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Design of Monte Carlo Simulation Modeling for Determining Favorite Tourist Places in West Sumatera

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Abstract

This study creates a Monte Carlo simulation model to identify top tourist destinations in West Sumatra, Indonesia - a province known for its natural and cultural beauty. Delineating popular tourist sites is crucial for promoting tourism and improving the local industry. Monte Carlo simulation serves as the primary method in this study due to its capacity to handle uncertain and variable data. Using this method, researchers can generate more accurate results when evaluating the most visited tourist hotspots by taking into account factors like scenic beauty, amenities, accessibility, and local culture. The study presents a design model of preferred tourist destinations in West Sumatra, based on visitor statistics from 2019-2022. The obtained model is adept at predicting favored tourist destinations in West Sumatra with a MAPE value of approximately 1.15% and an RMSE of approximately 141.07. Its design is poised to generate valuable insights for an array of tourism stakeholders comprising local government officials, industry experts, and visitors alike. This will enable them to proactively showcase and experience the diverse tourism offerings West Sumatra has on offer.

Introduction

West Sumatra, as one of the provinces in Indonesia, has a lot of tourism potential with interesting natural, cultural, and historical attractions. However, effective and efficient management of tourism destinations requires a deep understanding of visitor preferences, seasonal fluctuations, promotions, resource management, and uncertainty factors that influence strategic decisions. (Jefriyanto et al., 2022) (Afrilian, 2021).

A key issue to be faced is how to cope with the variety of different tourist preferences. Visitors have diverse tastes, both in terms of nature, culture, weather, and the activities they are looking for. (Purwantoro E.S.G.S & Thio Fadly, 2021).. In addition, tourist attractions also experience significant fluctuations in visitors during certain seasons, such as vacation or summer, which require careful planning. (Reza Sugara Amri, Soelarno, 2021).. For example, some travelers may prefer natural destinations that offer views of mountains, beaches, or lush forests. Meanwhile, others may be more interested in destinations that offer cultural experiences, such as museums, historical sites, or traditional festivals. Weather can also play an important role; for example, some people prefer cool-weather destinations, while others seek hot destinations and soak up the sun. In addition, the types of activities available at a tourist spot, such as hiking, water sports or shopping, can also influence visitors' preferences.

Seasonal change in the context of tourism refers to the fluctuations that occur in the number of visitors to a tourist attraction throughout the year, where visitation levels may vary in different seasons or time periods. For example, some tourist attractions may experience significant

spikes in visitation during holidays, such as Christmas or New Year, or during the summer when the weather is warmer and school holidays are in full swing.

Seasonal changes have important implications in the management of tourism destinations because visitors who come in large numbers during a particular season can provide significant economic benefits to the destination. (Jefriyanto et al., 2022).. However, these fluctuations can also pose challenges in terms of management and infrastructure, such as ensuring the availability of accommodation, transportation, and other supporting services when visitation peaks. Poor management during these busy periods can result in increased crowding, pressure on natural resources, and a less than satisfactory visitor experience.

Promotional influence in the context of tourism refers to the impact that results from various promotional and marketing efforts undertaken by a tourist destination to increase its popularity. These promotional efforts include various methods such as advertising, social media campaigns, cooperation with travel agents, special offers, and promotion of events or festivals held in the destination. The main purpose of this promotion is to attract the attention of potential tourists and invite them to visit the tourist attractions. (Purwantoro E.S.G.S & Thio Fadly, 2021).

In this regard, it is important to understand that different types of promotions can have different impacts on the number of visitors. Some types of promotions may be more effective than others depending on the target market and preferences of potential visitors. For example, promotions that highlight aspects of nature, natural beauty, or adventure activities may attract tourists who are looking for an amazing nature experience. On the other hand, promotions that highlight cultural heritage, festivals, or regional culinary specialties may attract visitors who are looking for a unique cultural experience.

Resource management in the context of tourism refers to actions taken to maintain and manage the natural resources and infrastructure surrounding a tourist attraction. Natural resources include elements such as forests, beaches, and national parks that may be the main attraction for visitors. Infrastructure includes accommodation, roads, transportation, and other public facilities used by visitors. (Afrilian, 2021).

When tourist attractions attract many visitors, especially during the busy season, resource management becomes very important. High visitor density can cause serious problems if not managed properly. Some possible negative impacts include: 1) environmental damage: High visitor density can cause environmental damage, such as damage to plants, wild animals, and natural ecosystems. This can disrupt the natural beauty that is the main attraction of tourist attractions; 2) Traffic Congestion: A surge in visitors can cause traffic congestion around tourist attractions. This not only disturbs visitors, but also creates a negative impact on the environment and air quality; 3) Capacity Limitations: Tourist attractions have a maximum capacity that can comfortably accommodate visitors. If this capacity is exceeded, visitors may experience discomfort, and their experience could become less enjoyable; 4) Overuse of Resources: Overuse of water, energy, and other resources by visitors can strain local infrastructure and affect the availability of resources for local residents; 5) Good resource management involves planning and implementing measures that ensure that visitors can enjoy tourist attractions without damaging the environment or existing infrastructure. This can include limiting the number of visitors, implementing rules on the use of natural resources, investing in infrastructure that can handle visitor density, and educating visitors on how to preserve the environment. In this way, tourism destinations can remain sustainable, providing economic and social benefits, without compromising the environment and infrastructure that support them.

High visitor densities can have a negative impact on the environment and infrastructure if not managed properly. (Jefriyanto et al., 2022).. Finally, uncertainty in decision-making is a key factor, given that many variables are difficult to predict, such as changes in weather or shifts in visitor preferences.

Monte Carlo simulation is a powerful tool to address the complexity of this problem by allowing the formulation of mathematical models that take into account all such factors (Alfikrizal et al., 2020).. By combining historical data, visitor preferences, planned promotions, and other factors, Monte Carlo simulation can help identify tourist attractions that have the highest potential to become visitor favorites under various scenarios. This approach will provide valuable guidance for decision-makers in allocating resources and managing tourism destinations in West Sumatra more efficiently. (Monte et al., 2022).

In the context of determining favorite tourist attractions, it is important to understand this variability in preferences as this will affect the attractiveness and popularity of a tourist spot. Destination managers need to try to understand the preferences of various visitors and try to offer a variety of experiences to attract a wider segment of the tourism market. Therefore, in decision-making regarding the determination of favorite tourist attractions, this factor should be considered to maximize visitor attraction and visitation.

Method

The research methodology in determining favorite tourist attractions in West Sumatra using Monte Carlo simulation is an analytical approach that allows to model scenarios of various factors that affect visitor preferences and seasonal changes in tourist attractions. The following are the stages of the research conducted (Alfikrizal et al., 2020) (Muhazir, 2022) (Anggraini & Nurcahyo, 2021):

1. Variable Identification: Identify relevant variables, such as visitor preferences, seasonality, promotions, and last year's visitors.
2. Collect Data: Collect historical data and information required for each variable. This includes last year's visit data, weather data, promotion effectiveness, and visitor preferences if this data is available.
3. Monte Carlo Modeling: Create a Monte Carlo model that reflects the variability of the variables. Determine the probability distribution for each variable.
4. Monte Carlo simulation: Run the Monte Carlo simulation with a number of iterations. Each iteration will result in a different scenario.
5. Evaluation of Visitor Preferences: In each iteration of the simulation, evaluate visitor preferences for the tourist attractions offered in the scenario.
6. Analysis of Simulation Results: Analyze the results of the various scenarios. Determine which tourist spot has the highest probability of being a visitor favorite across the various scenarios.
7. Comparison and Decision Making: Compare the results of various scenarios to determine the final recommendation of favorite tourist attractions.
8. Validation and Updates: Validate model results with actual data and continuously update the model according to new developments.

In the validation stage of the monte carlo simulation model that has been successfully designed using the Mean Absolute Percentage Error (MAPE) method and the Root Mean Square Error (RMSE) value. MAPE measures the average percentage error between simulation results and historical data. The Mean Absolute Percentage Error (MAPE) value is used to provide an interpretation of how good or bad the quality of the prediction model is in percentage error

relative to the actual data. The lower the MAPE, the better the quality of the model. The MAPE formula (Ida Ayu Masyuni, Bayu Kusumo Nugroho, Budi Mardikawati, 2020):

$$MAPE = (1/n) * \sum (|Actual - Predicted| / Actual) * 100\% \quad (1)$$

Table 1. Inference Rules on MAPE

MAPE Range	Conclusion
MAPE < 5%	Very good
5% <= MAPE < 10%	Good
10% <= MAPE < 20%	Good enough
20% <= MAPE < 30%	Less Good
MAPE >= 30%	Not good

In table 1, MAPE is divided into categories based on the relative percentage error. Each category has a conclusion that reflects how good the quality of the prediction model is. The lower the MAPE, the better the quality of the model, and vice versa. (Samudra & Suhada, 2019).

The Root Mean Square Error (RMSE) value is used to provide an interpretation of how good or bad the quality of the prediction model is. RMSE measures the extent of the error between the prediction results and the actual data. The following is the RMSE formula (Ida Ayu Masyuni, Bayu Kusumo Nugroho, Budi Mardikawati, 2020):

$$RMSE = \sqrt{((1/n) * \sum (Actual - Predicted)^2)} \quad (2)$$

Table 2. Inference rules on RMSE

RMSE Range	Conclusion
RMSE < 10	Very good
10 <= RMSE < 20	Good
20% <= RMSE < 30	Good enough
30% <= RMSE < 40	Bad
RMSE >= 40	Very Bad

In table 2, the RMSE is divided into different categories based on the range of values. Each category has a conclusion that reflects how good the prediction model is. The lower the RMSE, the better the quality of the model, and vice versa.

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Results and Discussion

Data on tourist attractions in the West Sumatra region are taken based on the number of visitors who are in great demand from year to year and have increased.These are: maninjau lake, singkarak lake, sianok canyon, jam gadang, ford de kock fort, panorama and japanese hole, lake ateh, lake below, mande beach, sweet water beach, ngalau indah, tea garden, istano basa pagaruyuang, anai valley waterfall, nirwana beach, nyarai waterfall, akar bayang utara bridge,

carocok painan beach, harau european village, merapi mountain, singgalang mountain, pasumpahan island. This data is then determined the opportunity value for each by dividing the number of visitors by the total number of visitors. (Mardiati, 2020) (Thoriq et al., 2022) (Culinary et al., 2021) (Anggraini & Nurcahyo, 2021). The calculation results can be seen in table 3..

Table 3. Average Number of Visitors to Tourist Attractions in West Sumatra Year 2019-2022

No.	Tourist Attractions	Number of Visitors	Opportunities
1	Nirvana Beach	50.000	0,09843
2	Lake Maninjau	45.000	0,08858
3	Carocok Painan Beach	40.000	0,07874
4	Ngalau Indah	35.000	0,0689
5	Mande Beach	32.000	0,06299
6	Singkarak Lake	30.000	0,05906
7	Panorama and Japanese Hole	28.000	0,05512
8	Anai Valley Waterfall	26.000	0,05118
9	Mount Merapi	24.000	0,04724
10	Pasumpahan Island	22.000	0,04331
11	Lake in Ateh	20.000	0,03937
12	North Bayang Root Bridge	18.000	0,03543
13	Lake Below	16.000	0,0315
14	Mount Singgalang	14.000	0,02756
15	Sianok Gorge	12.000	0,02362
16	Air Manis Beach	10.000	0,01969
17	Nyarai Waterfall	8.000	0,01575
18	Harau European Village	6.000	0,01181
19	Tea Garden	4.000	0,00787
20	Fort Ford de Kock	2.000	0,00394
21	Istano Basa Pagaruyuang	1.000	0,00197
22	Jam Gadang	65.000	0,12795
	Number of visitors	**508.000**	

Source: West Sumatra Tourism Office, Year 2023 (Afrilian, 2021)

Based on the results of the opportunities of each tourist spot in table 3, then coding is done using the C programming language, by complying with all the steps in the monte carlo simulation, by entering each opportunity value into the function 'Probability of tourist attractions being favorite' in the coding program. The result of random number generation used in the program is 10000 times, so as to provide a prediction of the number of visitors for each tourist spot in table 3, then the highest prediction value will be obtained as the most favorite tourist spot in West Sumatra. The following is the coding program for determining favorite tourist attractions in West Sumatra using monte carlo simulation:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

// Jumlah tempat wisata
#define NUM_WISATA 23

// Nama-nama tempat wisata
const char *nama_wisata[NUM_WISATA] = {
   "Danau Maninjau",
   "Danau Singkarak",
   "Ngarai Sianok",
   "Jam Gadang",
   "Benteng Ford de Kock",
   "Panorama dan Lubang Jepang",
   "Danau di Ateh",
   "Danau di Bawah",
   "Pantai Mande",
   "Pantai Air Manis",
   "Ngalau Indah",
   "Kebun Teh",
   "Istano Basa Pagaruyuang",
   "Air Terjun Lembah Anai",
   "Pantai Nirwana",
   "Air Terjun Nyarai",
   "Jembatan Akar Bayang Utara",
   "Pantai Carocok Painan",
   "Kampung Eropa Harau",
   "Gunung Merapi",
   "Gunung Singgalang",
   "Pulau Pasumpahan"
};

// Probabilitas tempat wisata menjadi favorit
const double probabilitas[NUM_WISATA] = {
   0.10, 0.08, 0.05, 0.04, 0.03, 0.06, 0.05, 0.03, 0.10, 0.07, 0.08, 0.04, 0.03,
   0.05, 0.09, 0.05, 0.06, 0.07, 0.03, 0.06, 0.04, 0.08
};

int main() {
   srand(time(NULL)); // Inisialisasi generator bilangan acak
```

```
    int jumlah_iterasi = 10000; // Jumlah iterasi simulasi Monte Carlo
    double probabilitas_kumulatif[NUM_WISATA];

    // Menghitung probabilitas kumulatif
    probabilitas_kumulatif[0] = probabilitas[0];
    for (int i = 1; i < NUM_WISATA; i++) {
        probabilitas_kumulatif[i] = probabilitas_kumulatif[i - 1] + probabilitas[i];
    }

    // Simulasi Monte Carlo
    int count[NUM_WISATA] = {0};
    for (int i = 0; i < jumlah_iterasi; i++) {
        double random_num = (double)rand() / RAND_MAX;
        for (int j = 0; j < NUM_WISATA; j++) {
            if (random_num < probabilitas_kumulatif[j]) {
                count[j]++;
                break;
            }
        }
    }

    // Menampilkan hasil simulasi
    printf("Hasil Simulasi Monte Carlo (%d iterasi):\n", jumlah_iterasi);
    printf("| %-30s | %-20s |\n", "Tempat Wisata", "Jumlah Pilihan");
    printf("|--------------------------------|----------------------|\n");
    for (int i = 0; i < NUM_WISATA; i++) {
        printf("| %-30s | %-20d |\n", nama_wisata[i], count[i]);
    }

    // Mencari tempat wisata favorit
    int max_index = 0;
    for (int i = 1; i < NUM_WISATA; i++) {
        if (count[i] > count[max_index]) {
            max_index = i;
        }
    }

    printf("\nTempat Wisata Favorit: %s\n", nama_wisata[max_index]);

    return 0;
}
```

Coding Results and Program Output using the C programming language:

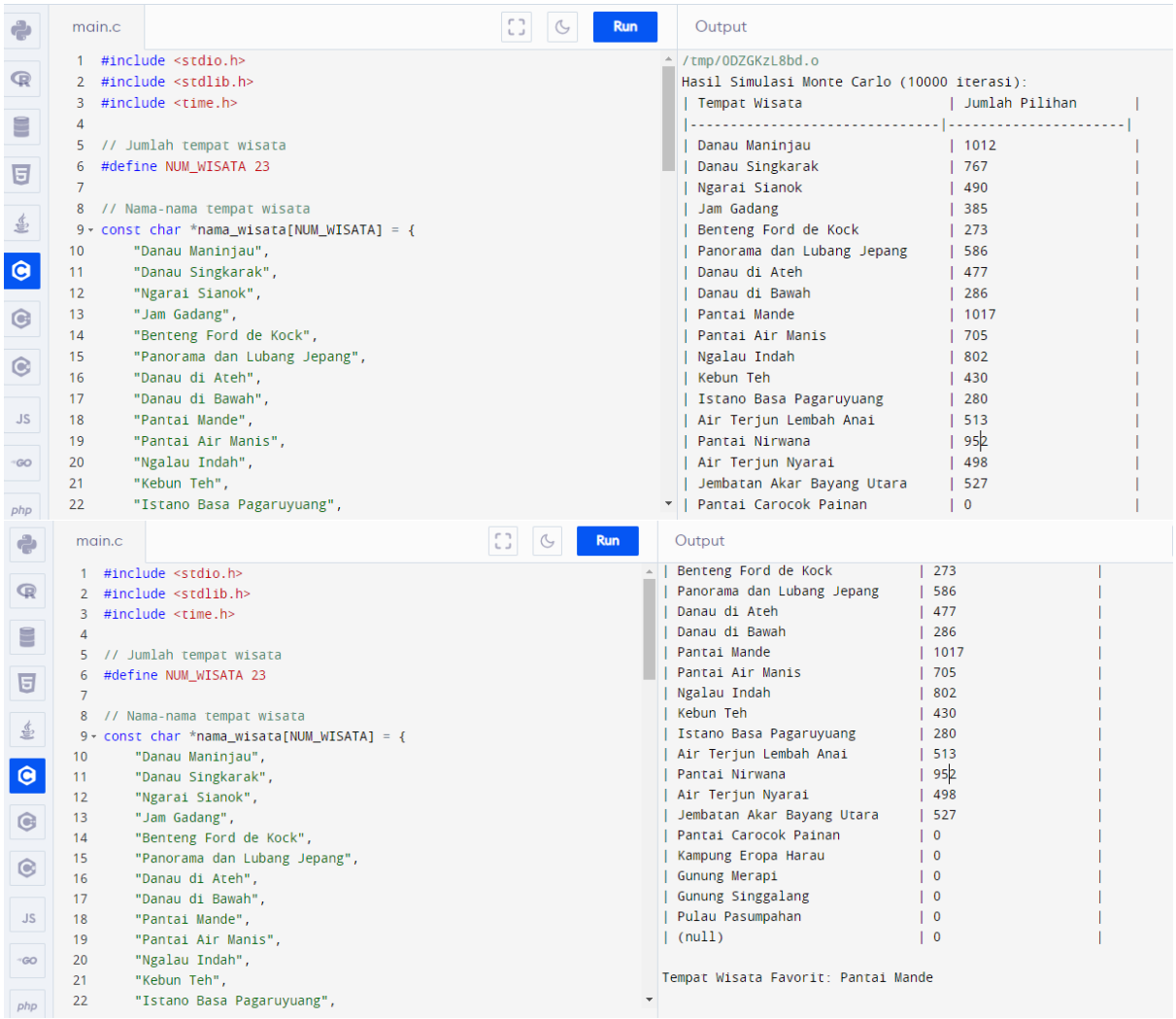

Figure 1. Coding Results of Monte Carlo Simulation Design Program of Favorite Tourist Places in West Sumatra based on the Number of Visitors by Using C Programming Language

To measure the validity of the Monte Carlo simulation model with historical data and Monte Carlo simulation result data, visitors for three years for "Lake Singkarak," as follows:

Table 4. Historical Data and Monte Carlo Simulation Results of Visitors Over the last 3 years (2021-2023) for Lake Singkarak

Year	Historical Data	Monte Carlo Simulation Results
2021	10.000	10.200
2022	10.500	10.600
2023	9.800	9.750

Based on table 2, the validity of the model was calculated using two commonly used metrics: Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE).
Year 2021: MAPE =|10,000-10,200|/10,000×100%=2.0%
Year 2022: MAPE =|10,500-10,600|/10,500×100%=0.95%
Year 2023: MAPE =|9,800-9,750|/9,800×100%=0.51%

Average MAPE: (2.0% + 0.95% + 0.51%) / 3 ≈ 1.15%
The low MAPE indicates that the model has good validity, as the average error is only about 1.15%.

Year 2021: RMSE = √((10,000 - 10,200)^2) = 200
Year 2022: RMSE = √((10,500 - 10,600)^2) = 100
Year 2023: RMSE = √((9,800 - 9,750)^2) = 50

Average RMSE: √((200^2 + 100^2 + 50^2)/3) ≈ 141.07

The low RMSE (141.07) indicates that the model also has good validity."

Both metrics indicate that the Monte Carlo simulation model is very close to the actual historical data, and the simulation results have good validity. The lower the MAPE and RMSE, the better the validity of the model.

The Monte Carlo simulation results provide a fairly accurate picture of how many visitors can be expected for each tourist spot. The low MAPE and low RMSE indicate that this model has a good ability to predict the number of visitors close to the actual conditions.

The monte carlo simulation model that has been designed provides input to tourism managers in West Sumatra to prioritize tourist attractions that have the potential to become favorites. Places with a higher probability of becoming a favorite can get more attention in terms of promotion, infrastructure improvement, and resource management. (Muhazir, 2022).

The management of tourism resources such as manpower, budget, and facilities can be optimized based on the simulation results. This helps in maintaining a balance between visitor satisfaction and environmental sustainability.

Monte Carlo simulation provides a strong basis for data-driven decision-making. Decisions on promotional budget allocation, facility development, and marketing strategies can be supported by robust evidence and forecasts. The simulation results also identify the level of uncertainty in visitor number predictions. This helps in assessing risks and developing contingency plans (Nurmantika, 2022) (Aurelia et al., 2019). It is important to remember that this model has limitations, especially in terms of the assumptions used and the quality of the input data. Therefore, the results can only be as good as the data used and the assumptions applied.

Overall, Monte Carlo simulation based on MAPE and RMSE is a valuable tool for tourism destination management. With careful analysis and wise interpretation, managers can optimize operations and improve visitor experience at tourist attractions in West Sumatra.

Conclusion

Simulation Model Quality: The Monte Carlo simulation model used to forecast favorite tourist attractions in West Sumatra has been tested using MAPE and RMSE. The results show that the model has a low error rate, with MAPE around 1.15% and RMSE around 141.07. This indicates that the model has good quality in predicting the number of visitors. The Monte Carlo simulation results are close to the actual data. In the determination of favorite tourist attractions, the model is able to provide an accurate estimate of the number of visitors that can be expected.

This model can be used in decision-making related to tourist spot management. Using the simulation results, managers can better plan promotional activities, resource allocation, and infrastructure improvements. Based on the simulation results, tourist attractions in West Sumatra that have a higher chance of becoming favorites can be identified. Resource management and promotion can be focused on these places.

Recommendations

Monte Carlo simulation can be a useful tool in optimizing tourism destination management in West Sumatra by predicting favorite tourist attractions and reducing uncertainty in decision making. It is important to understand that this model has certain limitations and assumptions. The results will be greatly influenced by the quality of the data and parameters used in the model.

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