“Managing change in nature-based tourism: A decision-making model using linear programming”

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MANAGING CHANGE IN NATURE-BASED TOURISM: A DECISION-MAKING MODEL USING LINEAR PROGRAMMING[1]

Abstract

In conditions of forced isolation, nature-based tourism meets the needs of safe and comfortable recreation and travel combined with the solution of acute issues of medical treatment and rehabilitation during the pandemic and post-pandemic periods. This study aims to develop a model for decision-making on change management in nature tourism based on the approach of linear economic and mathematical programming. The paper formalized changes in the variability of objective function parameters of the model and the system of its restrictions, following the structure of assets of nature-based tourism, balanced by the sustainability principle. The algorithm for implementing the model includes four stages: collection and processing of relevant data on nature-based tourism; considering changes in the objective function and the system of its limitations; linear programming with variability tests using the simplex method; defining ranges/limits in which decisions are made. The initial data are summarized and averaged based on the primary data analysis on the functioning of sanatoriums and other tourist and recreational facilities in Ukraine. Short-term nature-based tourism is considered, the services of which are classified according to the criterion of the primary purpose of travel: "wow-effect" tourism, sports tourism, health tourism, traditional recreation, and green tourism. The results make it possible to substantiate decisions on changes in recreational land areas and human resources, on the limits of changes in income due to the dynamics of service prices, as well as determine the price range while maintaining income structure and sustainability limits for natural and human assets of nature-based tourism.

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INTRODUCTION

As an area that combines social, economic, environmental, cultural, and other factors, nature tourism is experiencing increasing external influences caused by the effects of climate change, the COVID-19 pandemic, and other challenges (UNWTO, 2021). For example, in Ukraine, the situation is complicated by external geopolitical threats and military confrontation with the aggressor in the east, respectively, unstable macroeconomic situation, including delays in the formation of the market of recreational and tourist services, and low solvency of most people. In addition, the place and role of natural tourism in the economy (The Verkhovna Rada of Ukraine, 1995), particularly the state support and promotion of sustainable forms of tourism, remain not fully regulated at the level of national legislation. On the other hand, the spread of nature tourism as an effective economic activity is inextricably linked to the possibility of infrastructure development in recreational areas

1 The results and conclusions that directly concern Ukraine must be rethought, and they should be reviewed against the background of the full-scale aggression of Russia.

of unique natural areas, which also has complex legal nuances (The Verkhovna Rada of Ukraine, 1992), which need to be addressed by legislation.

In order to transform the external challenges of the macro-level into positive internal changes at the meso and micro-levels, a targeted impact is needed, which in such areas as nature tourism is considered in the interaction of government and tourism business, in particular, in the form of regional and local socio-economic development programs. This approach (Melchor, 2008) goes beyond the classical view that change management is considered at the level of the study of internal organizational processes, mainly related to the human factor. In addition, this approach is based on fundamental assumptions about the challenges of management (Drucker, 2001, p. 5), namely: "management's scope is legally defined; management is internally focused; the economy as defined by national boundaries is the 'ecology' of enterprise and management."

Combining economic, natural, and social components, change management highlights soft state intervention. The market underdevelopment and, consequently, inert income dynamics, focus on applying a resource approach and a similar approach to asset management, including natural assets (Boyce, 2001). These two preconditions explain the expediency of applying the linear economic and mathematical programming approach in the field of natural tourism, which, contrary to the implementation of mainly managerial planning function, can be used to justify decision-making and includes opportunities for change management. The advantage of this approach in comparison with others, which are closer to market relations methods of mathematical justification of economic processes, is the initial (Kantorovich, 1965) principle of the balance of diversity, including natural, economic, and social factors, which brings it closer to the concept of sustainable development.

Along with the increasing government's role in addressing security and other relevant issues of society's functioning and development, prioritizing its social component due to the coronavirus pandemic, the need to expand recreational needs in the natural environment is intensifying (Spalding et al., 2021). At the same time, new opportunities for the development of domestic natural tourism are emerging for Ukraine and other transition economies against the background of suspension of market transformations. In conditions of forced isolation, the destinations of nature tourism meet the population's needs in safe and comfortable recreation and travel in combination with the solution of acute issues of medical treatment and rehabilitation during the pandemic and post-pandemic periods.

1. THEORETICAL BACKGROUND

Change management as an "inevitable element for tourism businesses to increase their speed of response to market and competitive changes" is considered within the following limits: the use of administrative, economic, and socio-psychological instruments; transformation of business model and/or business processes; comprehensive understanding of management style (Hristova et al., 2019). Change management is seen in conjunction with changes in tourism policy, namely in creating an enabling environment to adapt to market transformations, as well as supporting small businesses to improve human resources (Pechlaner & Tschurtschenthaler, 2003). This symbiosis of organizational change and state regulation is aimed primarily at increasing productivity in tourism. The search for increased chances of survival and development in the market of tourist services is carried out in terms of the organizational theory of change management (By & Dale, 2008). In particular, such factors as adaptability and flexibility, continuous learning and improvement, are considered. In terms of leadership, hospitality, and communication, the human factor is one of the main ones within the management of changes in tourism organizations (Shulga, 2021).

In contrast to a narrower view within organizational change management theory, a comprehensive view of change management involves focusing more on the impact of changes than on the lead-

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ing role of the human factor in addressing them (Burnes, 2005). Changes are studied from a transdisciplinary perspective, including philosophical, psychological, biological, institutional, political, cultural, and other aspects (Graetz & Smith, 2010). For example, Liu et al. (2019) examined the relationship between climate, biological, and economic changes by using the example of the impact of climate change on the duration of autumn leaf discoloration and its contemplation by tourists in Japan. In this case, change management is appropriate in maximizing profits due to the increase in the tourist season due to the delay of autumn leaf coloration.

Climate change is one of the main external factors affecting tourism (Dogru et al., 2019). At the same time, the industry is more sensitive and resilient to climate change than other sectors of the economy. However, in countries with weak economies, tourism is significantly affected by climate change and is unstable to these changes; in developed countries, the opposite is true. In transition economies, one of the factors influencing the recreation and eco-tourism industry includes changes in land use (Shevchenko et al., 2016), in particular, the direct reduction of areas intended for the provision of services to vacationers (Nahuelhual et al., 2014).

Climate changes are negatively affecting the health of the population, which is a prerequisite for transforming tourist flows and destinations, especially for creating an alternative recreational environment for people whose health is at risk due to global warming (Patz et al., 2005). When managing changes in tourism caused by climate change and other external factors, it should be borne in mind that tourism also affects other industries, the environment, and living conditions of residents, etc. Tourism can even lead to conflict situations, for example, due to the alternative use of natural resources and the environment: the lake can be a center of tourist destination and, at the same time, a water area for fishing. An increase in the number of tourists will simultaneously complicate the working conditions of anglers, as well as increase the level of pollution of the coast and water in the lake (Lopes et al., 2017). To maintain the level of accessibility to wild and semi-wild areas with a significant increase in tourist flows, it is necessary to plan tourist visits, taking into account the types of demand and behavior of tourists, as well as natural values, including biodiversity (Csagoly et al., 2017).

Tourism is a factor in bringing communities together to develop a common territory (Jenkins & Romanos, 2014). In a situation where several communities manage shared natural resources, including recreational resources, their joint action should be used to combat climate change and promote sustainable tourism development (Bitsura-Meszaros et al., 2019).

Processes directly related to tourism and recreation (Shevchenko et al., 2020), including sports, can influence social changes (Ladda, 2014). Welfare growth, as well as positive political changes in the country, increase the demand for tourism services and, consequently, stimulate the tourism industry to develop its competitiveness (Henderson, 2015). One of the leading areas of sustainable business development is nature-based tourism through the use of the natural uniqueness of destinations (Berg et al., 2014), wildlife (Ajagunna et al., 2014), responsible use of natural resources (Trišić, 2020), and other local assets (Yan et al., 2021).

When making management decisions taking into account the impact of the above external changes on tourism, as well as other challenges, including the COVID-19 pandemic (Traskevich & Fontanari, 2021), is possible within the application of economic and mathematical programming methods. Thus, Hosseini et al. (2021) considered the target function that maximizes travelers' satisfaction with eco-tourism services, taking into account the limitations caused by the effects of coronavirus; the dual-target function minimizes the cost of forming these services.

Ziaabadi et al. (2017) used linear programming to determine the level of economic, social, and environmental sustainability of tourism. Lin and Yang (2016) investigated the recreational capacity of coastal areas in Hualien, Taiwan. Limitations to the maximization of tourism services are related to the need to protect natural landscapes, biodiversity, and cultural values of the local population. Barrientos et al. (2021) offered parametric modeling to justify ways to increase the protection of cultural and natural heritage in the fight against socio-economic and, in particular, the demographic crisis in rural areas at the global level.

Lozano-Oyola et al. (2019) investigated the planning of destinations within the management of sustainable tourism, using the approach of linear economic and mathematical programming to assess changes in the model's components. Bertocchi et al. (2020) used a fuzzy model of linear programming to study excessive tourist flows that cause socio-economic conflicts by using the example of Venice. Finally, Camatti et al. (2020) analyzed tourist capacity on the example of Dubrovnik in the context of improving the response policy and eliminating the negative effects of excessive tourist flows.

Using the integer linear programming approach makes it possible to optimize tourist routes (Nadizadeh, 2021; Zhu, 2020), particularly in smart cities (Mangini et al., 2021). In addition, Barrena et al. (2016) use integer linear programming to determine the prospects for the development of eco-tourism taking into account the interests of rural communities using the example of national parks in Spain.

Economic and mathematical programming is used to study cross-sectoral relationships in the field of tourism, such as the "tourism-energy" relationship, including integer linear programming in the study of energy consumption in hotels using the example of the Canary Islands (Meschede, 2020). Belliggiano et al. (2020) examined the sustainability of agritourism, particularly in aspects of its programming, in the transition from a linear to a circular economy. Bukša et al. (2019) apply a linear economic-mathematical model of finding compromises between the port management and, accordingly, the center of maritime tourism and consumers of yachting services, taking into account environmental costs. Finally, Lekić et al. (2018) investigated the model of non-parametric linear programming to determine the potential of the wine industry in order to diversify economic and tourism activities at the regional level using the example of Serbia.

Fedorchenko et al. (2020) investigate regional tourism logistics using the methods of linear and integer programming. Tourism is considered in the sense of integration at the interstate level. Hodžić and Alibegović (2019) use a linear programming approach to evaluate decisions on tourism development at the regional level using the example of Croatia. Shahraki et al. (2015) used this approach to identify the links between tourism and other sectors of the national economy, such as Iran, to identify the tourism industry's potential to promote macroeconomic development. The combination of linear programming and input-output analysis models makes it possible to explore economic issues related to energy, environmental and social factors and find multifaceted compromise solutions (Oliveira et al., 2016).

Along with broad mathematical possibilities (Rardin, 2017), linear programming is a universal approach and method in current transdisciplinary research. In particular, Rodriguez-Miranda et al. (2021) use this method to analyze retrospective scenarios for socio-economic development. Based on this approach, Petrushenko et al. (2019) built a model of investing in health recreation. Kulkarni et al. (2016) analyzed transport flows in the recreation field based on an iterative approach within the application of linear programming. Bichler (2017) uses a linear programming approach to design markets in a digital economy. Paris (2016) uses this approach to address decentralized economic planning.

Given the above, this study aims to develop a model for decision-making on change management in the field of nature tourism using the example of Ukraine based on the approach of linear economic and mathematical programming. This was done by formalizing the studied changes in the variability of parameters of the model's objective function and the system of its constraints in accordance with the structure of nature tourism assets balanced by the principle of sustainability.

The linearization of change management in the field of nature tourism in the context of the need to take into account socio-environmental factors of sustainable development of the transition economy in terms of natural asset management (Boyce, 2001; Martinez-Harms et al., 2018), when the market mechanism is inefficient to direct economic relations in the right direction (Menshikov, 2006), is appropriate and possible given the features of the classical model of economic and mathematical programming (Kantorovich, 1965), as well as its modifications (Danzig & Thapa, 2003), which are summarized as:

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- linear economic and mathematical programming in the context of descriptive modeling of restrictions on nature tourism management corresponds to the aspects of sustainable development, namely, formalizing restrictions on the use of financial, human, and natural assets, as well as their balance in the application of appropriate mathematical procedures;

- target function that maximizes revenues from nature tourism (dual minimization function is not detailed in this paper, as the aim of the study is to determine the variability of the main target function and the corresponding constraints), corresponds to the economic and mathematical content of the above assets, the effective use of which depends on their productivity and the management of relevant changes in the tourism sector;

- in the context of developing decision-making mechanisms, in particular within the framework of change management in the field of nature-based tourism, the proposed linearization has the following three advantages: "simplicity: arguments based on linear programming are both elementary and transparent; unity: the machinery of linear programming provides a way to unify results from disparate areas of mechanism design; reach: it provides the ability to solve problems that appear to be beyond the reach of traditional methods "(Vohra, 2011, p. 4).

2. RESULTS

Based on the above, the rationale for decision-making on change management in nature tourism requires the use of linear economic and mathematical programming as an alternative to the aggregation of many individual environmental, social, financial, and other indicators of this sphere (algorithm in Figure 1).

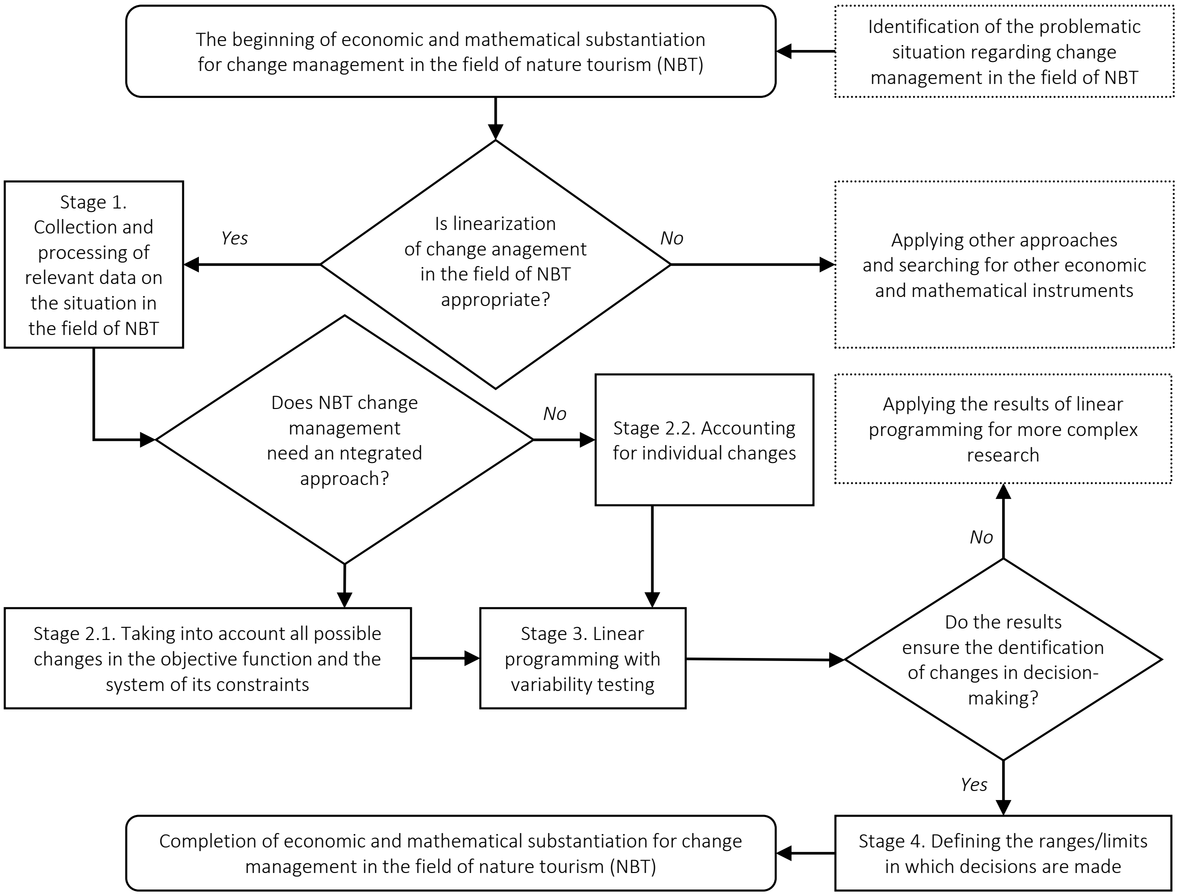

Figure 1. Algorithm for change management in the field of nature tourism based on linear programming

According to this algorithm, after proving the feasibility of using linear programming as opposed to other approaches and instruments, the first stage of change management begins. The initial data (Table A1) are summarized and averaged based on primary data analysis on the functioning of sanatoriums and other tourist and recreational facilities in Ukraine and abroad. The conditional example considers short-term tourism (during the weekend), which is in demand in conditions of forced isolation of the population during the COVID-19 pandemic (services are provided at the regional level in Ukraine). Given certain transformations in the recreational needs of the population during the pandemic, it is proposed to generalize the types of nature tourism services into 5 specialized groups (classified by the main goals of tourism), namely: "wow-effect" tourism, sports tourism, health tourism, traditional recreation, and green tourism. Furthermore, to simplify complex iterative calculations, nature tourism destinations are also classified by a limited number of types, namely: "wow-effect" tourism, green tourism and health tourism (depending primarily on the specifics of natural recreational resources within the location of these objects).

During the following stages, in accordance with the formalization of linear economic and mathematical programming, change management (in the context of analysis of the objective function coefficients – formula 1, as well as asset restrictions – formula 2) in the field of nature tourism (within one type of destination) is formulated as:

$$r(s)=\sum_{i=1}^{n}(m_i+\Delta m_i)\cdot s_i \to \max, \qquad (1)$$

$$\begin{cases} \sum_{i=1}^{n} a_{ik}\cdot s_i \le A_k+\Delta A_k, & k=1,2,\ldots,K \\ s_i \ge 0, & i=1,2,\ldots,n. \end{cases} \qquad (2)$$

where $r(s)$ – the result of economic activity of the nature-based tourism enterprise, thousand UAH; m_i (m_e, m_m, m_s, m_t, m_g) – market price of nature tourism services of the first type (thousand UAH/10 people): m_e – "wow-effect" tourism (based primarily on the tourist's unique experience related to the environment, such as glamping), m_m – health tourism (for example, sanatorium treatment), m_s – sports tourism (primarily in sports and training bases located in natural areas), m_t – traditional recreation (for example, stay in recreation centers in recreational areas in combination with gastro-tourism), m_g – green tourism (organized visits to ecosystems: rural, forest, protected wildlife tourism, etc.); Δm_i (Δm_e, Δm_m, Δm_s, Δm_t, Δm_g) – the magnitude of change in prices for nature tourism services of the i-th type, thousand UAH/10 people; s_i (s_e, s_m, s_s, s_t, s_g) – the number of services of the i-th type provided by an enterprise in the field of nature tourism, units; (S_i – the total volume of i-th services, thousand units.); A_k – the total value of assets (A_N – natural, A_H – human, A_F – financial) of nature tourism; A_N – total area of recreational land suitable for nature tourism services, Ap. a_{iN} (a_{eN}, a_{mN}, a_{sN}, a_{tN}, a_{gN}) – area of recreational land based on the number of nature tourism services, taking into account the ecological capacity of these lands, according to the source (The Verkhovna Rada of Ukraine, 2003), Ap/10 services; A_H – the total number of qualified human resources that can be involved in nature tourism, persons; a_{iH} (a_{eH}, a_{mH}, a_{sH}, a_{tH}, a_{gH}) – number of qualified human resources, by type of nature tourism, persons/10 services; A_F – the total amount of financial investments that can be attracted to the field of nature tourism within one type of tourist destination, thousand UAH. a_{iF} (a_{eF}, a_{mF}, a_{sF}, a_{tF}, a_{gF}) – financial investments by the i-th type of nature tourism, thousand UAH/10 services. To simplify the calculations and increase the weight of human and natural assets in nature tourism costs, it is assumed that the share of financial investments does not exceed half of the price of service; ΔA_k (ΔA_N, ΔA_H, ΔA_F) – the total value of change in the k-th type of assets of nature tourism, respectively: natural, human and financial. Since this example is an approximation for the further development of local small-scale projects in nature tourism, it is assumed that the total financial investment is not a constraint.

The calculations according to the above formulas assume compliance with the rules of filling in the standard table and iterative procedures (Table A2) given by Kantorovich (1965) and Danzig and Thapa (2003).

Changes that occur in the external economic and other environments and have an impact on the field of nature tourism are the object of management through their formalized internalization in the proposed model (formulas 1 and 2), which from an economic and mathematical standpoint (primarily by

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controlling the change in parameters (Δm_i and ΔA_k) to create a basis for making relevant decisions.

Depending on whether the problem of complex accounting of changes (step 2.1) or the problem of model analysis due to changes in a specific parameter (step 2.2) is solved, all possible options for changing model parameters (step 3) are explored. Finally, ranges of change are determined (step 4), within which decisions should be made to optimize the management of nature tourism in a changing environment.

At the beginning of stage 3, according to formulas 1 and 2, the results of basic calculations are obtained (Table 1), which is the basis for testing the variability model. An example of such calculations is given in Table A2:

- the initial values of the model parameters for each iteration are recorded in the upper corners of the cells; the calculated values are written in the lower corners of the cells, according to the optimization column and row (highlighted in the table by double lines);
- basic variables ($Y(A_k)$ – at the initial iteration) are replaced by the corresponding free variables before the final iteration, when the values of all free variables are positive (lower part of Table A2), which means the achievement of the optimal value of function $r(s^*)$ and the corresponding set of parameters in the column of basic variables (optimal program for the development of nature tourism).

Therefore, changes in model parameters are analyzed according to the following options:

- variability of prices for nature tourism services included/not included in the optimal program of its development;
- changes in restrictions on assets for which there is/no reserve within the optimal program of nature tourism development.

This analysis is carried out in more detail on the example of a destination that specializes in "wow-effect" tourism.

2.1. Analysis of the variability of prices for nature tourism services (Δm_i) included in the optimal program of its development

The optimal program for the development of nature tourism includes "wow-effect" services and traditional vacationing services (basic variables at

Table 1. Final iteration of the spreadsheet according to the standard record format in the linear programming model

The destination specializes in "wow-effect" tourism						
Basic variables (BV)	**Free parameter (FP)**	$Y(A_N)$	S_m	S_s	$Y(A_H)$	S_g
$r(s^*)$	647.04	0.412	4.408	2.645	2.352	42.944
S_e	8.82	0.015	0.264	0.308	–0.059	1.177
S_t	5.88	–0.024	1.176	0.706	0.294	–0.882
$Y(A_F)$	664.72	–0.159	–4.056	–2.734	–1.764	–16.708
The destination specializes in green tourism						
BV	**FP**	$Y(A_N)$	S_m	$Y(A_H)$	S_t	S_g
$r(s^*)$	688.565	0.631	15.042	0.571	1.799	110.29
S_e	9.725	0.058	0.39	–0.485	–0.678	8.25
S_s	8.565	–0.049	0.842	0.571	1.399	–5.71
$Y(A_F)$	609.085	–0.845	–7.14	4.539	9.351	–127.19
The destination specializes in health tourism						
BV	**FP**	S_m	$Y(A_H)$	S_s	S_t	S_g
$r(s^*)$	700.05	25.005	6.901	18.004	12.003	20.003
$Y(A_N)$	83.29	–21.671	–9.167	–24.17	–30.003	74.164
S_e	16.67	1.667	0.167	1.167	1	0.834
$Y(A_F)$	533.28	–26.672	–4.667	–16.67	–13.003	–14.336

the top of Table 1 are S_e and S_t, respectively). The search for economically acceptable (do not violate the condition of optimality $r(s^*)$ in Table 1) limits of changes in the coefficient m_e involves the analysis of an increase in $r^{\Delta}(s)$ of the objective function $r(s)$:

$$r(s) = 6,000 \cdot s_e + 3,500 \cdot s_m + +3,000 \cdot s_s + 2,000 \cdot s_t + +1,000 \cdot s_g \to \max, \tag{3}$$

$$r^{\Delta}(s) = (6,000 + \Delta m_e) \cdot s_e + +3,500 \cdot s_m + 3,000 \cdot s_s + +2,000 \cdot s_t + 1,000 \cdot s_g \to \max. \tag{4}$$

Then in Table A2: $m_m = 6,000 \rightarrow 6,000 + \Delta m_m$.

The result of iterative analysis (Table 2) is a system of inequalities.

$$\begin{cases} 0.412 + 0.015\Delta m_{\hat{a}e} \geq 0 \\ 4.408 + 0.264\Delta m_e \geq 0 \\ 2.645 + 0.308\Delta m_e \geq 0 \\ 2.352 - 0.059\Delta m_e \geq 0 \\ 42.944 + 1.177\Delta m_e \geq 0 \end{cases} \Rightarrow \begin{cases} \Delta m_e \geq -27.467 \\ \Delta m_e \geq -16.697 \\ \Delta m_e \geq -8.588 \\ \Delta m_e \leq 39.864 \\ \Delta m_e \geq -36.486 \end{cases}$$
$$\Rightarrow \begin{cases} \Delta m_e \geq -27.467 \\ \Delta m_e \geq -16.697 \\ \Delta m_e \geq -8.588 \Rightarrow \\ \Delta m_e \leq 39.864 \\ \Delta m_e \geq -36.486 \end{cases} \tag{5}$$
$$\Rightarrow -8.588 \leq \Delta m_e \leq 39.864.$$

Accordingly:

$$\begin{cases} \min \Delta m_e = -858.8 \\ \max \Delta m_e = 3,986.4 \end{cases} \Rightarrow$$
$$\Rightarrow \begin{cases} \min m_e = m_e + \min \Delta m_e \\ \max m_e = m_e + \max \Delta m_e \end{cases} \Rightarrow \tag{6}$$
$$\Rightarrow 5,141.2 \leq m_e \leq 9,986.4.$$

In a transitional economy, prices for nature tourism services can vary below market prices (at the so-called inclusive level – $m_{i(inc)}$) to cover a larger segment of potential domestic tourists. Given the growing solvency of the population, the trend of changes in prices for tourist services will be positive (exclusive price level – $m_{i(ex)}$): $5,141.2 \leq m_{e(inc)} \leq 6,000$; $6,000 \leq m_{e(ex)} \leq 9,986.4$. The change in price m_e within certain limits does not violate the structure of nature tourism services provided by an enterprise. However, there is a change in the row of objective function $r(s^*) \rightarrow r(s^{**})$, namely: $r(s^{**}) = r(s^*) + 8.82\Delta m_e$; $571.294 \leq r(s^{**}) \leq 986.40$.

The variability and limits of price sustainability for traditional recreation services are determined similarly – Table A3.

2.2. Analysis of price variability for nature tourism services (Δmi), which are not included in the optimal program of its development

Health, sports, and green tourism services were not included in the optimal program of nature tourism development (free variables at the top of

Table 2. Analysis of changes in the price of "wow-effect" of nature tourism services in the final iteration of programming

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_m	S_s	$Y(A_H)$	S_g
$r(s^*)$	$647.04+8.82\Delta m_e$	$0.412+0.015\Delta m_e$	$4.408+0.264\Delta m_e$	$2.645+0.308\Delta m_e$	$2.352-0.059\Delta m_e$	$42.944+1.177\Delta m_e$
S_e	8.82	0.015	0.264	0.308	–0.059	1.177
S_t	5.88	–0.024	1.176	0.706	0.294	–0.882
$Y(A_F)$	664.72	–0.159	–4.056	–2.734	–1.764	–16.708

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Table 1 are S_m, S_s, and S_g, respectively). Within the analysis of changes in the coefficients m_m = 3,500 UAH, m_s = 3,000 UAH, and m_g = 1,000 UAH (according to formula 1) relative to the economically permissible limits of these changes, in particular, for the coefficient m_m the increase of the objective function is (Table 3):

$$r(s) = 6,000 \cdot s_e + 3,500 \cdot s_m + \\ +3,000 \cdot s_s + 2,000 \cdot s_t + \\ +1,000 \cdot s_g \to \max, \tag{7}$$

$$r^{\Delta}(s) = 6,000 \cdot s_e + (3,500 + \Delta m_m) \cdot s_m + \\ +3,000 \cdot s_s + 2,000 \cdot s_t + 1,000 \cdot s_g \to \max. \tag{8}$$

The transition m_m = 3,500 → 3,500 + Δm_m causes only a change in the coefficient in the row of the objective function in column S_m, which is an additional double estimate V_m. That is, for 3500+Δm_m and the corresponding optimal value V_m^* = 4.408, there is a change V_m^{**} = 4.408 – Δm_m. An additional double estimate explains the disadvantages of providing services: V_m^* = 4.408 means that the marginal cost of production of health tourism services exceeds its price by 4.408/100 = 440.8 UAH.

The optimality of the value of the objective function meets the condition:

$$4.408 - \Delta m_m \geq 0 \Rightarrow \Delta m_m \leq 4.408, \\ V_m^* = 4.408 \Rightarrow \max \Delta m_m = V_m^* = 4.408. \tag{9}$$

Since S_m is not included in the optimal program of nature-based tourism development, Δm_m can be as small as possible: minΔm_m = –∞. Accordingly: –∞ < Δm_m ≤ 4.408.

$$\min m_m = m_m + \min \Delta m_m, \\ \max m_m = m_m + \max \Delta m_m, \\ \min m_m \leq m_m \leq \max m_m. \tag{10}$$

The price of the service is positive, accordingly:

$$0 \leq m_m \leq \max m_m, \\ 0 \leq m_m \leq m_m + V_m^*. \tag{11}$$

Since m_m = 3,500 UAH, V_m^* = 440.8 UAH, then the limits of change are 0 ≤ Δm_m ≤ 3,940.8. Within these limits' changes are observed only for V_m: $V_m^{**} = V_m^* - \Delta m_m$. Other model parameters remain unchanged.

Similarly, the variability and limits of price stability for sports tourism services are (0 ≤ Δm_s ≤ 3,264.5) and for green tourism (0 ≤ Δm_g ≤ 1,429.4).

2.3. Analysis of changes in asset constraints for which there is a reserve within the optimal program of nature-based tourism development

The reserve is for financial assets (Table 1): $Y(A_F)$ on the final iteration is in the column of basic variables, A_F = 664.72 thousand UAH. To find out how an increase in A_F + ΔA_F will affect other parameters of the model, the following inequality is considered:

$$30 \cdot s_e + 18 \cdot s_m + 15 \cdot s_s + \\ +12 \cdot s_t + 8 \cdot s_g \leq 1,000 + \Delta A_F, \tag{12}$$

$$Y(A_F) = (1,000 + \Delta A_F) - \\ -(30 \cdot s_e + 18 \cdot s_m + 15 \cdot s_s + 12 \cdot s_t + 8 \cdot s_g). \tag{13}$$

Provided that the initial conditions of investment are preserved (Table 4), that is A_F ≤ 1,000, ΔA_F ≥ 0:

Table 3. Analysis of changes in the price of health and medical services in the final iteration of programming

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_m	S_s	$Y(A_H)$	S_g
$r(s^*)$	647.04	0.412	4.408 – Δm_m	2.645	2.352	42.944
S_e	8.82	0.015	0.264	0.308	–0.059	1.177
S_t	5.88	–0.024	1.176	0.706	0.294	–0.882
$Y(A_F)$	664.72	–0.159	–4.056	–2.734	–1.764	–16.708

Table 4. Analysis of changes in the constraints of financial assets of "wow-effect" tourism on the final iteration of programming

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_m	S_s	$Y(A_H)$	S_g
$r(s^*)$	647.04	0.412	4.408	2.645	2.352	42.944
S_e	8.82	0.015	0.264	0.308	–0.059	1.177
S_t	5.88	–0.024	1.176	0.706	0.294	–0.882
$Y(A_F)$	664.72+ΔA_F	–0.159	–4.056	–2.734	–1.764	–16.708

$$\begin{cases} \min A_F = A_F + \min \Delta A_F \\ \max A_F = A_F + \max \Delta A_F \end{cases} \Rightarrow \Rightarrow \min A_F \le A_F \le \max A_F \Rightarrow \Rightarrow 335.28 \le A_F \le 1{,}000. \tag{14}$$

Therefore, the change in financial assets within certain limits does not affect the model's parameters, including the structure of nature-based tourism services. At the same time, the ability to change the size of the financial assets reserve is vital for decision-making.

2.4. Analysis of changes in assets' constraints for which there is no reserve within the optimal program of nature-based tourism development

According to Table 1, on the final iteration $Y(A_N)$ and $Y(A_H)$ are in the row of free variables, respectively, the reserve is absent for nature-based (A_N = 1,000 Ap) and human (A_H = 100 persons) assets. To find out how an increase in $A_N + \Delta A_N$ will affect other parameters of the model, the following inequality is considered:

$$100 \cdot s_e + 50 \cdot s_m + 45 \cdot s_s + +20 \cdot s_t + 100 \cdot s_g \le 1{,}000 + \Delta A_N, \tag{15}$$

$$Y(A_N) = (1{,}000 + \Delta A_N) - -(100 \cdot s_e + 50 \cdot s_m + 45 \cdot s_s + 20 \cdot s_t + 100 \cdot s_g). \tag{16}$$

The optimal solution is:

$$\begin{cases} 8.82 + 0.015\Delta A_N \ge 0 \\ 5.88 - 0.024\Delta A_N \ge 0 \\ 664.72 - 0.159\Delta A_N \ge 0 \end{cases} \Rightarrow \Rightarrow \begin{cases} \Delta A_N \ge -588 \\ \Delta A_N \le 245 \\ \Delta A_N \le 4{,}180.629 \end{cases} \Rightarrow \Rightarrow -588 \le \Delta A_N \le 245. \tag{17}$$

Within the determined limits, the change in the area of recreational lands (as a unified basis of natural tourism assets) does not violate the structure of nature-based tourism services ("wow-effect" tourism destination), but affects the amount of income and number of services by types S_e and S_t (Table 5):

$$\begin{cases} \min A_N = A_N + \min \Delta A_N \\ \max A_N = A_N + \max \Delta A_N \end{cases} \Rightarrow \Rightarrow \min A_N \le A_N \le \max A_N \Rightarrow \Rightarrow 412 \le A_N \le 1{,}245, \tag{18}$$

Table 5. Analysis of changes in the limitations of natural assets of "wow-effect" tourism on the final iteration of programming

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_m	S_s	$Y(A_H)$	S_g
$r(s^*)$	647.04 + 0.412ΔA_N	0.412	4.408	2.645	2.352	42.944
S_e	8.82 + 0.015ΔA_N	0.015	0.264	0.308	–0.059	1.177
S_t	5.88 – 0.024ΔA_N	–0.024	1.176	0.706	0.294	–0.882
$Y(A_F)$	664.72 – 0.159ΔA_N	–0.159	–4.056	–2.734	–1.764	–16.708

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$$r\left(s^{**}\right)=r\left(s^{*}\right)+0.412\Delta A_N,$$
$$404.784 \le r(s^{**}) \le 747.98, \tag{19}$$

$$\begin{cases} S_e^{**}=S_e^{*}+\ 0.015\Delta A_N \\ S_t^{**}=S_t^{*}-0.024\Delta A_N \end{cases} \Rightarrow \begin{cases} 0 \le S_e^{**} \le 124 \\ 0 \le S_t^{**} \le 199 \end{cases}. \tag{20}$$

Similarly, Table A4 presents variability and limits of sustainability for human resource constraints ("wow-effect" tourism destination), determined by qualification requirements for the provision of quality tourism services, including the level of special education, experience, and hospitality.

The results of economic and mathematical substantiation according to the above algorithm are given in Tables A5-A8 (green tourism destination) and Tables A9-A10 (destination of health and medical tourism). The generalized results of testing the variability of the developed model's parameters presented in Table A11 are an integral completion in forming the basis for change management in the field of nature tourism based on linear programming. Given the approximate nature of the model and the specifics of the field of change management, more important are not absolute, but relative values of indicators and the format of ranges in the resulting table.

CONCLUSION

The study develops a model for decision-making on change management in nature-based tourism using economic and mathematical programming approximated to a linear form to simplify iterative calculations. Using the example of destinations in Ukraine, the model considers short-term tourism services classified according to the criterion of the main goal of travel by type: "wow-effect" tourism, sports tourism, health tourism, traditional recreation, and green tourism. The substance of the changes formalized in the model is determined by the factors of tourist risks and safety, quality of services, and recreational environment, in their socio-economic and natural-ecological context. In particular, the negative value of changes in the parameter of natural assets may reflect an anthropogenic decline in the capacity of the recreational area. Both market and other institutional factors explain the dynamics of restrictions on natural and other assets. When formulating restrictions for the assets of natural tourism destinations two cases are considered: assets for which there are reserves, in particulars, financial ones, and assets for which there are no reserves. The iterative analysis revealed that for all destinations where services are included in the optimal program of nature-based tourism development at the regional level in Ukraine, the limits on human assets have no reserves, which affects the number of services and the income of tourism companies. A change in the amount of financial assets for which there is a reserve does not affect the amount of income. The results of assessing the variability of the model parameters make it possible to analyze and make appropriate decisions on changes in recreational areas and human resources, on the limits of changes in income due to the dynamics of service prices and to determine sustainability limits for restrictions on natural and human assets of nature-based tourist destinations. These results also substantiate adjustments to the relevant legislation, particularly the methodology for calculating the volumes of tourism activities in Ukraine.

AUTHOR CONTRIBUTIONS

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APPENDIX A

Table A1. Input data for the model of change management in the field of nature-based tourism in Ukraine (conditional example)

Source: Calculated by the authors based on Booking Holdings (n.d.), Sanatoriums of Ukraine (n.d.), Condé Nast Traveler (n.d.), Travel + Leisure (n.d.).

Parameters by types of destination	Type of nature-based tourism services				
	"Wow effect" tourism	Health and medical tourism	Sports tourism	Traditional recreation	Green tourism
Cost, thousand UAH/10 services					
"Wow effect" tourism	60	35	30	20	10
Green tourism	40	30	35	20	20
Health and medical tourism	42	45	31	30	15
Natural assets, Ap					
Total	1,000	1,000	1,000	1,000	1,000
/10 services					
"Wow effect" tourism	100	50	45	20	100
Green tourism	60	65	50	30	200
Health and medical tourism	55	70	40	25	120
Human assets, persons					
Total	100	100	100	100	100
/10 services					
"Wow effect" tourism	8	8	6	5	5
Green tourism	5	7	6	5	7
Health and medical tourism	6	10	7	6	5
Financial assets, thousand UAH					
Total	1,000	1,000	1,000	1,000	1,000
/10 services					
"Wow effect" tourism	30	18	15	12	8
Green tourism	27	16	15	12	10
Health and medical tourism	28	20	16	15	9

Table A2. Iterations of linear programming (destination of nature-based tourism specializing in services of "wow-effect" tourism)

Basic variables (BV)	Free parameter (VP)	Free variables				
		S_e	S_m	S_s	S_t	S_g
$r(s)$	0 600	–60 0.6	–35 30	–30 27	–20 12	–10 60
$Y(A_N)$	1,000 10	100 0.01	50 0.5	45 0.45	20 0.2	100 1
$Y(A_H)$	100 –80	8 –0.08	8 –4	6 –3.6	5 –1.6	5 –8
$Y(A_F)$	1,000 –300	30 –0.3	18 –15	15 –13.5	12 –6	8 –30
Intermediate iteration						
BV	**VP**	$Y(A_N)$	S_m	S_s	S_t	S_g
$r(s)$	600 47.04	0.6 –0.188	–5 9.408	–3 5.645	–8 2.352	50 –7.056
S_e	10 –1.18	0.01 0.005	0.5 –0.236	0.45 –0.142	0.2 –0.059	1 0.177
$Y(A_H)$	20 5.88	–0.08 –0.024	4 1.176	2.4 0.706	3.4 0.294	–3 –0.882
$Y(A_F)$	700 –35.28	–0.3 0.141	3 –7.056	1.5 –4.234	6 –1.764	–22 5.292

Table A2 (cont.). Iterations of linear programming (destination of nature-based tourism specializing in services of "wow-effect" tourism)

Basic variables (BV)	Free parameter (VP)	Free variables				
		S_e	S_m	S_s	S_t	S_g
Final iteration						
BV	**VP**	$Y(A_N)$	S_m	S_s	$Y(A_H)$	S_g
$r(s^*)$	647.04	0.412	4.408	2.645	2.352	42.944
S_e	8.82	0.015	0.264	0.308	–0.059	1.177
S_t	5.88	–0.024	1.176	0.706	0.294	–0.882
$Y(A_F)$	664.72	–0.159	–4.056	–2.734	–1.764	–16.708

Table A3. Price variability for traditional recreation services (destination of nature-based "wow-effect" tourism)

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_m	S_s	$Y(A_H)$	S_g
$r(s^*)$	$647.04 + 5.88\Delta m_t$	$0.412 - 0.024\Delta m_t$	$4.408 + 1.176\Delta m_t$	$2.645 + 0.706\Delta m_t$	$2.352 + 0.294\Delta m_t$	$42.944 - 0.882\Delta m_t$
S_e	8.82	0.015	0.264	0.308	–0.059	1.177
S_t	5.88	–0.024	1.176	0.706	0.294	–0.882
$Y(A_F)$	664.72	–0.159	–4.056	–2.734	–1.764	–16.708

$$\begin{cases} 0.412 - 0.024\Delta m_t \ge 0 \\ 4.408 + 1.176\Delta m_t \ge 0 \\ 2.645 + 0.706\Delta m_t \ge 0 \\ 2.352 + 0.294\Delta m_t \ge 0 \\ 42.944 - 0.882\Delta m_t \ge 0 \end{cases} \Rightarrow \begin{cases} \Delta m_t \le 17.167 \\ \Delta m_t \ge -3.748 \\ \Delta m_t \ge -3.747 \Rightarrow -3.747 \le \Delta m_t \le 17.167, \\ \Delta m_t \ge -8.000 \\ \Delta m_t \le 48.689 \end{cases} \tag{21}$$

$$\begin{cases} \min \Delta m_t = -374.7 \\ \max \Delta m_t = 1{,}716.7 \end{cases} \Rightarrow \begin{cases} \min m_t = m_t + \min \Delta m_t \\ \max m_t = m_t + \max \Delta m_t \end{cases} \Rightarrow 1{,}625.3 \le m_t \le 3{,}716.7, \tag{22}$$

$$1{,}625.3 \le m_{t(c)} \le 2{,}000, \quad 2{,}000 < m_{t(e)} \le 3{,}716.7, \tag{23}$$

$$r\left(s^{**}\right) = r\left(s^*\right) + 5.88\Delta m_t, \quad 625.008 \le r(s^{**}) \le 747.982. \tag{24}$$

Table A4. Changes in human assets limitations for "wow-effect" tourism destination at the final iteration of programming

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_m	S_s	$Y(A_H)$	S_g
$r(s^*)$	$647.04 + 2.352\Delta A_H$	0.412	4.408	2.645	2.352	42.944
S_e	$8.82 - 0.059\Delta A_H$	0.015	0.264	0.308	–0.059	1.177
S_t	$5.88 + 0.294\Delta A_H$	–0.024	1.176	0.706	0.294	–0.882
$Y(A_F)$	$664.72 - 1.764\Delta A_H$	–0.159	–4.056	–2.734	–1.764	–16.708

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$$\begin{cases} 8.82 - 0.059\Delta A_H \geq 0 \\ 5.88 + 0.294\Delta A_H \geq 0 \\ 664.72 - 1.764\Delta A_H \geq 0 \end{cases} \Rightarrow \begin{cases} \Delta A_H \leq 149.492 \\ \Delta A_H \geq -20 \\ \Delta A_H \leq 376.825 \end{cases} \Rightarrow -20 \leq \Delta A_H \leq 150, \tag{25}$$

$$\begin{cases} \min A_H = A_H + \min \Delta A_H \\ \max A_H = A_H + \max \Delta A_H \end{cases} \Rightarrow \min A_H \leq A_H \leq \max A_H \Rightarrow 80 \leq A_H \leq 250, \tag{26}$$

$$r\left(s^{**}\right) = r\left(s^{*}\right) + 2.352\Delta A_H, \quad 600 \leq r(s^{**}) \leq 999.84, \tag{27}$$

$$\begin{cases} S_e^{**} = S_e^{*} - 0.059\Delta A_H \\ S_t^{**} = S_t^{*} + 0.294\Delta A_H \end{cases} \Rightarrow \begin{cases} 0 \leq S_e^{**} \leq 100 \\ 0 \leq S_t^{**} \leq 499 \end{cases}. \tag{28}$$

Table A5. Price variability for "wow-effect" tourism services (green tourism destination)

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_m	$Y(A_H)$	S_t	S_g
$r(s^*)$	$688.565 + 9.725\Delta m_e$	$0.631 + 0.058\Delta m_e$	$15.042 + 0.39\Delta m_e$	$0.571 - 0.485\Delta m_e$	$1.799 - 0.678\Delta m_e$	$110.29 + 8.25\Delta m_e$
S_e	9.725	0.058	0.39	–0.485	–0.678	8.25
S_s	8.565	–0.049	0.842	0.571	1.399	–5.71
$Y(A_F)$	609.085	–0.845	–7.14	4.539	9.351	–127.19

$$r(s) = 4{,}000 \cdot s_e + 3{,}000 \cdot s_m + 3{,}500 \cdot s_s + 2{,}000 \cdot s_t + 2{,}000 \cdot s_g \to \max, \tag{29}$$

$$r^{\Delta}(s) = (4{,}000 + \Delta m_e) \cdot s_e + 3{,}000 \cdot s_m + 3{,}500 \cdot s_s + 2{,}000 \cdot s_t + 2{,}000 \cdot s_g \to \max, \tag{30}$$

$$\begin{cases} 0.631 + 0.058\Delta m_e \geq 0 \\ 15.042 + 0.39\Delta m_e \geq 0 \\ 0.571 - 0.485\Delta m_e \geq 0 \\ 1.799 - 0.678\Delta m_e \geq 0 \\ 110.29 + 8.25\Delta m_e \geq 0 \end{cases} \Rightarrow \begin{cases} \Delta m_e \geq -10.879 \\ \Delta m_e \geq -38.569 \\ \Delta m_e \leq 1.177 \\ \Delta m_e \leq 2.653 \\ \Delta m_e \geq -13.368 \end{cases} \Rightarrow -10.879 \leq \Delta m_e \leq 1.177, \tag{31}$$

$$\begin{cases} \min \Delta m_e = -1{,}087.9 \\ \max \Delta m_e = 117.7 \end{cases} \Rightarrow \begin{cases} \min m_e = m_e + \min \Delta m_e \\ \max m_e = m_e + \max \Delta m_e \end{cases} \Rightarrow 2{,}912.1 \leq m_e \leq 4{,}117.7, \tag{32}$$

$$2{,}912.1 \leq m_{e(inc)} \leq 4{,}000, \quad 4{,}000 < m_{e(ex)} \leq 4{,}117.7, \tag{33}$$

$$r\left(s^{**}\right) = r\left(s^{*}\right) + 9.725\Delta m_e, \; 582.767 \leq r(s^{**}) \leq 700.011. \tag{34}$$

Table A6. Price variability for sports tourism services (green tourism destination)

Basic variables	Free parameter	Free variables					
		$Y(A_N)$	S_m	$Y(A_H)$	S_t	S_g
$r(s^*)$	$688.565 + 8.565\Delta m_s$	$0.631 - 0.049\Delta m_s$	$15.042 + 0.842\Delta m_s$	$0.571 + 0.571\Delta m_s$	$1.799 + 1.399\Delta m_s$	$110.29 - 5.71\Delta m_s$
S_e	9.725	0.058	0.39	–0.485	–0.678	8.25
S_s	8.565	–0.049	0.842	0.571	1.399	–5.71
$Y(A_F)$	609.085	–0.845	–7.14	4.539	9.351	–127.19

$$\begin{cases} 0.631-0.049\Delta m_s \geq 0 \\ 15.042+0.842\Delta m_s \geq 0 \\ 0.571+0.571\Delta m_s \geq 0 \\ 1.799+1.399\Delta m_s \geq 0 \\ 110.29-5.71\Delta m_s \geq 0 \end{cases} \Rightarrow \begin{cases} \Delta m_s \leq 12.878 \\ \Delta m_s \geq -17.865 \\ \Delta m_s \geq -1.000 \\ \Delta m_s \geq -1.286 \\ \Delta m_s \leq 19.315 \end{cases} \Rightarrow -1.000 \leq \Delta m_s \leq 12.878, \tag{35}$$

$$\begin{cases} \min \Delta m_s = -100.0 \\ \max \Delta m_s = 1,287.8 \end{cases} \Rightarrow \begin{cases} \min m_s = m_s + \min \Delta m_s \\ \max m_s = m_s + \max \Delta m_s \end{cases} \Rightarrow 3,400.0 \leq m_s \leq 4,787.8, \tag{36}$$

$$1,625.3 \leq m_{e(inc)} \leq 2,000, \quad 2,000 < m_{e(ex)} \leq 3,716.7, \tag{37}$$

$$r\left(s^{**}\right) = r\left(s^*\right) + 8.565\Delta m_s, \quad 680.000 \leq r(s^{**}) \leq 798.865. \tag{38}$$

Table A7. Changes in restrictions on natural assets of green tourism destinations in the final iteration of programming

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_s	$Y(A_H)$	S_t	S_g
$r(s^*)$	$688.565+0.631\Delta A_N$	0.631	15.042	0.571	1.799	110.29
S_e	$9.725+0.058\Delta A_N$	0.058	0.39	–0.485	–0.678	8.25
S_s	$8.565-0.049\Delta A_N$	–0.049	0.842	0.571	1.399	–5.71
$Y(A_F)$	$609.085-0.845\Delta A_N$	–0.845	–7.14	4.539	9.351	–127.19

$$100 \cdot s_e + 50 \cdot s_m + 45 \cdot s_s + 20 \cdot s_t + 100 \cdot s_g \leq 1,000 + \Delta A_N, \tag{39}$$

$$Y(A_N) = (1,000 + \Delta A_N) - (100 \cdot s_e + 50 \cdot s_m + 45 \cdot s_s + 20 \cdot s_t + 100 \cdot s_g), \tag{40}$$

$$\begin{cases} 9.725+0.058\Delta A_N \geq 0 \\ 8.565-0.049\Delta A_N \geq 0 \\ 609.085-0.845\Delta A_N \geq 0 \end{cases} \Rightarrow \begin{cases} \Delta A_N \geq -167.672 \\ \Delta A_N \leq 174.796 \\ \Delta A_N \leq 720.811 \end{cases} \Rightarrow -167.672 \leq \Delta A_N \leq 174.796 \tag{41}$$

$$\begin{cases} \min A_N = A_N + \min \Delta A_N \\ \max A_N = A_N + \max \Delta A_N \end{cases} \Rightarrow \min A_N \leq A_N \leq \max A_N \Rightarrow 832 \leq A_N \leq 1,175, \tag{42}$$

$$r(s^{**}) = r(s^*) + 0.631\Delta A_N, \quad 582.764 \leq r(s^{**}) \leq 798.861, \tag{43}$$

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$$\begin{cases} S_e^{**} = S_e^* + 0.058\Delta A_N \\ S_s^{**} = S_s^* - 0.049\Delta A_N \end{cases} \Rightarrow \begin{cases} 0 \le S_e^{**} \le 199 \\ 0 \le S_t^{**} \le 168 \end{cases}. \tag{44}$$

Table A8. Changes in restrictions on human assets of green tourism destinations in the final iteration of programming

Basic variables	Free parameter	Free variables				
		$Y(A_N)$	S_m	$Y(A_H)$	S_t	S_g
$r(s^*)$	688.565 + 0.571ΔA_H	0.631	15.042	0.571	1.799	110.29
S_e	9.725 – 0.485ΔA_H	0.058	0.39	–0.485	–0.678	8.25
S_s	8.565 + 0.571ΔA_H	–0.049	0.842	0.571	1.399	–5.71
$Y(A_F)$	609.085 + 4.539ΔA_H	–0.845	–7.14	4.539	9.351	–127.19

$$\begin{cases} 9.725 - 0.485\Delta A_H \ge 0 \\ 8.565 + 0.571\Delta A_H \ge 0 \\ 609.085 + 4.539\Delta A_H \ge 0 \end{cases} \Rightarrow \begin{cases} \Delta A_H \le 20.052 \\ \Delta A_H \ge -15 \\ \Delta A_H \ge -134.189 \end{cases} \Rightarrow -15 \le \Delta A_H \le 20.052, \tag{45}$$

$$\begin{cases} \min A_H = A_H + \min \Delta A_H \\ \max A_H = A_H + \max \Delta A_H \end{cases} \Rightarrow \min A_H \le A_H \le \max A_H \Rightarrow 85 \le A_H \le 121, \tag{46}$$

$$r(s^{**}) = r(s^*) + 0.571\Delta A_H, \quad 680 \le r(s^{**}) \le 700.015, \tag{47}$$

$$\begin{cases} S_e^{**} = S_e^* - 0.485\Delta A_H \\ S_t^{**} = S_s^* + 0.571\Delta A_H \end{cases} \Rightarrow \begin{cases} 0 \le S_e^{**} \le 170 \\ 0 \le S_s^{**} \le 200 \end{cases}. \tag{48}$$

Table A9. Price variability for "wow-effect" tourism services (destination of health and medical tourism)

Basic variables	Free parameter	Free variables				
		S_m	$Y(A_H)$	S_s	S_t	S_g
$r(s^*)$	700.05 + 16.67Δm_e	25.005 + 1.667Δm_e	6.901 + 0.167Δm_e	18.004 + 1.167Δm_e	12.003 + 1.00Δm_e	20.003 + 0.834Δm_e
$Y(A_N)$	83.29	–21.671	–9.167	–24.17	–30.003	74.164
S_e	16.67	1.667	0.167	1.167	1.0	0.834
$Y(A_F)$	533.28	–26.672	–4.667	–16.67	–13.003	–14.336

$$r(s) = 4,200 \cdot s_e + 4,500 \cdot s_m + 3,100 \cdot s_s + 3,000 \cdot s_t + 1,500 \cdot s_g \to \max, \tag{49}$$

$$r^{\Delta}(s) = (4,200 + \Delta m_e) \cdot s_e + 4,500 \cdot s_m + 3,100 \cdot s_s + 3,000 \cdot s_t + 1,500 \cdot s_g \to \max, \tag{50}$$

$$\begin{cases} 25.005 + 1.667\Delta m_e \ge 0 \\ 6.901 + 0.167\Delta m_e \ge 0 \\ 18.004 + 1.167\Delta m_e \ge 0 \\ 12.003 + 1.000\Delta m_e \ge 0 \\ 20.003 + 0.834\Delta m_e \ge 0 \end{cases} \Rightarrow \begin{cases} \Delta m_e \ge -15.000 \\ \Delta m_e \ge -41.323 \\ \Delta m_e \ge -15.428 \\ \Delta m_e \ge -12.003 \\ \Delta m_e \ge -23.984 \end{cases} \Rightarrow -12.003 \le \Delta m_e \le 0, \tag{51}$$

$$\begin{cases} \min \Delta m_e = -1,200.3 \\ \max \Delta m_e = 0.0 \end{cases} \Rightarrow \begin{cases} \min m_e = m_e + \min \Delta m_e \\ \max m_e = m_e + \max \Delta m_e \end{cases} \Rightarrow 2,999.7 \le m_e \le 4,200, \quad (52)$$

$$2,999.7 \le m_{e(inc)} < 4,200, \quad 4,200 \le m_{e(ex)}, \quad (53)$$

$$r(s^{**}) = r(s^{*}) + 16.67\Delta m_e, \quad 499.960 \le r(s^{**}) \le 700.05. \quad (54)$$

Table A10. Changes in restrictions on human assets of health and medical tourism destinations in the final iteration of programming

Basic variables	Free parameter	Free variables				
		S_m	$Y(A_H)$	S_s	S_t	S_g
$r(s^*)$	$700.05 + 6.901\Delta A_H$	25.005	6.901	18.004	12.003	20.003
$Y(A_N)$	$83.29 – 9.167\Delta A_H$	–21.671	–9.167	–24.17	–30.003	74.164
S_e	$16.67 + 0.167\Delta A_H$	1.667	0.167	1.167	1.0	0.834
$Y(A_F)$	$533.28 – 4.667\Delta A_H$	–26.672	–4.667	–16.67	–13.003	–14.336

$$\begin{cases} 83.29 - 21.671\Delta A_H \ge 0 \\ 16.67 + 0.167\Delta A_H \ge 0 \\ 533.28 - 4.667\Delta A_H \ge 0 \end{cases} \Rightarrow \begin{cases} \Delta A_H \le 3.843 \\ \Delta A_H \ge -99.820 \\ \Delta A_H \le 114.266 \end{cases} \Rightarrow -94.0 \le \Delta A_H \le 3.843, \quad (55)$$

$$\begin{cases} \min A_H = A_H + \min \Delta A_H \\ \max A_H = A_H + \max \Delta A_H \end{cases} \Rightarrow \min A_H \le A_H \le \max A_H \Rightarrow 6 \le A_H \le 104, \quad (56)$$

$$r(s^{**}) = r(s^{*}) + 6.901\Delta A_H, \quad 51.356 \le r(s^{**}) \le 726.571, \quad (57)$$

$$S_e^{**} = S_e^{*} + 0.167\Delta A_H \Rightarrow 0 \le S_e^{**} \le 173. \quad (58)$$

Table A11. Generalized results of change management substantiation in the field of nature-based tourism using the model of linear programming

Indicators by groups of nature–based tourism services	Type of tourism destination					
	"Wow effect" tourism	%	Green tourism	%	Health and medical tourism	%
Number of services, units/weekend: "Wow effect" tourism	88	100.00	97	100.00	167	100.00
Health and medical tourism	–	–	–	–	–	–
Sports tourism	–	–	86	100.00	–	–
Traditional recreation	59	100.00	–	–	–	–
Green tourism	–	–	–	–	–	–
Inclusive range of change in natural assets, Ap): "Wow effect" tourism	88-124	140.91	97-199	205.15	–	–
Sports tourism	–	–	86-168	195.35	–	–
Traditional recreation	59-199	337.29	–	–	–	–
Inclusive range of changes in the number of human assets, persons: "Wow effect" tourism	88-100	113.64	97-170	175.26	167-173	103.59
Sports tourism	–	–	86-200	232.56	–	–
Traditional recreation	59-499	845.76	–	–	–	–

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Table A11 (cont.). Generalized results of change management substantiation in the field of nature-based tourism using the model of linear programming

Indicators by groups of nature–based tourism services	Type of tourism destination					
	"Wow effect" tourism	%	Green tourism	%	Health and medical tourism	%
Income, thousand UAH	647.04	100.00	688.57	100.00	700.05	100.00
Range of changes in the amount of income (minΔ – maxΔ) due to the dynamics of prices for services: "Wow effect" tourism	571.294-998.640	88.29-154.34	582.767-700.011	84.63-101.66	499.96-700.05	71.42-100.00
Sports tourism	–	–	680.000–798.865	98.76–116.02	–	–
Traditional recreation	625.008-747.982	96.59-115.60	–	–	–	–
Range of prices with the preservation of income structure (min – max), UAH: "Wow effect" tourism	5,141.2-9,986.4	85.69-166.44	2,912.1-4,117.7	72.80-102.94	2,999.7-4,200.0	71.42-100.00
Sports tourism	–	–	3,400.0-4,787.8	97.14-136.79	–	–
Traditional recreation	1,625.3-3,716.7	81.27-185.84	–	–	–	–
Inclusive range of prices, UAH: "Wow effect" tourism	5,141.2-6,000.0	85.69-100.00	2,912.1-4,000.0	72.80-100.00	2,999.7-4,200.0	71.42-100.00
Sports tourism	–	–	3,400.0-3,500.0	97.14-100.00	–	–
Traditional recreation	1625.3-2000.0	81.27-100.00	–	–	–	–
Exclusive range of prices, UAH: "Wow effect" tourism	6,000.0-9,986.4	100.00-166.44	4,000.0-4,117.7	100.00-102.94	4,200.0	100.00
Sports tourism	–	–	3,500.0-4,787.8	100.00-136.79	–	–
Traditional recreation	2,000.0-3,716.7	100.00-185.84	–	–	–	–
Sustainability limits for restrictions on natural assets (min – max), UAH	412-1,245	41.20-124.50	832-1,175	83.20-117.50	–	–
Sustainability limits for human assets (min – max), persons	80-250	80.00-250.00	85-121	85.00-121.00	6-104	6.00-104.00
Financial assets, thousand UAH	335.28	100.00	390.90	100.00	466.72	100.00
Coefficient of investment attractiveness, UAH / UAH	1.930	100.00	1.761	100.00	1.500	100.00
Range of investment attractiveness, UAH/UAH taking into account changes in the price of services: "Wow effect" tourism	1.704-2.979	88.29-154.35	1.491-1.791	84.67-101.70	1.071-1.500	71.40-100.00
Traditional recreation	1.864-2.231	96.58-115.60	–	–	–	–
Sports tourism	–	–	1.740-2.044	98.81-116.07	–	–