SELECTION OF TOURISM ACCOMMODATION FACILITIES FOR DEVELOPMENT: AN ADAM-BASED APPROACH

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Abstract: *The selection of an adequate type of accommodation facility for construction has multiple influences on the tourism destination: economic, social, and environmental. Selecting an alternative that will appreciate all of the existing criteria is essential. This article proposes the application of the Multiple-Criteria Decision-Making (MCDM) approach involving three methods: the Preference Selection Index (PSI), the PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA), and the Axial-Distance-based Aggregated Measurement (ADAM). The PSI and the PIPRECIA methods were used to define the criteria weights, while the ADAM method was applied to rank the alternatives. The possibilities of the proposed approach were observed in the real case study borrowed from the literature. Five alternative accommodation facilities planned for the construction on Golija Mountain were assessed against seven criteria. The final results confirmed the applicability and reliability of the proposed approach and enabled the selection of tourism accommodation to be refined.*
Keywords: *ADAM method, PSI method, PIPRECIA method, accommodation facilities, tourism.*

INTRODUCTION

The construction of a tourism facility in a particular destination influences it economically, socially, and environmentally. Besides, deciding which facility to build is very complex because this kind of project is financial and time-consuming. A spectrum of criteria should be perceived during this decision process. The existence of a more significant number of conflicting criteria imposes the application of the Multiple-Criterion Decision-Making (MCDM) methods as a reasonable and logical tool for facilitating this kind of issue.

The authors recognized the potential of the MCDM methods for im-

proving the quality of the decision process in the tourism field and used it to resolve various business problems. Rashmi et al. (2019) determined the best state for tourism operating in India, while Stević et al. (2019) used the MCDM approach to evaluate the cultural heritage sites. The sustainable development index for urban and rural town tourism in five tourism towns in northern Taiwan was evaluated using the integrated MCDM approach (Lin, 2020). The authors applied the MCDM methods to assess the comprehensive influence of tourism in Hainan (Lin et al., 2020). With the help of the MCDM framework, the authors successfully defined the obstacles to tourism development in rural areas in India (Jena & Dwivedi, 2023). Topic regarding the location of the hotels and the selection of the hotel construction projects occupied the researcher's attention as well (Popovic et al., 2019a,b; Zolfani et al., 2018, 2019; Kaya, 2021; Ulucan, 2021). In this article, we propose the integrated approach based on the use of the Preference Selection Index (PSI), the PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA), and the Axial-Distance-based Aggregated Measurement (ADAM).

The PSI method (Maniya & Bhatt, 2010) enables the definition of criteria weights and the ranking of alternatives. It belongs to the group of objective MCDM weighting methods because it defines the weighting coefficients based on the input data. Until now, this method has been used for resolving various types of decision problems such as hotel location selection (Aksoy & Ozbuk, 2017), materials selection (Yadav et al., 2019; Ulutas et al., 2021), wear parameter optimization of ceramic coating (Kumar et al., 2023), and risk assessment of the supply chains (Sutrisno & Kumar, 2023).

The subjective PIPRECIA method (Stanujkić et al., 2017) originates from the SWARA method and retains its good features, such as simplicity and ease of use. However, contrary to the SWARA method, it does not require sorting the criteria according to their expected significance before starting the evaluation procedure. This fact makes the PIPRECIA method suitable for application in the group decision environment. The research used this method for defining the criteria weights in many decision-making cases (Jauković-Jocić et al., 2020; Truong & Thinh, 2022; Hadad et al., 2023; Qaddoori & Breesam, 2023). The main shortcoming of the PIPRECIA method is the absence of consistency checking.

The ADAM method (Krstić et al., 2023) is a newly proposed method that introduces a new generation of the MCDM methods – geometric MCDM. Even though it is relatively novel, this method has been already applied for facilitation of decision process in the following areas: agroin-

dustry (Agnusdei et al., 2023; Krstić et al., 2023; Coluccia et al., 2024), logistics (Andrejić et al., 2023; Tadić et al., 2024), efficiency assessment of the electronic vehicles (Gökgöz & Yalçın, 2024), and entrepreneurial ecosystems assessment (Popović et al., 2024). The presented studies indicate that the ADAM method has the potential to be a suitable decision-making aid that will be used for the selection of the appropriate accommodation facility in the present case.

All of the presented methods have strong points. By combining them, we formed a model that will increase the reliability of decisions regarding the facility that should be used for tourist purposes. The example that will help demonstrate the applicability of the created approach is borrowed from the literature and is directed to selecting the facility type that should be constructed on Golija mountain in Serbia. Three respondents familiar with the issue regarding construction projects in tourism were involved in the decision-making process. The article is organized in the following way to present the integrated model and outline its possibilities. Section 2 presents the methodological approach where the computation procedures of all three methods are clearly explained. An example of selecting the optimal type of accommodation facility is presented in Section 3, followed by a conclusion.

METHODOLOGICAL APPROACH

This section contains the methodological approach proposed for assessing available alternative projects for the construction of tourism accommodation facilities. As we stated previously, the proposed approach is based on three MCDM methods: the PSI, PIPRECIA, and ADAM. The computation procedure of each of the mentioned methods is observed and explained in detail.

The PSI method

The PSI method is an objective method intended to determine the criteria weight and rank the alternatives (Maniya & Bhatt, 2010). Its computation procedure is simple and can be illustrated using the following steps.

Step 1. Criteria and alternatives selection.

Step 2. Alternatives assessment regarding the selected criteria and initial decision matrix *D* forming:

$$D= [x_{ij}]_{nxm}, \qquad (1)$$

where x_{ij} is the performance ratings of the alternative *i* relative to the criterion *j*, *n* is the number of alternatives, and *m* is the number of criteria.

Step 3. Computing the normalized decision matrix in the following way:

$$r_{ij} = \frac{x_{ij}}{x_{ij}} \text{ for benefit criteria,} \quad (2)$$

$$r_{ij} = \frac{x_{ij}}{x_{ij}} \text{ for non-benefit criteria.} \quad (3)$$

Step 4. The preference variation value computation regarding each criterion as follows:

$$\chi_j = \sum_{i=1}^{m} \left(r_{ij} - \bar{r}_j\right)^2, \quad (4)$$

where is the mean value of normalized ratings of criterion *j* determined in the following manner:

$$\bar{r}_j = \frac{1}{m} \sum_{i=1}^{m} r_{ij}. \quad (5)$$

Step 5. The deviation in the preference variation value computation as follows:

$$\Omega_j = 1 - X_j. \quad (6)$$

Step 6. The criteria weights definition using the equation (7):

$$w_j = \frac{\Omega}{\sum_{i=1}^{n} \Omega_j}. \quad (7)$$

Step 7. The preference selection index of alternatives is computed in the following manner:

$$S_i = \sum_{j=1}^{n} r_{ij} w_j. \quad (8)$$

The alternative with the highest preference selection index value is the best option.

The PIPRECIA method

The PIPRECIA method represents the subjective type of the MCDM method for determining the criteria weights introduced by Stanujkić et al. (2017). It became popular because of its simple computation procedure, which can be outlined using the following steps.

***Step* 1.** Evaluation criteria selection, which pre-sorting is not required as in the SWARA method.

***Step* 2.** The relative importance s_j determination starts from the second criterion, as it is explained:

$$s_j = \begin{Bmatrix} > 1 & when & C_j \succ C_{j-1} \\ 1 & when & C_j = C_{j-1} \\ < 1 & when & C_j \prec C_{j-1} \end{Bmatrix}. \quad (9)$$

***Step* 3.** The coefficient k_j determination as follows:

$$k_j = \begin{Bmatrix} 1 & j = 1 \\ 2 - s_j & j > 1 \end{Bmatrix}. \quad (10)$$

***Step* 4.** The recalculated value q_j calculation as it is presented:

$$q_j = \begin{Bmatrix} 1 & j = 1 \\ \frac{q_{j-1}}{k_j} & j > 1 \end{Bmatrix}. \quad (11)$$

***Step* 5.** The relative criteria weights determination by using the following equation:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}, \quad (12)$$

where w_j represents the relative weight of the criterion *j*.

***Step* 6.** In the case when the decision process is performed in the group environment, then the overall criteria weights are defined in the following manner:

$$w_j^* = \left(\prod_{r=1}^{R} w_j^{nr}\right)^{1/R}, \quad (13)$$

$$w_j = \frac{w_j^*}{\sum_{j=1}^{n} w_j^*}, \quad (14)$$

where is the weight of criterion *j* that is determined by the respondent *r*, *R* represents the total number of the respondents, denotes the group weight of criterion *j* before its adjusting in order to fulfill the condition , and is the overall weight of criterion *j*.

The ADAM method

The ADAM method, recently proposed, represents the geometric MCDM method (Krstić et al., 2023). The computation procedure of the ADAM method could be briefly outlined using the following steps.

Step 1. Initial decision matrix *D* definition.

Step 2. The sorted decision matrix *S* determination:

$$S = [s_{ij}]_{nxm}, \quad (15)$$

where is the sorted evaluations in descending order according to the criteria weights.

Step 3. The normalized sorted decision matrix *N* determination as follows:

$$n_{ij} = \begin{Bmatrix} \frac{s_{ij}}{\max\limits_{i} s_{ij}} & for \quad j \in B \\ \frac{\min\limits_{i} s_{ij}}{s_{ij}} & for \quad j \in C \end{Bmatrix}, \quad (16)$$

where represents the normalized evaluations, *B* is the set of benefit, and *C* is the set of non-benefit criteria.

Step 4. The coordinates (*x, y, z*) of the reference () and weighted reference () points computation that defines the complex polyhedron as follows:

$$x_{ij} = n_{ij} \times \sin \alpha_j, \ \forall j = 1, \dots, m; \ \forall i = 1, \dots, n, \quad (17)$$

$$y_{ij} = n_{ij} \times \cos \alpha_j, \ \forall j = 1, \dots, m; \ \forall i = 1, \dots, n, \quad (18)$$

$$z_{ij} = \begin{cases} 0, for \ R_{ij} \\ w_j, for \ P_{ij} \end{cases}, \ \forall j = 1, \dots, m; \ \forall i = 1, \dots, n, \quad (19)$$

where is the angle that defines the direction of the vector that determines the value of the alternative, defined as it is shown:

$$\alpha_j = (j-1)\frac{90^{\circ}}{m-1}, \forall j = 1, \dots, m. \quad (20)$$

Step 5. The volumes of complex polyhedral as the sum of the volumes of the composing pyramids are calculated in the following way:

$$V_i^C = \sum_{k=1}^{m-1} V_k, \ \forall i = 1, \dots, m, \quad (21)$$

where represents the volume of the pyramid defined by using the equation (22):

$$V_k = \frac{1}{3} B_k \times h_k, \forall k = 1, \dots, m-1, \quad (22)$$

where is the surface of the base of the pyramid determined by the reference and weighted reference points of two successive criteria in the

following way:

$$B_k = c_k \times a_k + \frac{a_k \times (b_k - c_k)}{2}, \quad (23)$$

where denotes the Euclidean distance between the reference points of two successive criteria, defined in the following way:

$$a_k = \sqrt{(x_{j+1} - x_j)^2 + (y_{j+1} - y_j)^2}, \quad (24)$$

and are the magnitudes of the vectors corresponding to the weights of two successive criteria:

$$b_k = z_j, \quad (25)$$

$$c_k = z_{j+1}, \quad (26)$$

denotes the height of the pyramid from the defined base to the top of the pyramid discovered in the coordinate origin (*O*), which is computed as follows:

$$h_k = \frac{2\sqrt{s_k(s_k - a_k)(s_k - d_k)(s_k - e_k)}}{a_k}, \quad (27)$$

where is the semicircumference of the triangle defined by the and coordinates of two successive criteria and the coordinate origin, calculated in the following manner:

$$d_k \sqrt{x_j^2 + y_j^2}, \quad (28)$$

$$e_k = \sqrt{x_{j+1}^2 + y_{j+1}^2}. \quad (29)$$

Step 6. The alternatives should be ranked in decreased order according to the volumes of complex polyhedral . The best-ranked alternative has the highest volume value.

DATA AND RESULTS

The applicability of the proposed MCDM approach is verified using the example borrowed from Popović et al. (2021). The procedure is directed at selecting appropriate tourism accommodations for the construction on Golija Mountain. Possible types of accommodation facilities are presented in **Table 1**.

Table 1. Alternative accommodation facilities

Acronym	Type of accommodation facility
A_1	Destination Hotel
A_2	B&B Pension
A_3	Condotel
A_4	Townhouse
A_5	Chalet

Source: (Popović et al., 2021)

Alternative accommodations were estimated against seven criteria which are presented in **Table 2**.

Table 2. Evaluation criteria

Acronym	Criteria	Criteria type	Unit
Nu	The number of accommodation units per ha of parcel	max	unit
Su	The surface of the accommodation unit	max	m^2
In	Investment	min	euro/m^2
Pr	Price of accommodation unit per overnight staying	max	euro/night
Ef	Ecological footprint	min	gm^2/day
Sw	Social well-being	max	number of employees
Ep	Economics prosperity	max	euro

Source: (Popović et al., 2021)

Prices have changed, and it is possible that the presented investment costs do not represent the current state. However, this fact will not compromise the research because the main goal is to prove the applicability

of the proposed MCDM approach for the facilitation of decision-making in the tourism field.

The data that were submitted under evaluation are presented in **Table 3**.

Table 3. The initial data

	Nu	***Su***	***In***	***Pr***	***Ef***	***Sw***	***Ep***
	unit	m^2	euro/m^2	euro/night	gm^2/day	number of employees	euro
	max	*max*	*min*	*max*	*min*	*max*	*max*
A_1	250	52.50	925	35.50	1075.00	163	2,250,000
A_2	145	45	805	27.50	550.00	220	2,800,000
A_3	490	52.50	875	25.50	850.00	50	865,000
A_4	365	85	905	27.50	730.00	110	3,650,000
A_5	220	105	950	44.50	715.00	60	4,100,000

Source: (Adapted according to Popović et al., 2021 and Horwath HTL, 2007)

To facilitate the decision-making process, input data are presented as crisp numbers, although in the used sources, they are not presented as exact values (Popović et al., 2021; Horwath HTL, 2007). We calculated the arithmetic mean for the particular values and then adjusted the data for estimation using the proposed methodology.

First, the criteria weights using the objective PSI method were defined. The obtained results are shown in **Table 4**.

Table 4. The criteria weights obtained using the PSI method

Criteria	Weight
Nu	0.1293
Su	0.1409
In	0.1833
Pr	0.1623
Ef	0.1619
Sw	0.1075
Ep	0.1147

Source: (Authors' calculation)

The objective PSI method revealed that the most significant criterion is – *Investemnt* (0.1833), while the least important is the criterion *Sw – Social well-being* (0.1075).

To get more reliable results, we used the subjective PIPRECIA method and three respondents familiar with the issues regarding facility construction to evaluate the significance of the criteria. **Table 5** presents the obtained criteria weights from the respondents and the overall criteria significance, representing the geometric mean of the obtained results from respondents.

Table 5. The criteria weights obtained using the PIPRECIA method

Criteria	Respondent 1	Respondent 2	Respondent 3	Overall weight
Nu	0.1378	0.1104	0.1424	0.1299
Su	0.1252	0.1104	0.1499	0.1281
In	0.1565	0.1380	0.1666	0.1539
Pr	0.1565	0.1533	0.1514	0.1544
Ef	0.1304	0.1394	0.1165	0.1290
Sw	0.1304	0.1549	0.1294	0.1384
Ep	0.1631	0.1936	0.1438	0.1663

Source: (Authors' calculation)

The results revealed that respondents had different opinions regarding the significance of the criteria. As **Table 5** shows, respondent 1 and respondent 2 prioritized *Ep – Economics prosperity* (0.1631 and 0.1936, respectively), while respondent 3 saw *In – Investment* (0.1666) as the most critical criterion. The geometric mean of the obtained weights emphasize*s Ep – Economics prosperity* (0.1663) as the most influential criterion. According to the results, the least significant criterion is criterion *Su – Surface of the accommodation unit* (0.1281).

We calculated the geometric mean of the weights obtained using the PSI and PIPRECIA methods to achieve more reliable input for further procedure and a final ranking of the alternative accommodations (**Table 6**).

Table 6. The criteria weights obtained using the PIPRECIA method

Criteria	PSI	PIPRECIA	Final weights
Nu	0.1293	0.1299	0.1303
Su	0.1409	0.1281	0.1350
In	0.1833	0.1539	0.1688
Pr	0.1623	0.1544	0.1591
Ef	0.1619	0.1290	0.1452
Sw	0.1075	0.1384	0.1226
Ep	0.1147	0.1663	0.1388

Source: (Authors' calculation)

The final weighting coefficient indicates that the most significant criteria *are In – Investment* (0.1688) and *Pr – Price of accommodation unit per overnight stay* (0.1591). The criterion *Sw – Social well-being* is designated as the least influential (0.1226). These final weights were used in procedure for evaluation of the considered alternatives.

The results of the ADAM method are presented graphically in figures bellow.

Figure 1 graphically presents results of the ADAM method for the *Destination Hotel* (A_1).

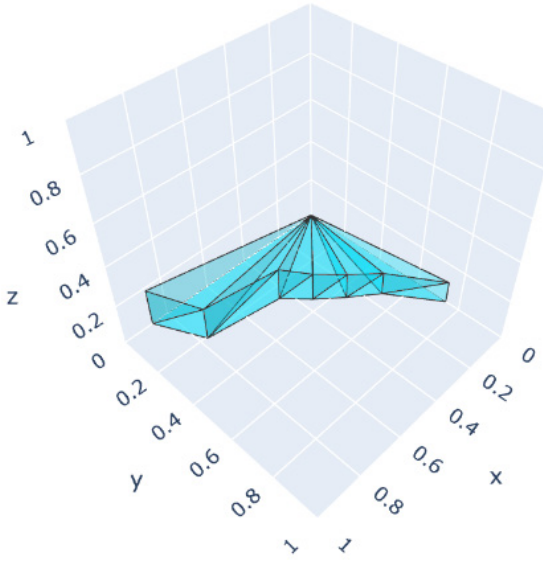

Figure 1. Graphical representation of the results for *Destination Hotel* (A_1) – the ADAM method

Source: (Authors′ calculation)

The results of the ADAM method for the *B&B Pension* (A_2) are graphically showcased in **Figure 2**.

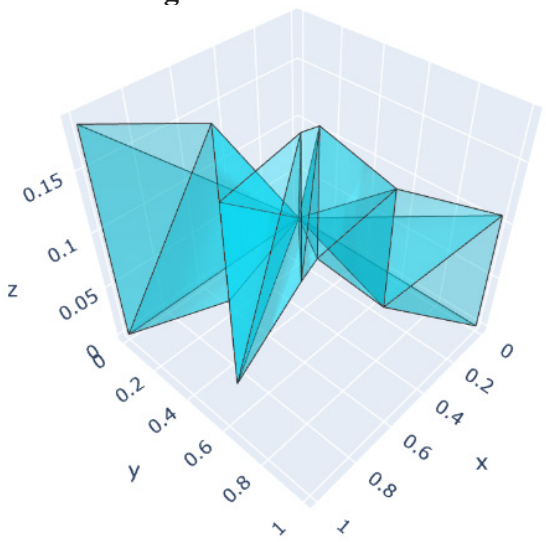

Figure 2. Graphical representation of the results for *B&B Pension* (A_2) – the ADAM method

Source: (Authors′ calculation)

Figure 3 graphically illustrates results of the ADAM method for the *Condotel* (A_3).

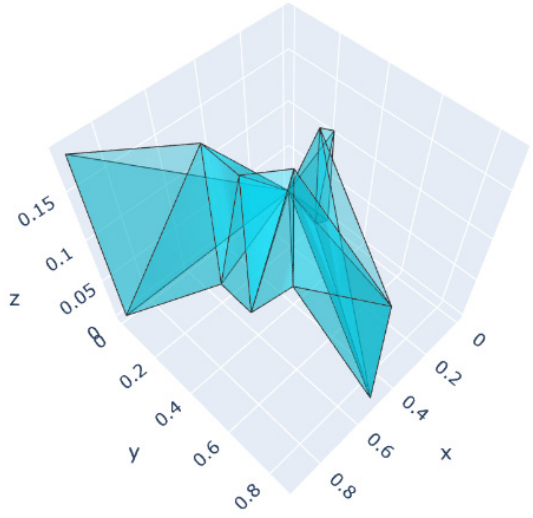

Figure 3. Graphical representation of the results for *Condotel* (A_3) – the ADAM method

Source: (Authors′ calculation)

The results of the ADAM method for the *Townhouse* (A_4) are presented in **Figure 4**.

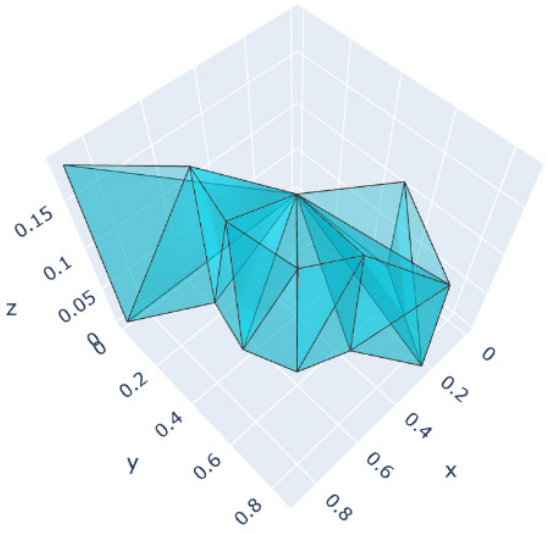

Figure 4. Graphical representation of the results for *Townhouse* (A_4) – the ADAM method

Source: (Authors′ calculation)

Figure 5 graphically showcases results of the ADAM method for the *Chalet* (A_5),

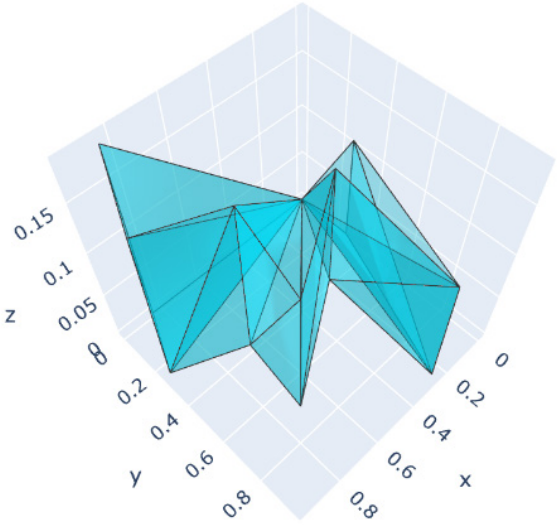

Figure 5. Graphical representation of the results for *Chalet* (A_5) – the ADAM method

Source: (Authors′ calculation)

Table 7 shows the ranking order of the considered alternatives.

Table 7. Ranking order of the alternatives

Rank	Alternative	Acronym	Volume
1	Chalet	A_5	0.0498
2	Townhouse	A_4	0.0416
3	B&B Pension	A_2	0.0334
4	Destination Hotel	A_1	0.0289
5	Condotel	A_3	0.0234

Source: (Popović et al., 2021)

The results revealed that the most acceptable accommodation facility that should be a priority for construction is alternative A_5 – *Chalet* (0.0498). The last position occupies the alternative A_3 – *Condotel* (0.0234) as the least attractive in the considered case.

CONCLUSION

In this article, we presented the application of the MCDM approach based on the ADAM, PSI, and PIPRECIA methods for facilitating the decision process regarding selecting the optimal tourism accommodation facility for construction. The evaluation process involved five alternative accommodations facilities, seven criteria, and three respondents who gave opinions regarding the criteria's significance. The final results emphasize that the most significant criterion in this case is *In – Investment.* The current business conditions justified such results because the economic environment and constant price increases spotlight the investment. The results also show that the alternative A_5 – *Chalet* is the optimal choice. In the article of Popović et al. (2021), this option was in second place. The involvement of the objective MCDM method for defining the criteria weights could be the reason for this slight difference.

As with the other research, this one also has some limitations. The research accuracy is limited because the case study is borrowed from the literature. This constatation leads to the conclusion that the prices on the market have changed, which could affect the reliability of the results. Besides, the model implies using crisp numbers that could not appreciate the state of the environment properly. Furthermore, only three respondents were included in the decision process. The involvement of a more significant

number of respondents from different business structures will contribute to the reliability of the results. All these limitations represent the propositions for future research. Nevertheless, it could not be denied that the proposed approach facilitated the decision process and enabled the scientifically grounded results to be gained.

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