to the development of the system of protected areas (from isolationary to integrative);
- gradual change in the ecological thinking of the population, environmental awareness and understanding of the importance of protected areas for the environmental well-being of regions;
- lack of tested systems for assessing the environmental and economic sustainability of protected areas.

The following problems can be singled out as most important when assessing the environmental and economic sustainability of protected areas:

- lack or limited access to information necessary for the assessment, as a result of the inter-agency fragmentation of economic and environmental management entities;
- insufficient numbers of skilled specialists capable of generating and processing environmental information, including the use of Geographic Information System (GIS), remote sensing, etc.;
- low availability of technical equipment required for such an assessment;
- lack of databases of environmental assessments necessary for forecasting and modeling the situation;
- lack of a unified approach to assessing the environmental and economic sustainability of protected areas.

The sustainability assessment of any economic system can be carried out on the basis of two basic concepts: the concept of threats and the concept of reliability. The threat concept is based on the three key components: identifying threats, assessing the probability of a risk, and managing the likely risk. Risk assessment is carried out by an expert method and is a probabilistic characteristic of the threat. Risk management is a set of measures that, based on the previous experience of critical socio-economic situations and modeling of the current situation, can prevent the future incidents or reduce the impact and consequences. Therefore, the assessment of environmental and economic sustainability is based not only on the analysis of factors and threats, but also on the forecast of economic and social losses (damage). Reliability is a contrasting concept in relation to risk. The reliability assessment is based on an expert assessment method, which is predictive and probabilistic in nature [10].

The state of reliability (stability) of a complex system can be determined by analyzing the aggregated values of indicators characterizing it, which make it possible to assess with a certain degree of probability the behavior and possible reactions of the system to internal and external changes (threats). Thus, the notions of “system stability” and “threat” are closely related: the higher the threat level, the lower the stability of the system. At the same time, the development of a system of indicators for assessing the environmental and economic sustainability of an object should be based on an analysis of its threats. That is, the content of the system of indicators for assessing the environmental and economic sustainability of protected areas and the choice of assessment method depend on the object of study (protected areas), as well as on the goals. Thus, one of the main stages of the assessment should be the stage of analysis of the conditions of a particular specially protected natural area, and factors and threats to its environmental and economic sustainability.

The negative influence of the above factors can result in various threats to environmental and economic sustainability of a protected area. The most common of them are presented in table 2.

Summarizing all the above, we conclude that the following indicators should be the main components of the economic block for assessing the environmental and economic sustainability of protected areas:

- the importance of environmental services;
- the level of recreational development of protected areas;
- the effectiveness of recreational activities in the territory of protected areas.
**Table 2.** Threats to the environmental and economic sustainability of protected areas.

| Threats                     | Characteristic                                                                                                                                                                                                 |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Environmental hazards       | the deterioration of the state of the environment as a whole and of protected areas in particular, leading to a reduction in animal and plant diversity;                                                          |
|                             | natural disasters and phenomena leading to a decrease in the integrity and preservation of the potential of protected areas (forest fires, landslides);                                                            |
|                             | climate change leading to changes in species distributions; changes in the biological cycles; impact on species demographic indicators (survival and fecundity); population decline; spread of diseases; an increase in the population numbers of some competing species over others; distribution of alien plants, animals and pathogenic organisms. |
| Infrastructural and economic threats | lack of funding, leading to the impossibility or poor performance of tasks entrusted to protected areas;                                                                                                        |
|                             | excessive economic development exceeding the carrying capacity of ecosystems of protected areas; the impact of economic activities carried out in territories adjacent to protected areas on ecosystems of protected areas; |
|                             | construction, reconstruction and operation of communications and structures located on the territory of protected areas.                                                                                      |
| Legislative threats         | adoption of laws that do not contribute to maintaining the integrity and carrying capacity of protected areas.                                                                                             |
| Consumer threats            | deliberate destruction of protected areas (fire);                                                                                                                                                           |
|                             | illegal hunting and fishing, grazing and deforestation;                                                                                                                                                     |
|                             | recreational impact as a result of visits to protected areas by outsiders;                                                                                                                                   |
|                             | the impact of the activities of residents of nearby settlements (pollution by household waste, air pollution from stationary sources and vehicles; recreation; and pollution of water sources). |

The characteristics of the proposed indicators are presented in table 3, and the block of environmental indicators is presented in table 4.

Let us discuss in more detail the methods for obtaining some of the indicators. The indicator of the economic block of assessment, “cost-effectiveness of the provision of recreational services”, as well as the indicator of the environmental unit of assessment, “level of compliance with the norms of recreational load”, are quantitative in nature, and their values are found by simple calculations based on information available to the management of protected areas. However, it should be noted that there are several methods for finding the indicator “recreational load norm” which is necessary for calculating the indicator “level of compliance with recreational load standards”.

The common practice of regulatory policy regarding recreational nature management does not have an unambiguous representation, since the regulatory and legislative acts have significant differences in the norms for the use of various natural resources. Specially protected natural areas as a complex ecosystem are characterized by their resistance to recreational loads. The stability of such territories is their ability to retain their properties and characteristics under the influence of anthropogenic pressures until they reach a tipping point, after which irreversible processes and loss of reproduction ability occur. Recreational load means the activities carried out with the involvement of an allowable number of recreants in protected areas per unit time.
### Table 3. Characteristics of indicators for assessing the environmental and economic sustainability of protected areas: the block of economic indicators.

| Indicator                                      | Characteristic                                                                 | Assessment criteria                                                                 |
|------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Importance of environmental services           | Ratio of ecosystem benefits to the costs of maintaining protected areas       | - the amount of budgetary contributions to protected areas;                         |
|                                                |                                                                                | - environmental benefits of protected areas;                                       |
|                                                |                                                                                | - social benefits of protected areas                                               |
| Cost-effectiveness of recreational services    | Ratio of net profit received from the sale of recreational services to their cost | - net profit from the sale of services;                                             |
|                                                |                                                                                | - cost of services                                                                  |
| Level of recreational development of protected areas | Ratio of the level of the actual development of protected areas to the level of potential development | - the proportion of recreational areas in protected areas;                         |
|                                                |                                                                                | - real / potential density of recreants;                                           |
|                                                |                                                                                | - real / potential density of the network of tourist routes;                       |
|                                                |                                                                                | - real / potential saturation of recreational infrastructure                         |

### Table 4. Characteristics of indicators for assessing the environmental and economic sustainability of protected areas: the block of ecological indicators.

| Indicator                                      | Characteristic                                                                 | Assessment criteria                                                                 |
|------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Level of compliance with recreational load standards | Ratio of the number of visitors to protected areas to the established norm of recreational load | - the number of fixed recreants per unit area per unit time;                        |
|                                                |                                                                                | - the norm of recreational load per unit time                                       |
| Level of compliance with the rules and regulations of hunting / fishing | Analysis of the number and dynamics of identified violations leading to a change in the quantitative composition of the hunting (water) resources of protected areas | - the number and type of violations detected in the territory of protected areas at different time periods; |
|                                                |                                                                                | - the number of issued hunting and fishing permits                                  |
| Level of anthropogenic threat                   | Level of impact of anthropogenic factors on the ecosystems of protected areas | Probability, strength and duration of exposure:                                    |
|                                                |                                                                                | - forest fires;                                                                    |
|                                                |                                                                                | - motor vehicles;                                                                  |
|                                                |                                                                                | - illegal extraction of natural resources;                                         |
|                                                |                                                                                | - secondary forest management;                                                     |
|                                                |                                                                                | - soil pollution by solid waste;                                                    |
|                                                |                                                                                | - watercourse pollution                                                            |
| Level of negative impact of natural factors     | Change in the natural environment of protected areas under the influence of natural factors | - the impact of climate change;                                                    |
|                                                |                                                                                | - the influence of pathogenic factors;                                              |
|                                                |                                                                                | - the influence of non-pathogenic factors                                           |
Uncontrolled load resulting in irreversible processes in ecosystems is called critical. Controlled load, which is close to critical, but not causing irreversible changes, is called maximum permissible.

Recreational load is an integral indicator reflecting the cumulative effect of recreational activities on protected areas affected by those activities. Rationing of recreational loads is determined by a number of features [11]:

1. The number of recreants is subject to rationing, but the impact of infrastructure and transport facilities is not taken into account.

2. The approach to the formation of a balanced system of indicators of recreational load and to a measurement system (qualitatively-quantitative) of these indicators is ambiguous [11], namely: a) the number of people who can simultaneously be in a unit area of the territory; b) the number of people who can simultaneously be in a unit area of the territory during a certain period of its operation; c) the number of people staying at recreational facilities per day during the season; d) the number of people passing per unit area per unit time; e) the number of people involved in recreational activities at a time per unit area, taking into account the total time of each type of recreation for the reported period. The quality and condition of protected areas are not taken into account by any of the indicators.

3. Recreational loads should be normalized in accordance with the type of operation and purpose of the protected areas: environmental, functional or psychological.

Based on the foregoing, the recreational load is a specific category that should be described, in terms of objectivity of assessment, by both quantitative and qualitative indicators, namely, by temporary, seasonal, biological, botanical and natural-climatic indicators. The norms of all loads should be maximum permissible, and the volume of recreational operation of protected areas should not exceed maximum permissible values, taking into account the characteristics of certain types of recreation (technological), the psychophysiological comfort of visitors and the resistance of ecosystems to anthropogenic pressures [12]. The qualitative aspect of rationing the recreational load is manifested in the obligatory preliminary analysis of the landscape and functional-economic structure of the territory.

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