

DEVELOPMENT OF SUSTAINABLE AND ENVIRONMENTALLY FRIENDLY TOURISM THROUGH THE APPLICATION OF TECHNOLOGIES

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Abstract

The study of harmonious and environmentally friendly tourism development emphasizes that sustainable tourism ensures that development meets the needs of current society without harming natural resources and leaving sufficient resources for future generations. To use the action of the technological process (robot activity in the environment) in the field of tourism, it is not limited only to guest service, environmental care, transport services and others. Robotic activity can be used as a spectacle to attract tourists. The activity of several or a dozen autonomous robots with mutual assistance to each other would be an interesting sight that tourists would like to see. This study aims to develop and test a model that learns on the basis of organizational reflex, performs tourist curiosity analysis and coordinates tourist attraction centers. The study reveals the benefits of robots not only in environmental care but also in tourism development.

Keywords: sustainable tourism, organizational reflex, technology, computer modeling

Introduction

Sustainable tourism meets the needs of current and future generations, is ecological and leaves sufficient resources for future generations. Ecological principles include responsible use of natural resources, waste reduction and biodiversity conservation (Baloch *et al.*, 2023; Trišić *et al.*, 2023; Van den Bergh, & Nijkamp, 1991). Sustainable tourism includes not only economic benefits, but also takes into account social well-being and ecological balance. It seeks to reduce harmful effects of tourism activities on the environment, economy and society by building a long-term, sustainable tourism industry. Sustainable tourism promotes fair wages, cooperation with local communities, and sustainable economic growth (Solís-Radilla *et al.*, 2019; Kişi, 2019). Therefore, there is currently a debate that the use of robots in the field of tourism is not limited to guest services, but also includes environmental care, transportation services, tourist monitoring and other areas. A great variety of aspects of the application of robots to tourism and its potential are presented by tourism scientists and practitioners (Chan, & Tung, 2019; Donhauser *et al.*, 2021; Van Wynsberghe, & Donhauser, 2018; Maurer *et al.*, 2016). Popularity of anthropomorphic robots in tourism suggests that tourists tend to prioritize technologies that simulate human traits and behaviors. This opens up new opportunities for improving the tourist experience and the overall efficiency of the tourism industry (Fuentes-Moraleda *et al.*, 2020; Belanche *et al.*, 2021; Christou *et al.*, 2020). The impact of rapidly developing technologies on the tourism sector is noticeable, especially when it comes to self-moving mechanisms and environmental robots. These technologies can not only help respond to changes in the environment, climate and biodiversity, but also contribute to the development of ecological care and sustainable tourism (Maurer *et al.*, 2016; Tussyadiah, 2020; Ivanov *et al.*, 2023).

However, as highlighted, the transformation of the tourism sector towards sustainability and ecology requires an integrated approach. This includes not only the implementation of technology, but also the cooperation of various interest groups, policy

development, education promotion and other factors. In addition, studies that evaluate not only the economic, but also the social impact of the use of robots in the tourism sector need to be carefully evaluated (Pan *et al.*, 2018; Fauzi, 2023).

The integration of robots into the tourism sector not only improves efficiency, but also brings with it challenges and opportunities towards sustainability and responsibility. This is an important step towards a future in which technology and tourism can coexist harmoniously.

Therefore, the *problem* should reflect how to use robotic activities effectively to develop sustainable and environmentally friendly tourism. The *goal* set to solve this problem is to create an environment-friendly tourism model using technology.

The developed model includes monitoring, situational analysis and the concept of organizational reflex and the execution of actions. Its purpose is to observe tourist attractions, assess their interest in the environment and coordinate the activities of robots. The model develops sustainable tourism through environmental surveillance.

Theoretical modeling and computer modeling were chosen to achieve the goal of the study. To explain and predict dynamic phenomena in the tourist environment, different methods of theoretical modeling are applied. The simplest, but still effective, is a method based on phenomenological laws, which helps to build not only a theoretical model, but also to implement the principles of sustainable tourism in practice (Husserl, 2006). Computer simulation was performed using Spyder (Python 3.8 environment) and applying functions that represent the behavior of the model.

1. Principles of sustainable and environmentally friendly tourism

Sustainable tourism is a unique tourism sector that implements the principles of sustainable development and focuses not only on economic profitability, but also on ecological and socio-cultural balance. According to Macbeth (2005), Fauzi (2023), the harmonious development of sustainable tourism ensures that tourism development meets the needs of the current society, does not exhaust natural resources and leaves enough resources for future generations. Intergenerational equity aims to ensure that current generations have the opportunity to experience the benefits of tourism without reducing opportunities for future generations (Rojas *et al.*, 2023), as ethical and holistic approach to development includes aspects of the ethics and comprehensiveness of tourism activities. According to Holden (2003), ethical tourism emphasizes fair treatment of local communities, environment, and preservation of cultural heritage, while a holistic approach emphasizes the comprehensive impact on the local economy, culture, and environment (Tasci, 2020). By paying attention to ecological principles, sustainable tourism emphasizes compliance with environmental standards. These include responsible use of natural resources, energy efficiency, waste reduction and biodiversity conservation (Van den Bergh, & Nijkamp, 1991). It is noteworthy that sociocultural principles in sustainable tourism, as noted by (Zhang *et al.*, 2021; Roberts, 2023) promote respect for indigenous cultures and traditions. Sustainable tourism is not only the development of a profitable tourism industry. In it, it is important to create conditions for tourism activities that contribute to ecological balance, promote economic growth, are fair and ethical in relation to society. Pan *et al.* (2018) observe that sustainable tourism aims to reduce the harmful effects of tourism activities on the environment, economy and society in order to achieve a sustainable ecology, a viable

economic, just and ethical society. Therefore, ecological balance is achieved through the environment friendly tourism models that promote the responsible use of natural resources in the tourism business and the stimulation of sustainable economic growth (Shedenov *et al.*, 2019; Tang, 2015). According to Li *et al.*, (2024), sustainable tourism seeks not only for economic benefits, but also to increase social welfare in local communities. In educating a just and ethical society, sustainable tourism takes into account social justice and ethical principles, which means that tourism activities must not have negative consequences for local communities, and visitors should respect local culture, traditions and the way of life of the inhabitants (Alamineh *et al.*, 2023; Zaidan, 2016). According to Firman *et al.* (2023), Trišić *et al.* (2023) sustainable ecology includes conservation of natural resources and compliance with environmental standards.

2. The role of organizational reflex in the use of technology

The organizational reflex is important not only in the implementation of the principles of sustainable tourism, but also in other areas. After delving into the theoretical statements about the processes of the human reflex arc, it becomes clear that the organizational reflex hypothetically plays an active role in the process of receiving information from the environment and forming a response (Vaitkevicius *et al.*, 2021). The ability to respond to environmental changes in the management of tourism flows, in isolation from the whole, forms a process: signal, reaction, response. Similar to the case of the human nervous system. With the help of the organizational reflex, a model that makes decisions taking into account tourist flows promptly responds to various changes in the environment and adapts to them, which increases the movement of tourist flows and the satisfaction of tourists. Simply by definition, it can be said that with the help of the organizational reflex, the model responds to external stimulus. In this case, the organizational reflex includes a constant assessment of performance, learning from experience and the ability to adapt to changing circumstances. This is how the organizational reflex can be applied to sustainable tourism.

There is currently a lot of interest in applying robots to sustainable tourism. The use of robots in this area is associated with goal of implementing the principles of sustainable and environmentally friendly tourism (Tussyadiah, 2020; Ivanov *et al.*, 2023). Robots can be used in various areas of tourism, from guest service (Chan, & Tung, 2019) and environmental supervision (Donhauser *et al.*, 2021; Van Wynsberghe, & Donhauser, 2018) to the provision of transport services (Maurer *et al.*, 2016). Murphy *et al.* (2017) see progress in the widespread use of robots in manufacturing, military forces, medicine, home care services and increasingly in hospitality and tourism. While some of these robots perform basic and routine tasks in hotels and restaurants (e.g., robotic floor cleaners). However, Christou *et al.* (2020) reveal that tourists prefer using anthropomorphic robots over any other type of robots. This innovation promises not only to improve the operational efficiency of the tourism industry, but also to contribute to the development of sustainability and responsible tourism (Fuentes-Moraleda *et al.*, 2020). According to Belanche *et al.* (2021), every step towards a robonomics future must be taken responsibly. According to Maurer *et al.* (2016), autonomous movement of a mechanism is a popular topic of discussion in the field of science, and sometimes very emotional, because a self-moving mechanism inspires admiration for its independent abilities. (Palacios-Florencio *et al.*, 2021. Tussyadiah (2020)

reveals the need to shape automated tourism as a social phenomenon and economic activity in the future. New forms of human dependence on such robots and new ways in which robots can improve the quality of life and environmental health (Donhauser *et al.*, 2021). In this case, a robot could educate tourists about ecology and remind them of the standards of ecological behavior (Pan *et al.*, 2018). Fauzi (2023) states that robots will become an integral part of tourism. As observed by Van Wynsberghe *et al.*, (2018), Belanche *et al.* (2021), environmental scientists and engineers are monitoring the application of robotics to integrate robots into ecosystems to help respond to accelerating changes in the environment, climate, and biodiversity, and researchers are promoting the study of environmental robotics. According to Palacios-Florencio *et al.* (2021), the tourism industry is probably one of the most affected by the crisis caused by Covid-19. The development of sustainable tourism can help alleviate the perceived fear of tourists visiting places with high concentrations of people. Ivanov, & Webster (2020) are critical of the economic aspects of service robots in tourism. According to Chan, & Tung (2019), Ivanov *et al.* (2020), robotic services may not necessarily improve the brand experience, as this is influenced by the role of moderation in the hotel segment.

In addition, it is important to note that the technologies used are another fundamental aspect that promotes sustainable tourism and responsible environmental management. As mentioned, these technologies could be related to diagnostics, planning, distribution of responsibilities, documentation, monitoring and measurements.

This shows that in the implementation of this model, it is important to have a system capable of learning and adapting to changing conditions in order to achieve the long-term and sustainable survival of the tourism sector. Oleśniewicz *et al.* (2020) created an exemplary natural environment management system in the park, which allows reducing harmful effects on the environment in a way that benefits both tourists and the environment.

According to Zhu, & Chang (2019), robot chefs are starting to replace human chefs in the restaurant industry. A robot chef as an object may or may not be attractive to locals and tourists. Palrão *et al.* (2023) analyze the management of robot activity in the tourism industry, how people react to the presence of robots in tourist attractions, their culture, attitude to novelty. Some may admire it, while others are angry that they occupy a person's workplace.

On this basis we carry out simulation assumption whether tourists would like to observe the activity of robots, where:

Number of tourists in the environment (N):

N_r – number of tourists when robots are operating in the environment.

N_{nr} – number of tourists when robots are not operating in the environment

Tourist emotion (P):

P_r – likelihood that tourists enjoy watching the activity of robots.

P_{nr} – likelihood that tourists do not like to watch the activity of robots.

Relationship of probabilities: let's say that tourists have only two choices.

$$P_r + P_{nr} = 1; \quad (1)$$

Assume that the average number of tourists in an environment when robots do not perform activities is N_{nr} , and when robots perform activities the number of tourists can increase, or decrease, depending on how they rate robotic activity spectacle. Then the number of tourists N_r can be expressed as:

$$N_r = N_{nr} \cdot (1 + k); \quad (2)$$

where k is the coefficient showing influence on the number of tourists.

We model different scenarios with different k values depending on the opinion of tourists about the spectacle of robotic activity:

if $k > 0$, spectacle of robotic activity attracts tourists.

if $k < 0$, spectacle of robotic activity scares off tourists.

if $k = 0$, spectacle of robotic activity does not affect the number of tourists.

In Figure 1, we represent graphically how changes the number of tourists N_r depending on k , compared to N_{nr} .

The study showed how the number of tourists in the environment (N_r) changes depending on the coefficient of influence (k), compared to the average number of tourists in the environment (N_{nr}). The red line denotes the average number of tourists in the environment ($N_{nr}=100$). This is the base level against which we compare the number of tourists (N_r). The blue line shows changes of the number of tourists in the environment (N_r) depending on the coefficient of influence (k). Positive k values:

If $k > 0$, the spectacle of robotic activity attracts more tourists. For example, when $k=0.5$, the number of tourists increases to 150. Negative k values: if $k < 0$, the spectacle of robotic activity scares off tourists. For example, when $k=-0.5$, the number of tourists decreases to 50. If $k=0$, the spectacle of robotic activity, has no effect, and the number of tourists remains the same as in the environment without robots ($N_{nr}=100$).

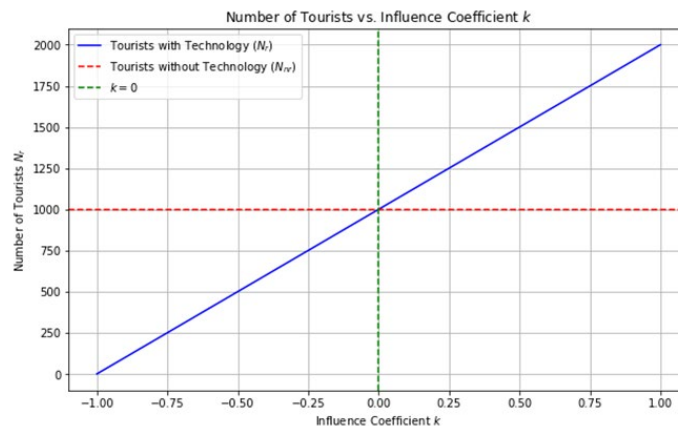


Figure 1. Graph of dependencies N_r , k , N_{nr}

It was found that the image of the activity of robots can attract or stop the flow of tourists depending on their attitude to technology. In the evaluation, it can be assumed based on the simulation results that the image of the robot activity will appeal to tourists, but not necessarily to everyone. Therefore, taking into account the fact that tourists enjoy observing the activities of robots, a model of sustainable and environmentally friendly tourism is being developed.

3. Presentation of theoretical model

The development of a sustainable and environmentally friendly tourism model encourages tourists to behave more environmentally friendly at the destination. This includes methods for creating greener tourist behavior, emphasizing that emotional reactions can be related to the reputation of a green destination and tourist memories, which in turn can promote environmentally responsible behavior. These principles, according to the aforementioned researchers Dolnicar (2020) and Su & Boostrom (2020), form a model of sustainable and environmentally friendly tourism that seeks to reduce the negative impact on areas and promote the long-term survival of the tourism sector (see Figure 2).

An essential aspect in this model is the process of environmental monitoring and information analysis to manage the places visited by tourist flows. This system uses tracking tools to obtain information about tourist behavior. The results of the analysis are used to make decisions about the organization in order to maintain the interest and attendance of tourists. This is a dynamic system that adapts to changing volumes of tourists. The organizational reflex plays an important role in allowing the system to learn and store information for future complex decision-making. The main task is to monitor the behavior of tourists and manipulate the place of activity of robots, controlling the attention of tourists in time and quantity.

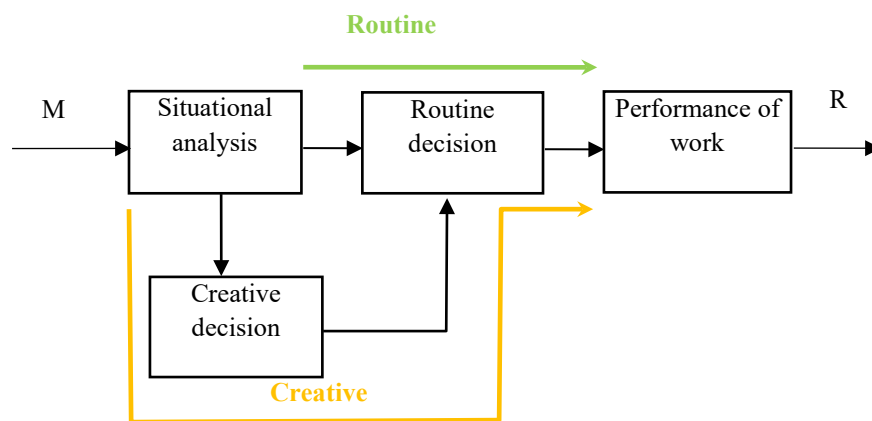


Figure 2. *A model of sustainable and environmentally friendly tourism*

Monitoring (M) function is the continuous monitoring of the tourist destination, the purpose of which is to monitor the tourist volumes. This monitoring also assesses the

dynamics of the environment, identifies objects and instructs them to classify them in order to effectively recognize the impact of tourism.

Situational analysis is related to classification and assignment of negative effects on nature to the object. This allows to assess the current situation and determine whether a routine or creative solution is needed.

Routine decision a standard procedure or process is one that has been developed or improved and optimized by a creative process and transferred to a routine process for continuous use.

Development of more complex processes and solutions that require human intervention (developed, improved and optimized).

Execution (Performance of work) is performing of a command/task formed by a decision. This is implemented through both routine and creative solutions that have been developed considering the results of environmental monitoring and situational analysis.

3.1. Mathematical Concept of the Model

Here: M – monitoring, N – number of tourists, K – environmental capacitance, R – technological mode, T – stopping time for tourists, γ – exponential degree of overflow effect, a – coefficient before logarithm, b – coefficient of technological mode impact, d – coefficient of overflow impact.

1. Monitoring

$$M(t) = \quad (1)$$

2. Performance of work

$$T_n^{istechnology} = (N_m, R_i) = a_m \cdot \ln \left((N_m + 1) \cdot \left(1 + b_i \cdot R_i - d_m \left(\frac{N_m}{K} \right)^\gamma \right) \right); \quad (2)$$

$$T_n^{notechnology} = (N_m) = a_m \cdot \ln \left((N_m + 1) \cdot \left(1 - d_m \left(\frac{N_m}{K} \right)^\gamma \right) \right); \quad (3)$$

3. Situational analysis

$$S(t) = T_n^{istechnology}(N_m(t), R_i(t)) - T_n^{notechnology}(N_m(t)); \quad (4)$$

4. Routine decision

$$Decision(t) = \begin{cases} Isatechnologicalaction, \wedge if S(t) > threshold \\ Thereisnotechnologicalaction, \wedge if S(t) \leq threshold \end{cases}; \quad (5)$$

5. Creative decision in this case, this step is informally incorporated into the model by ensuring continuous improvement and adaptation.

3.2. Computer simulation

The compiled initial model (a) is trained using algorithms from the Python 3.8 environment library, where it allows fitting the model parameters to real data, thus reducing errors. The model (b) becomes more accurate and better reflects trends in the data. Learning allows the model to be more accurately adapted to real conditions, thereby increasing the efficiency and reliability of decision-making, therefore robotic activity in tourist areas becomes more reasonable and efficient (see. Figure 3). Where, X-Axis (N_m): - Number of tourists; Y-Axis (R_i) - Number of robots; Z-Axis (T_n) - Computed value of T_n . The colors on the surface plot represent the values of T_n in the color map, the colors range from dark purple (low values) to yellow (high values).

- The shape of the surface indicates how T_n varies with different numbers of tourists and robots. For initial coefficients, you can observe how the value of T_n changes as both N_m and R_i vary.
- This plot shows the impact of optimized coefficients on the value of T_n . Compared to the initial coefficients, this plot may have different trends or patterns, reflecting the changes in coefficients that optimize the system.

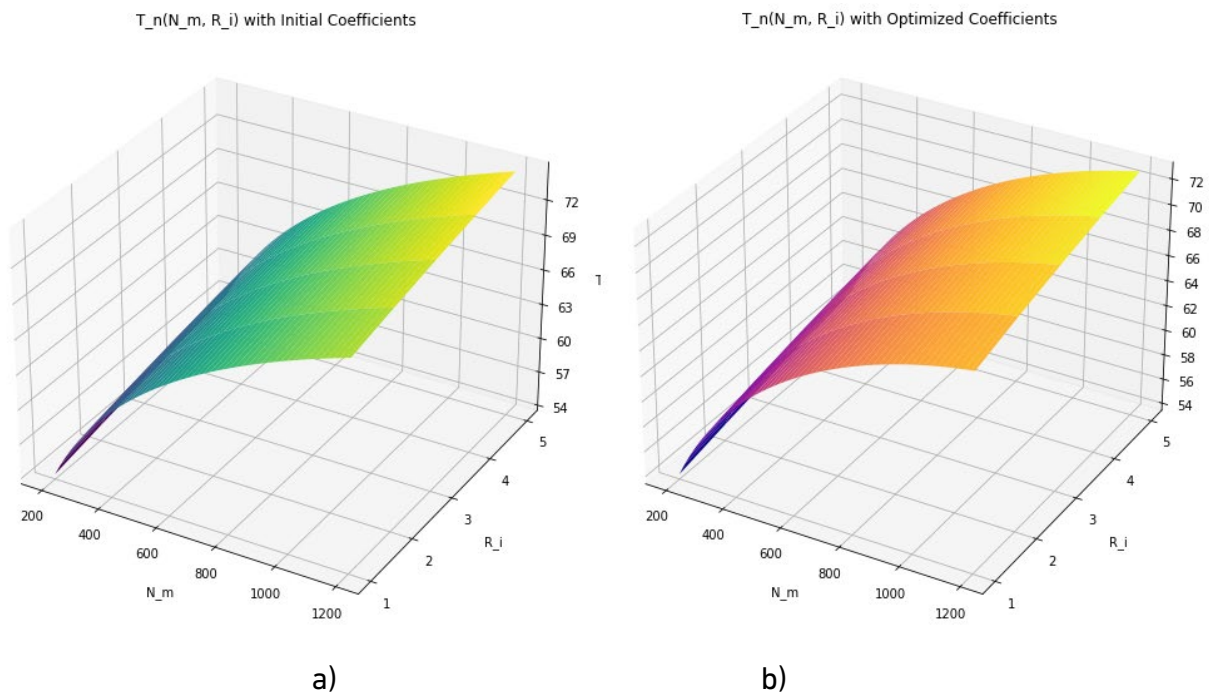


Figure 3. Process results a) initial model, b) optimized model

T_n changes with varying numbers of tourists and robots under different coefficient scenarios from the graphs it can be seen that the difference between the initial and the trained model is very small, so it can be said that the trained model corresponds quite well to the initial model, since the base term of the logarithm is almost identical. The spectacle of technological action usually has a positive effect on the stopping time of tourists, tourists like to look at it, but the stopping time of tourists decreases with a large number of tourists, when the capacity of the area becomes an important factor affecting the comfort of tourists.

Tourists are more interested in stopping and watching when there is more robotic action. The model shows when and where the optimal tourist and technological action creates the best experience. The model after training can better assess the effect of discomfort of tourists when their number becomes too large, observing the activity of robots.

Conclusions

After the development and analysis of both the initial and optimized models, we can state that proper management of robot activities and tourists is critical for optimal use of the area and a pleasant tourist experience. The optimized model allows for better prediction and planning of these interactions based on real-world observations and data. In this case, it is assumed that the very spectacle of robotic activity cannot harm the environment and ecology, the activity of robots is pre-planned independently whether there will be tourists or not, but with the appropriate adjustment and carrying out manipulations, the attraction of tourists is possible. If tourists liked the spectacle of robot activity, it gives a long-term positive memory. It is likely that he will recommend the area to others as well, or that he will return after a while.

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DANRAUS IR APLINKAI PALANKAUS TURIZMO PLĖTRA TAIKANT TECHNOLOGIJAS

Palmira Papšienė

Santrauka

Šiame tyrime nagrinėjama tvaraus ir aplinkai palankaus turizmo plėtra, pasitelkiant pažangias technologijas, ypač robotizuotas sistemas. Tvarus turizmas, atliepiantis esamų ir būsimų kartų poreikius, integruoja ekologinius, ekonominius ir sociokultūrinius principus, siekiant sumažinti aplinkos žalą ir užtikrinti ilgalaikį tvarumą. Tyrime išskiriama mokslinė problema – kaip efektyviai panaudoti robotų veiklą tvaraus turizmo plėtrai grindžiant organizacinio reflekso koncepcija. Šis modelis apima turistų srautų stebėjimą, situacijos duomenų analizę ir sprendimų priėmimą, siekiant optimizuoti aplinkos ir lankytojų patirtis. Ši dinaminė sistema prisitaiko prie kintančių turistų srautų ir aplinkos sąlygų, naudodama autonominius robotus ne tik funkciniais tikslais, tokiems kaip svečių aptarnavimas, aplinkos priežiūra ar transportas, bet ir kaip patrauklias pramogas. Tyrimo metu siekiama atkreipti dėmesį, kad koordinuota robotų veikla gali tapti reginiu, pritraukiančiu turistų susidomėjimą ir skatinančiu ekologinį sąmoningumą. Empiriniai ir teoriniai metodai, įskaitant kompiuterinį modeliavimą su „Python“ (Spyder 3.8), buvo taikomi modeliui testuoti. Modeliavimo scenarijai vertino turistų pasirinkimus, susijusius su robotų veikla, ir parodė, kad tokios veiklos patrauklumas teigiamai arba neigiamai veikia turistų srautus, priklausomai nuo patyrimo. Matematinis modeliavimas buvo naudojamas atspindėti santykius tarp pagrindinių kintamųjų, tokių kaip turistų skaičius, aplinkos talpa ir robotų veikla. Rezultatai pabrėžia robotų potencialą gerinti turizmo patirtis, kartu skatinant tvarius elgesio modelius per aplinkos stebėjimą, situacijos analizę ir adaptyvų sprendimų priėmimą.

Apibendrinant galima teigti, kad robotų integracija ne tik didina turizmo veiklos efektyvumą, bet ir atitinka tvarumo tikslus, skatindama ekologinę atsakomybę ir mažindama turistų sukeltą aplinkos poveikį. Be to, robotai gali šviesti turistus apie ekologinius standartus ir skatinti žaliąsias praktikas lankytinose vietose. Tyrimo metu nustatyta, kad tvaraus turizmo modeliai, apimantys organizacinį refleksą ir robotų veiklą, gali reikšmingai prisidėti prie tvaraus turizmo sektoriaus vystymo ir ekologinės pusiausvyros.

Raktiniai žodžiai: tvarus turizmas, organizacinis refleksas, technologijos, kompiuterinis modeliavimas.