Problem Chosen	2023	Team Control Number
B	MCM/ICM Summary Sheet	202309874

Committed to the Harmonious Coexistence of Humans and Wildlife

With the continuous expansion of the local population, the wildlife in the reserve is facing serious threats to survival. Reasonable laws should be formulated to manage the conflict between humans and wild animals. It is imminent. The purpose of this report is to establish a management strategy model for local protected areas to balance the mutual interests between local residents and wildlife in Kenya.

Three models are established: Model I: Human-Wildlife Relationships Optimization Model; Model II: Decision Model Based on Entropy Weight Method; Model III: Gray Relational Forecasting Model.

Before all models are eastablish, We need to divide the research area according to industry type so that we can analyze it better. In addition, we use various visualization methods to make the results more intuitive.

For Model I, We first searched for various data on the Masai Mara area, and then divided the protected area into three parts, **planting areas, protected areas, and livestock areas**, and then performed correlation analysis on different areas to obtain the reduction in the number of wild animals and dense population degree, arable land area, and forest area are highly correlated, and then establish **a nonlinear programming model** with **multiple strategies**, and finally get the following plan for the planting area: 1. Reduce the population density by 9.81%, 2. Reduce the arable land area by 0.98%, 3. Increase the forest area by 14.25%. For the protected area, the following plans should be adopted: 1. Reduce the camp by 13.00%, 2. Reduce the release by 2.64%, 3. Increase the rhino habitat by 3.00%.

For Model II, We divide each policy into three levels: **1. Economic level, 2. Conflict level, 3. Ecological level**, and then establish a topsis-entropy weight method comprehensive evaluation model, quantify various policies, and give each policy a corresponding Score, sorted by comparing the scores. For planting areas: the population density should be limited to 60; for protected areas, the percentage of rhino habitat should be increased to 30%; for livestock areas, the proportion of cattle grazing expansion should be limited to 10% .

For Model III, Due to the remote location of Maassai Mara and the lack of technological development, the data collected in this paper are small. Therefore, we decided to adopt a prediction model for small samples. Based on the principle of information incompleteness of GM (1,1) model and the principle of realistic information optimizationThe conclusion can be seen in **Figure 10 and Figure 11**.

In addition, Since the above three models have greater objectivity, it can be seen from the sensitivity analysis that the strategy proposed in this report is also applicable to other wildlife management areas.

Eventually, this report discusses how to ommitted to the harmonious coexistence of humans and wildlife. We wrote a report to make suggestions for the local government

Keywords: Pearson correlation coefficient, Multiple nonlinear regression, TOPSIS, Grey correlation prediction, Pearson correlation coefficient.

Contents

1 Introduction

1.1 Problem Background

“When man is happy, he is in harmony with himself and his environment.” said by Oscar Wilde, a Irish writer, and the siginificance of harmonious coexistence between man and nature can be foreseen. To provide more equitable sharing of resources, Kenya’s parliament passed the Wildlife Conservation and Management Act, 2013 , as well as to allow alternative, community-based management efforts. Kenya has since added amendments to address gaps in the legislation to provide more clear governance, finance, and penalties for violators. By consulting a large number of references, we have summeded up specifics of Masai Mara Nature Reserve and its surrounding districts as the Figure 1 shows:

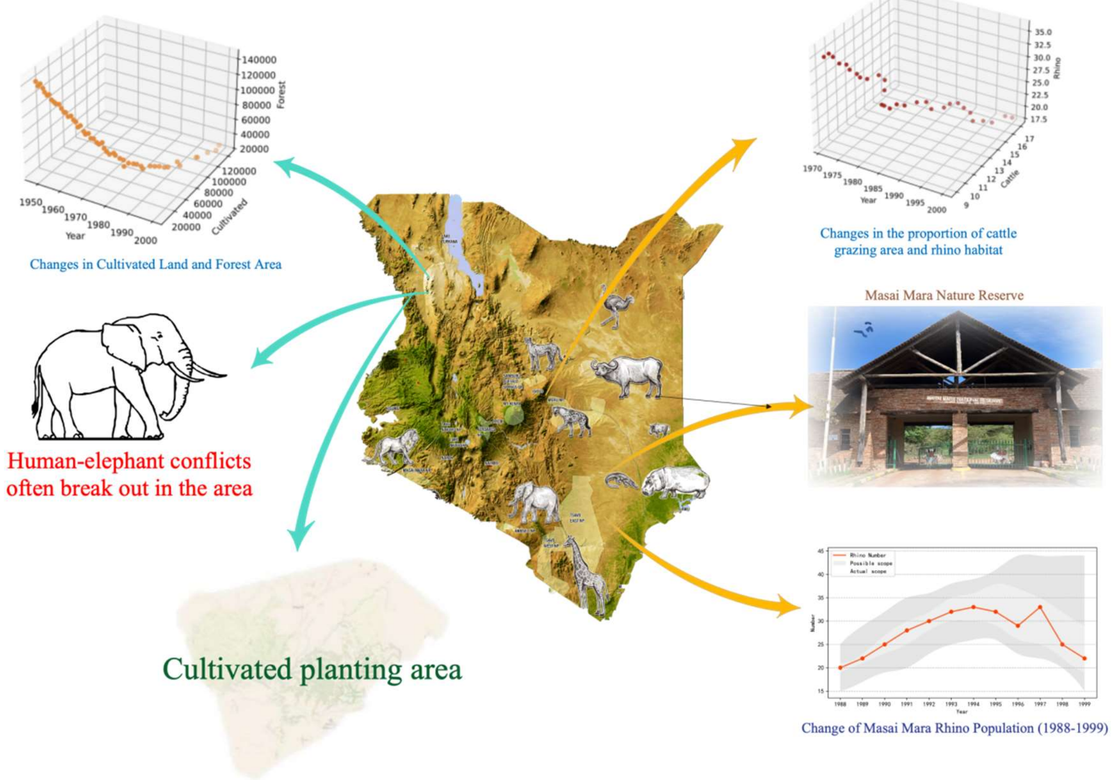


Figure 1: Schematic diagram of Masai Mara

The data above comes from the periodical **Wildlife and People: Conflict and Conservation in Masai Mara, Kenya**, it can be searched on **Google Scholar**[1].

1.2 Restatement of the Problem

Focusing on one large game preserve, the Maasai Mara and restricted conditions identified in the problem statement, we need to solve the following problems:

- Consider and recommend specific policy and management strategies for different districts within the current protected district to protect wildlife and other natural resources while balancing the interests of the people who live in the district.

- Develop and describe a methodology to determine which policies and management strategies will result in the optimal outcomes.
- Given your proposed plan, provide predictions about the long-term trends that will result from your recommendations. Analyze and provide estimates of the certainties and impacts of the possible long-term outcomes.

1.3 Literature Review

This question is mainly about determining alternate ways to manage the resources within and outside the current boundaries of the park. In recent years, search on social ecological system framework, combined with conflict theory, system theory is very hot. We sorted out the literatures witch study established a social ecological system framework[2] of nature reserve and human activity district, with a view to optimizing the conflict management model between nature reserves and surrounding communities, and coordinating the relationship between nature reserves and human activity district governance theory.

❖ In terms of the relevant data of each district to determine their correlation, usually use the Gray Correlation Model or use the Pearson Correlation Coefficient to establish a Correlation Model. However, the gray relational model is not suitable for widespread use[3], and has the nature of partial generalization.

❖ In order to evaluate the effect of policies, it is necessary to quantify the effects of each policy into indicators and score them after weighting. After searching the literature, it is found that the weight can be calculated by the Entropy Weight Method[4] or the Analytic Hierarchy Process (AHP). Since the weight calculation with AHP is greatly affected by subjective factors, so we use Entropy Weight Method to calculate the weight.

❖ The strengths and weaknesses of the planning space can be visually presented and is shown in Figure 2:

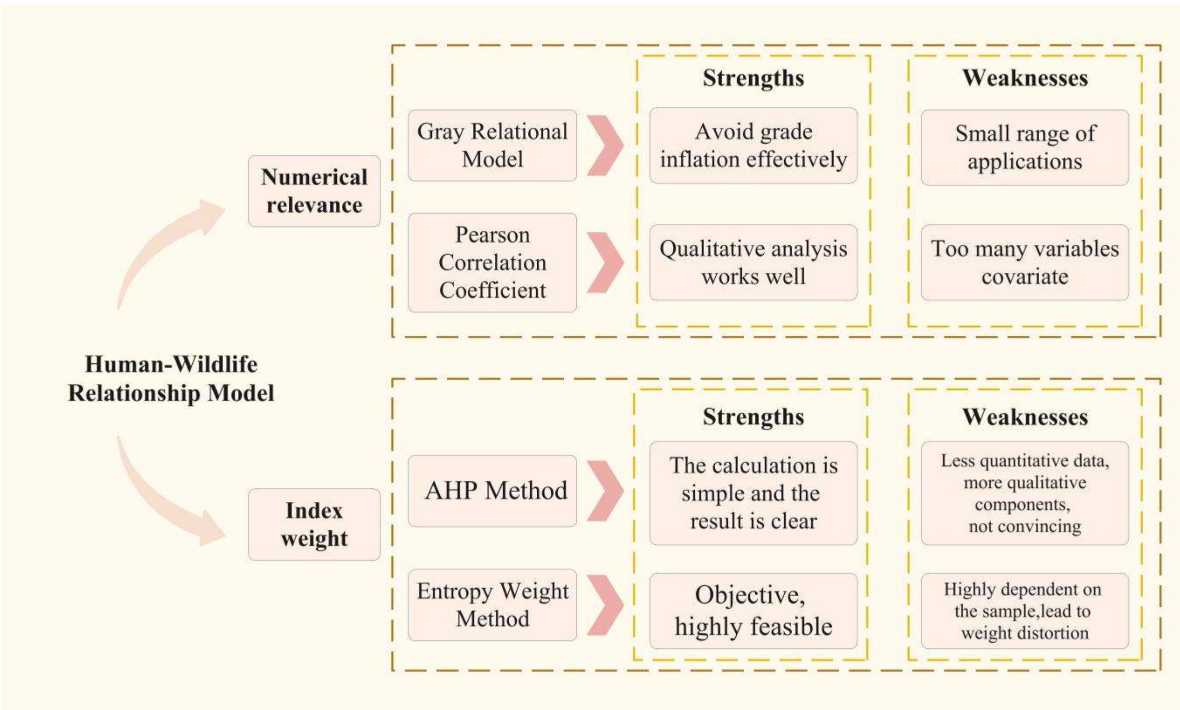


Figure 3: Flow Chart of Our Work

1.4 Our work

The topic requires us to to determine alternate ways to manage the resources within and outside the current boundaries of the park

Our work mainly includes the following:

1) Based on various historical data of Masai Mara, a Correlation Model is established;
2) Calculating the Weight of Influencing Factors with Topsis Entropy Weight Method.
3) Based on

In order to avoid complicated description, intuitively reflect our work process, the flow chart is shown in Figure 3:

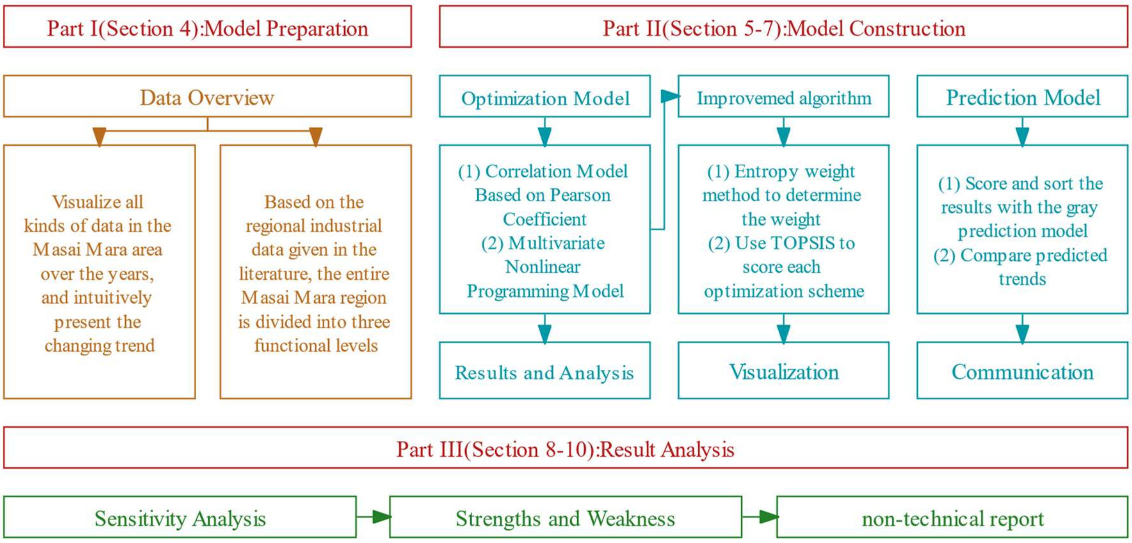


Figure 3: Flow Chart of Our Work

2 Assumptions and Explanations

To simplify the problem, we make the following basic assumptions, each of which is properly justified.

- **Assumption 1: Ignoring the impact of natural factors on the Masai Mara.**
  Explanation: Although it is known in the literature that the Masai Mara Nature Reserve is easily affected by various natural factors, such as volcanic eruptions and natural droughts, in order to make the model more concise, we reduce variables to facilitate our calculations and only consider human factors Influence

- **Assumption 2: The policy issued by the local government has been implemented.**
  Explanation: Every law and regulation issued by the local government is a human factor,

which will affect the results of the data, and the title requires a comparison of the results of the policies.

- **Assumption 3: No large-scale changes occur in the MMNA during implementation period of the plan.**
  Explanation: Because it is necessary to predict the long-term trend that my proposal will produce, if there is a change in the ownership of the rese or a change in the government during the period, the uncertainties will be greatly increased, and the effect of the prediction model will be deteriorated.

- **Assumption 4: Assume the research data is accurate.**
  Explanation: We assume that the historical data of Masai Mara, do not show obvious measurement deviation and are believed that they are fake, so we can establish a more reasonable quantitative model based on it.

3 Notations

The key mathematical notations used in this paper are listed in Table 1.

Table 1: Notations used in this paper

Symbols	Definition
N_i	Number of wild animals in year i
x_i (i=1,2,3)	When i=1, it's the loss of population, when i=2, it represents the decrease in cultivated land, when i is equal to 3, it's forest growth
a_i	The population of district A in year i
b_i	The cultivated district of district A in year i
c_i	The forest district of district A in year i
Y_i (i=1,2,3)	When i=1,Cumulative number of camps and accommodation (within and around the MMNR),when i=2, it represents the percentage reduction in grazing,when i=3, it represents the percentage increase in rhino habitat
S_i (i=1,2,3)	When i=1, it represents the number of human casualties caused by elephants, when i=2, it represents the number of human casualties caused by herbivores, and when i=3, it represents the number of human casualties caused by predators
a_i'	Number of camps and accommodations in district B for Year i

b_i'	Percentage of district B grazing in year i
c_i'	Percentage of rhino habitat in district B in year i
N_i	Number of wild animals in year i

4 Model Preparation

4.1 Data Overview

The question did not provide us with data directly, so we need to consider which data to collect in the model building. Through the analysis of the problem, we need to collect the of Masai Mara and so on. Due to the amount of data is large and not intuitive, we directly visualize some of the data for display.

4.1.1 Data Collection

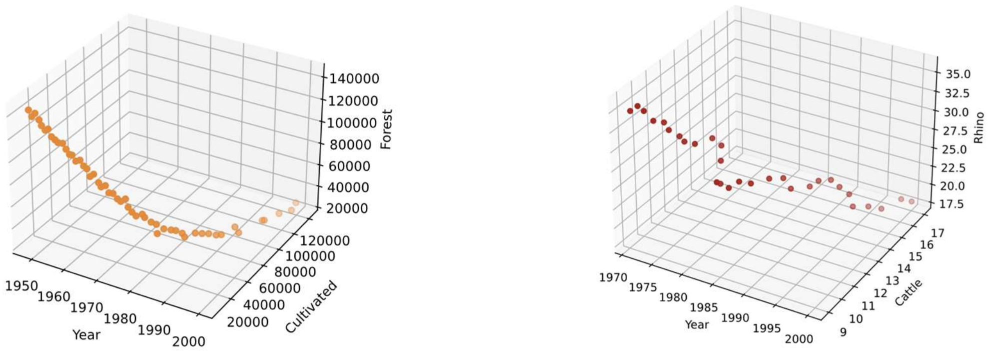
The data we used mainly included data on forestry, agrotourism and human-wildlife conflict in and around the Masai Mara. Table 2 summarizes the data sources.

Table 2: Data source collation

Database Names	Database Websites Data	Type
MMU	https://www.mmarau.ac.ke	Government
GIMCP	http://www.dsac.cn/DataProduct/Index/10	Geography
MMT	https://www.masaimara.travel/animals-wildlife.php	Geography
Google Scholar	https://scholar.google.com/	Academic paper

4.1.2 Data Screening

Based on the existing literature, the Masai Mara National Reserve from 1948 to 2000 was compiled, the data on the district occupied by cattle grazing, the changes in rhino habitats, and the changes in the number of tourist camps in and around the reserve, The number of incidents of wild animals hurting people in the protected district. Due to the huge amount of data, it is not directly displayed in detail in the article, so we visualize the data, and the changing trend and situation are shown in the Figure 4.



(a) Changes in Cultivated Land and Forest district

(b) Changes in the proportion of cattle grazing district and rhino habitat

Figure 4: Data screening

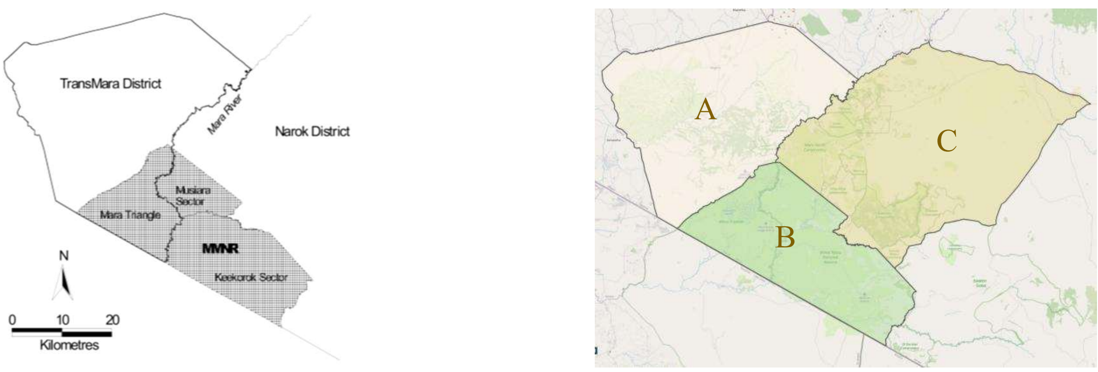
(a) **Changes in Cultivated Land and Forest district**: This can clearly show the general trend that the cultivated land district is gradually increasing and the forest district is gradually decreasing.

(b) **Changes in the proportion of cattle grazing district and rhino habitat**: It clearly show the general trend that the proportion of land used for grazing cattle is gradually increasing, while the proportion of rhinoceros habitat is gradually decreasing.

4.2 Division of districts

4.2.1 Divided by Operating Industry

Through a large amount of literature on the production and management methods of people in the Masai Mara Nature Reserve and its surrounding districts, we can divide the entire large district into three districts A, B, and C, which are planting district, nature reserve and pastoral district according to the different types of industries in each part. A brief schematic diagram is shown in Figure 5.



(a) Map of the study district

(b) Functional division

Figure 5: Division of districts

(a) **Map of the study district**: It is excerpted from a journal titled **Wildlife and People: Conflict and Conservation in Masai Mara, Kenya** (IIED Wildlife & Development Series No. 14, March 2003) .It gives the specific name and the type of industry in this large district.

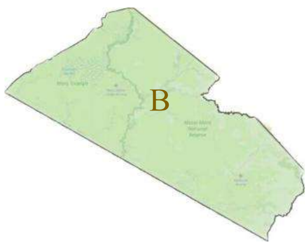
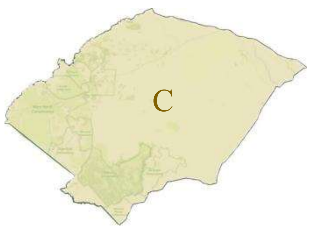
(b) **Functional division**: Based on relevant literature evidence, we divide the whole map into three small districts according to the different industries in different districts.District A is mainly arable land, district B is a nature reserve park, and district C is mainly a grazing district.

It can be seen from the literature that human-elephant conflicts often occur at the junction of districts A and B, and even elephant casualties occur from time to time. The main contradiction between district C and district B is that the cattle from district C encroach on the habitat of rhinos in district B, and there are cases of wild animals attacking residents and tourists at the junction of B and C from time to time.

4.2.2 Relevant Policies in Each District

Different policies in different districts can be drawn from periodical **Wildlife and People: Conflict and Conservation in Masai Mara, Kenya.** We organize them in Table 3.

Table 3: Laws and Regulations in Different District

District Type	Corresponding laws and regulations
	✓ Prohibition of private hunting of elephants. ✓ Raise residents' awareness of forest protection. ✓ Create a cross-border security unit.
	✓ Establishing cross-border monitoring for rhinos. ✓ Encourage educational institutions to conduct regular surveys and continuous monitoring of the tourism industry. ✓ Strengthen the concept of laws and regulations, and conduct legal training for tour guides and tourists. ✓ Use signs along roads in MMNR.
	✓ Tougher penalties for offenders who introduce cattle into MMNR ✓ Private grazing is prohibited, and grazing needs to be carried out in the specified district and time.

It can be seen that the difference between different districts is quite large, so we solve the problem according to different division districts

5 Model I: Human-Wildlife Relationships Optimization Model

5.1 Correlation Model Based on Pearson Coefficient

Pearson correlation analysis is a simple method to measure the relationship between response characteristics and responses. The direction and degree of linear correlation between the two are expressed by the positive and negative values and absolute values of the Pearson correlation coefficient[5].

According to the relevant requirements of the topic, we can get the following formula:

$$r_p = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2 (y_i - \overline{y})^2}} \tag{1}$$

Where rp is the Pearson correlation coefficient, the value range is [-1, 1],The larger the absolute value, the stronger the correlation; xi and yi are the sample observations of the two variables, respectively, and the corresponding averages of the two are represented by x- and y-; n is the sample observation. In addition, the correlation is also subject to significance, which is significant when it is less than 0.05, and extremely significant when it is less than 0.01.

Then, According to the collected data, put it into SPSS for inspection, the linear correlation table as shown in the figure below can be obtained:

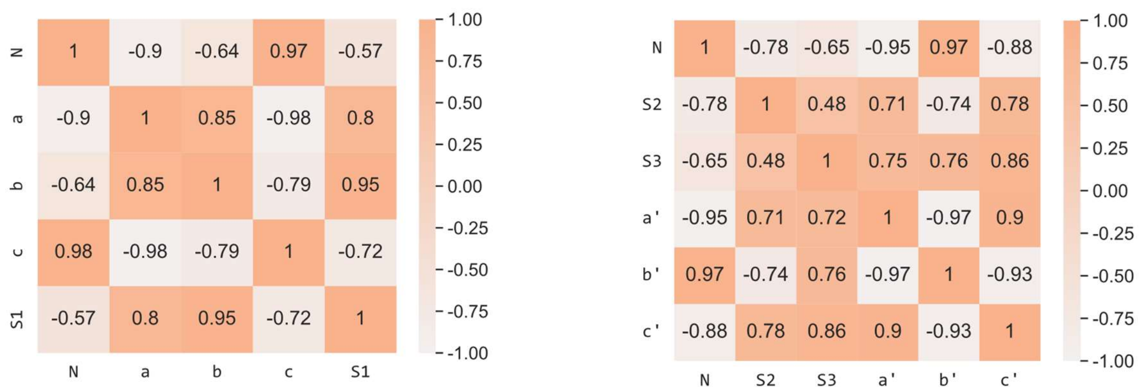
Table 3: Correlationof district A

N	a	b	c	S1
1.0000	-0.9731	-0.7850	0.9952	-0.7282
-0.9731	1.0000	0.8512	-0.9765	0.7948
-0.7850	0.8512	1.0000	-0.7855	0.9520
0.9952	-0.9765	-0.7855	1.0000	-0.7204
-0.7282	0.7948	0.9520	-0.7204	1.0000

Table 4: Correlationof district B

N	a‘	b'	c'	S2	S3
1.0000	-0.6977	-0.5741	-0.9004	-0.7260	-0.9420
-0.6977	1.0000	0.5555	0.7704	0.2651	0.6465
-0.5741	0.5555	1.0000	0.7152	0.1254	0.5568
-0.9004	0.7704	0.7152	1.0000	0.5025	0.8693
-0.7260	0.2651	0.1254	0.5025	1.0000	0.8446
-0.9420	0.6465	0.5568	0.8693	0.8446	1.0000

Finally, we visualize the data to get the following heat map：



(a) Pearson correlation coefficient heat map of District A (b) Pearson correlation coefficient heat map of District B

Figure 6: Pearson correlation coefficient heat map

5.2 Multivariate Nonlinear Programming Model

Firstly, there is the need to protect wildlife and other natural resources in the district, and second, there is the need to ensure that the people in the district have some opportunity to make a profit. Therefore, we need to build a multi-objective optimization model. For the different policies of the two places, We set up the following objective function:

✧ District A：

$$objective{:}min\ Z=(k_1\cdot e^{x_1}+k_2\cdot e^{x_2})^2-(k_3\cdot e^{x_3})^2 \tag{2}$$

The vaeiable x_i, when i=1, it's the loss of population,when i=2, it represents the decrease in cultivated land,when i is equal to 3, it's forest growth.

According to the data we have collected, the population and arable land have been increasing from 1948 to 2000, so the decrease of population and arable land should be limited to 2000. And in order to balance the amount of farmland for humans, forests should not grow more than they have lost in recent years.So you get the following constraints:

$$s.t.\begin{cases} 0\leqslant x_1<a_{2000} \\ 0\leqslant x_2<b_{2000} \\ 0<x_3\leqslant|c_{2000}-c_{1948}| \\ \dfrac{\sum\limits_{i=1948}^{2000}\frac{b_i}{a_i}}{(2000-1948)+1}\leqslant\dfrac{b_{2000}-x_2}{a_{2000}-x_1} \end{cases}$$

After correlation analysis by IBM SPSS software, the objective relationship between man and nature in district B is shown as follows:

✧ District B:

$$objective{:}max\ P=k_3\cdot e^{y_3} \tag{3}$$

$$objective{:}min\ Z=k_1e^{y_1}+k_2e^{y_2} \tag{4}$$

The vaeiable Y_i when i=1, Cumulative number of camps and accommodation (within and around the MMNR), when i=2, it represents the percentage reduction in grazing,when i=3, it represents the percentage increase in rhino habitat

Due to the lack of tourism in the district prior to 1971, the number of camp accommodations was minimal, so to better analyze the relationship between the number of camp accommodations, the percentage of grazing, and the percentage of rhino habitat, we needed to limit the range of all three.

$$s.t.\begin{cases} a'_{2000} - a'_t \leqslant Y_1 \leqslant a'_{2000} \\ b'_{2000} - b'_t \leqslant Y_2 \leqslant b'_{2000} \\ 0 < Y_3 \leqslant R \\ \dfrac{c'_{2000} + Y_3}{b'_{2000} - Y_2} \geqslant \dfrac{\sum\limits_{i=1948}^{2000} \frac{C_i'}{B_i'}}{(2000-1948)+1} \end{cases}$$

We can figure out the range of t from the following formula:

$$t = \arg\min_j \left[\frac{\sum\limits_{i=1}^{n} \frac{B_i}{C_I}}{(2000-1948)+1} - \frac{B_i}{C_i} \right] \tag{5}$$

And that tells us that a'_t should be equal to 10 and b'_t should be 21,so from the correlation of y2, y1 and y3, we can determine the range of Y3, R = 17.
By running the code through python, we get the solution result of region A as follows:

$$\begin{cases} x_1 = 9.81 \\ x_2 = 0.98 \\ x_3 = 14.25 \end{cases}$$

Therefore, for region A, the following programmes should be adopted: 1. Reduce the population by 9.81 per cent, 2. The district of cultivated land decreased by 0.98%, and the district of forest increased by 14.25%

The same can be said for:

$$\begin{cases} x_1 = 13.00 \\ x_2 = 2.64 \\ x_3 = 3.00 \end{cases}$$

Therefore, for district B, the following options should be adopted: 1. Reduction of camp by 13.00%, 2. Decrease the grazing district by 2.64% and increase the rhino habitat district by 3.00%

Finally we have the conclusion that: x_1 = 9.81, x_2 = 0.98, x_3 = 14.25, x_1'= 13.0, x_2' = 0.98, x_3'= 14.25 So for district A and B, the following scheme should be adopted:

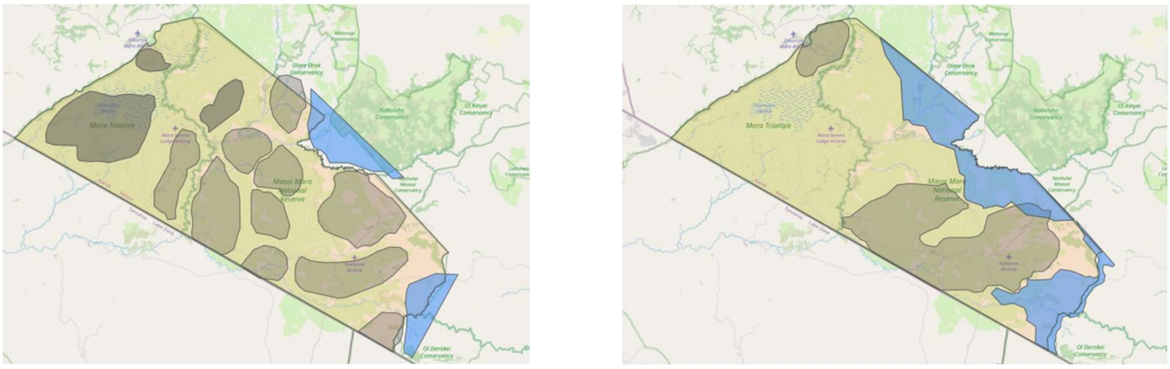
- Reduce 9.81% of the population density.
- Reduce 0.98% of cultivated land district.
- Increase 14.25% of forest district.

District A

- Reduce 9.81% of the population density.
- Reduce 0.98% of cultivated land district.
- Increase 14.25% of forest district.

District B

By collecting data, we can get the transition diagram as follows



(a) Distribution in 1971 (b) Distribution in 2000

Note: The blue shaded district indicates the cattle grazing district, and the dark green shaded district indicates the rhino habitat

Figure 7: Changes in rhino habitat (1971-2000)

It can be seen from Figure 9 that the cattle from district C have invaded the habitat of the rhino, and the grazing district of the cattle has gradually expanded. By 2000, rhino habitats overlapped with cattle grazing districts, further implying that the probability of human-wildlife conflicts will increase significantly.

6 Model II: Decision Model Based on Entropy Weight Method

First of all, according to the references, we will get the following weight according to the importance of each index.

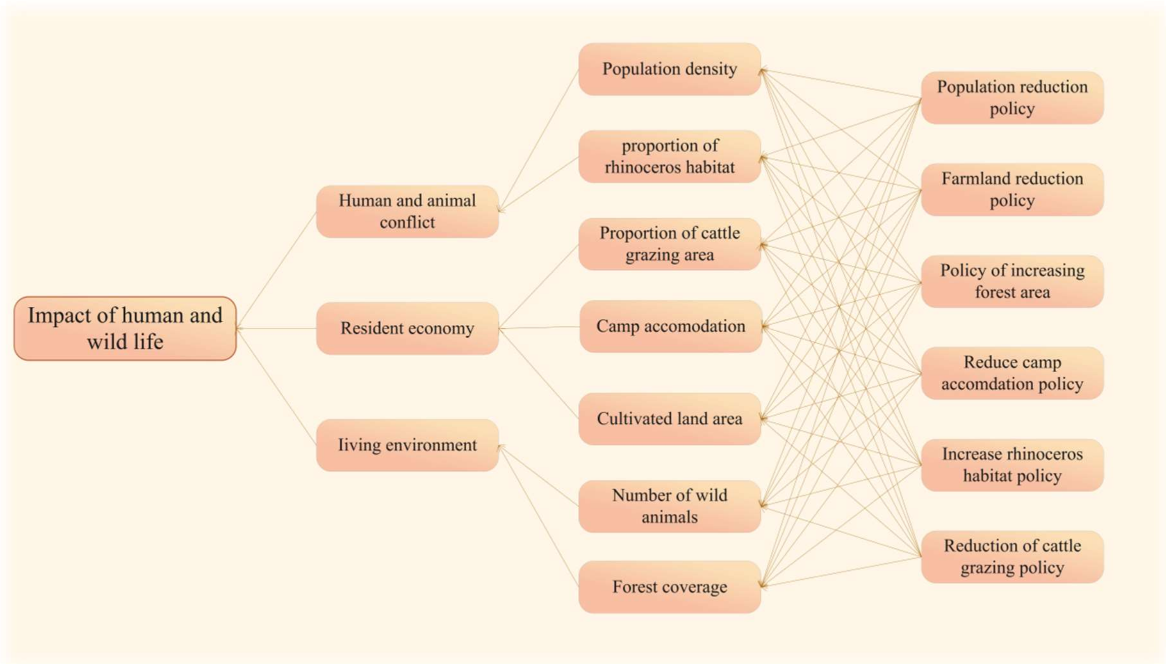


Figure 8: Schematic diagram of hierarchical analysis

Table 5: Weight table

Scale of scale	Meaning
1	i and j are equally important
3	i is slightly more important than j
5	i is more important than j
7	i is strongly more important than j
9	i is extremely important than j
2,4,6,8	The median of the above adjacent judgments

6.1 TOPSIS Evaluation Model of Entropy Weight

From Table 5, we can get the judgment matrix, and then turn the decision matrix forward,Where j=1,2,4 and 6 are very small indicators,Therefore, the following method is used to process the data:

$$X'_{ij} = \frac{X_{ij} - X_{\min}}{X_{\max} - X_{\min}} \tag{6}$$

The forward matrix $X'_{i,j}$ is normalized:

$$Z_{ij} = \frac{X'_{ij}}{\sqrt{\sum_{i=1}^{n} X'_{ij}}} \tag{7}$$

And then you get the probability matrix P_{ij}

$$P_{ij} = \frac{Z_{ij}}{\sum_{i=1}^{n} Z_{ij}} \tag{8}$$

For each index, the formula for calculating information entropy is as follows:

$$e_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} P_{ij} \ln(P_{ij}) \tag{9}$$

When $P_{i,j} = 0$ and $\ln(P_{i,j}) = 0$:

$$d_j = 1 - e_j \tag{10}$$

So we can calculate the entropy weight:

$$W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{11}$$

6.2 Results of Entropy Weight

In order to intuitively display the weight ratio of each indicator, we visualized the weight:

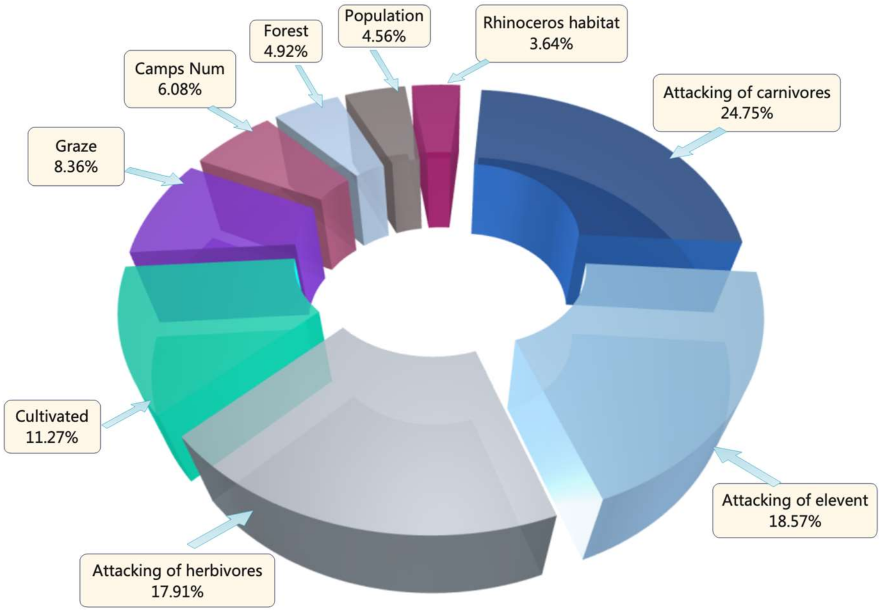


Figure 9: Weight based on entropy weight method

6.3 Analysis

Through Topsis Analysis, the program runs to the conclusion that for region A, between policy 18 and policy 26, policy 22 gets the highest score, and the population density in region A should be limited to 60 people per square kilometer. For region B, between policy 4 and policy 17, policy 6 gets the highest score, and the percentage of rhino habitat in region B should be increased to 30%, while for region C, According to Policy 1 to Policy 3, policy 3 should be preferred, so that the controlled grazing district is limited to 10%. Therefore, the specific measures taken by various regions are as follows:

✧ Region A：

1. The government leases land to residents around the reserve to expand the range of wildlife.

2. Residents who do not want to move need to learn relevant laws and regulations of the reserve, live in harmony with wildlife and participate in wildlife protection in the park. Residents can choose to serve as rangers, and the park will pay corresponding wages. If residents who insist on not moving need to bear the risk of arable land being damaged by animals. There will be no more government compensation. The investigation found that the Narok regional government had paid farmers compensation for wildlife damage to their crops, but was soon unable to pay, suggesting that the policy

was not suitable for long-term development.

3. We will establish a severe punishment mechanism for violations of wildlife protection regulations and implement supervision, further publicize and popularize the wildlife protection law, so that both tourists and local people can establish the awareness of protecting these wildlife and transform from passive to active.

✧ Region C：

1. The government leases land to residents around the reserve to expand the range of wildlife.

2. It is known that wildebeest, zebra and gazelle from other districts will migrate here every June, and herders need to move their grazing land in a planned way. In order to control the district of grazing district, staggered peak grazing is recommended.

3. Over the past century, wildlife experts around the world have discovered that the creation of nature reserves can effectively protect endangered species and their habitats, but that local extinction can occur if protected districts are fragmented and animals cannot find each other. Therefore, if an ecological corridor can be established in this district, it will greatly promote the recovery of local animal populations, and to a certain extent, it can effectively prevent the intersection of animal activities and human grazing time and space.

6.4 Conclusion

- For District A:

According to the 18-26 policy, we should choose policy 22, and the population density should be limited to 60.

- For District B:

According to policy 4-17, policy 6 should be selected preferentially, and the percentage of rhino habitat should be increased to 30%

- For District C:

According to policies 1-3, policy 3 should be selected according to the best, and the proportion of cattle grazing expansion should be limited to 10%

7 Model III: Gray Relational Forecasting Model

Due to the remote location of Maassai Mara and the lack of technological development, the data collected in this paper are small. Therefore, we decided to adopt a prediction model for small samples. Based on the principle of information incompleteness of GM (1,1) model and the principle of realistic information optimization, it is very suitable to study the Maassai Mara area. The steps of establishing this model will be explained below:

Gray differential equation of one variable and one order:

$$x^{(0)}(k)+az^{(1)}(k)=b$$

$$z^{(1)}(k)=0.5x^{(1)}(k)+0.5x^{(1)}(k-1)$$

$x^{(0)}$ is a non-negative sequence：

$$x^{(0)}=(x^{(0)}(1),x^{(0)}(2),...,x^{(0)}(n))$$

$$x^{(0)}(k)\geqslant 0,\quad k=1,2,...,n$$

$x^{(1)}$ is the 1-AGO sequence of $x^{(0)}$:

$$x^{(1)}=(x^{(1)}(1),x^{(1)}(2),...,x^{(1)}(n))$$

Among them,

$$x^{(1)}(k)=\sum_{i=1}^{k}x^{(0)}(i),\quad k=1,2,...,n$$

$Z^{(1)}$ is the adjacent mean generating sequence of $X^{(1)}$:

$$Z^{(1)}=(z^{(1)}(1),z^{(1)}(2),...,z^{(1)}(n))$$

$$z^{(1)}(k)=0.5x^{(1)}(k)+0.5x^{(1)}(k-1),\quad k=1,2,...,n$$

$$y=\begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix} \qquad B=\begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{bmatrix}$$

Then the least square estimation parameter column of grey differential equation satisfies:

$$\hat{a}=(B^{T}B)^{-1}B^{T}y$$

This part needs to combine the actual data and the strategy obtained in question 2 to predict the long-term development trend of Masai Mara region under the strategy formulation.

According to the effect of the highest score strategy obtained above,for area A, the population density should be limited to 60 people per square kilometer, the proportion of rhino habitat in area B should be raised to 30%, and for area C, the controlled grazing area should be limited to 10%.

Then combined with the actual data, our construction strategy is as follows:

1. Since the local government has strictly enforced the policy since 1971, it can consider the proportion of rhino habitat greater than 30 percent as 30 percent. If the grazing area of Area C is not more than 10%, it is considered as 10%. Similarly, if the population density is more than 60 people per square kilometer, it can also be considered as 60.

2. Since the number of camp accommodations from 1971 to 2000 has increased over the years but has remained below 35, the number of camps should not be adjusted to reflect the actual situation.

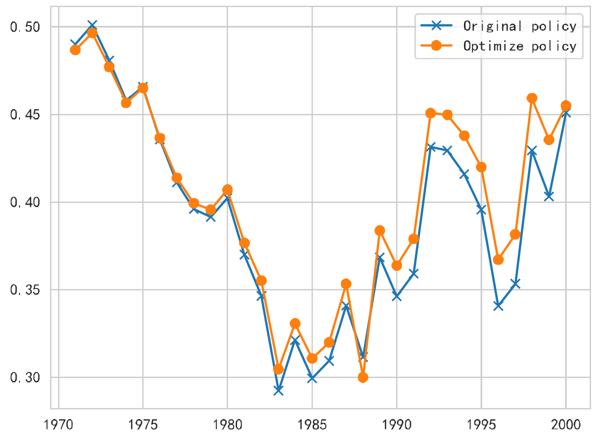


Figure 10 Historical data score of the actual data under the optimal strategy

The data score under the influence of strategy and the actual data score without the influence of strategy are substituted into the GM(1,1) model to predict its development trend, and the data from 1971 to 2000 are calculated according to the expression.

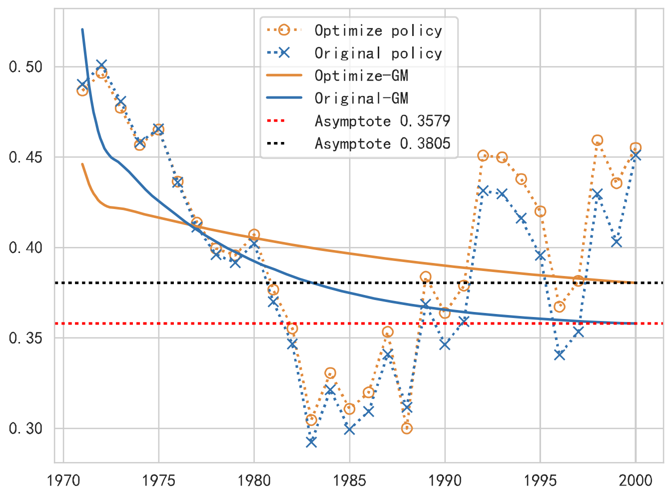


Figure 10 Trend analysis graph of policy-affected data and raw data

It is not difficult to see from the figure that Optimize-GM is higher than original-GM, that is, the score of the data affected by the strategy is higher than that of the Original data. The overall trend of GM model under the influence of policies is higher than that of the original data model, and both tend to be stable, which means that in a relatively long period of time, if there is no interference from other factors, the strategy score will tend to be constant, which can represent the final stable state of the strategy under certain conditions. As can be seen from the figure, the final score of the data affected by the policy is stable at around 0.3768, while the score of the original data is stable at around 0.3589. You can see that in the end, it's better to be influenced by policy.

8 Sensitivity Analysis

By adding a random value to the constant, the result shown in the figure can be obtained.

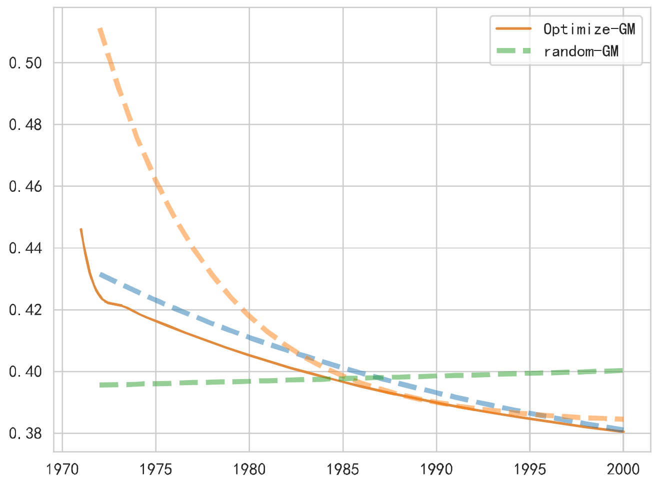


Figure 15: Sensitivity analysis

It can be seen that the robustness of the model is good.

9 Conclusion

9.1 Summary of Results

9.1.1 Result of Problem 1

According to the calculation results from Model I , we draw the following conclusions:

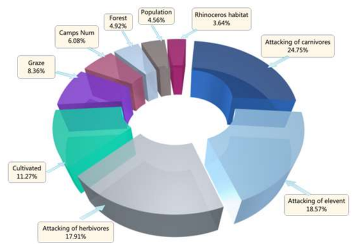
- Reduce 9.81% of the population density.
- Reduce 0.98% of cultivated land district.
- Increase 14.25% of forest district.

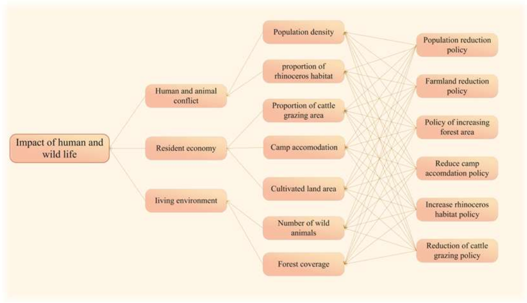
District A

- Reduce 9.81% of the population density.
- Reduce 0.98% of cultivated land district.
- Increase 14.25% of forest district.

District B

9.1.2 Result of Problem 2

<table>
<tr>
<td>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- For District A:

According to the 18-26 policy, we should choose policy 22, and the population density should be limited to 60.

- For District B:

According to policy 4-17, policy 6 should be selected preferentially, and the percentage of rhino habitat should be increased to 30%

- For District C:

According to policies 1-3, policy 3 should be selected according to the best, and the proportion of cattle grazing expansion should be limited to 10%
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<tr>
<td>(a) TOPSIS</td>
<td>(b) The location of fishes (std)</td>
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9.1.3 Result of Problem 3

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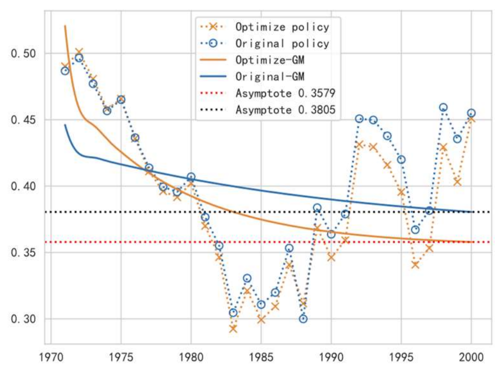
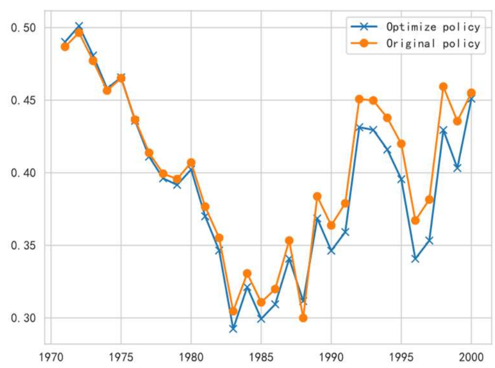


(a) Profit trends



(b) Bankruptcy Time Distribution Histogram

9.2 Strengths

Our model offers the following strengths:

- The **Decision Model Based on Entropy Weight Method** is scientific and reasonable. The model carries out **TOPSIS Entropy Weight Analysis**, which is progressive layer by layer, strictly according to objective data, with strong hierarchy and strong convincing degree.
- The **visualization work** is done very well by us. For example, in the middle of the

question background, we drew a map that fully introduces the various influencing factors in Masai Mara district, covering almost all the content in the district, sorry for being easy for readers to understand. The literature review and our work flow chart are displayed to make it easier for readers to understand.

- In the preparation of the model, we **divided the entire district** into three parts according to the function, so that the collected data can be used in the most accurate place, and the data in different districts will not have an impact, which greatly improves the accuracy of our paper results.
- Effectiveness of the model can be demonstrated under different parameter of the model by **sensitivity analysis**. So the model can be applied to much more events.

9.3 Possible Improvements

- ◆ Due to uncontrollable external factors, such as natural disasters, infectious diseases among animals, wars and other factors, the predicted results will be slightly different from the actual situation
- ◆ Some approximate analysis methods are applied to model the management of local gavermnent, which may lead to the situation contrary to the actual in extreme cases.

Protecting MMNR is urgent

— Harmonious Coexistence of Humans and Wild Animals

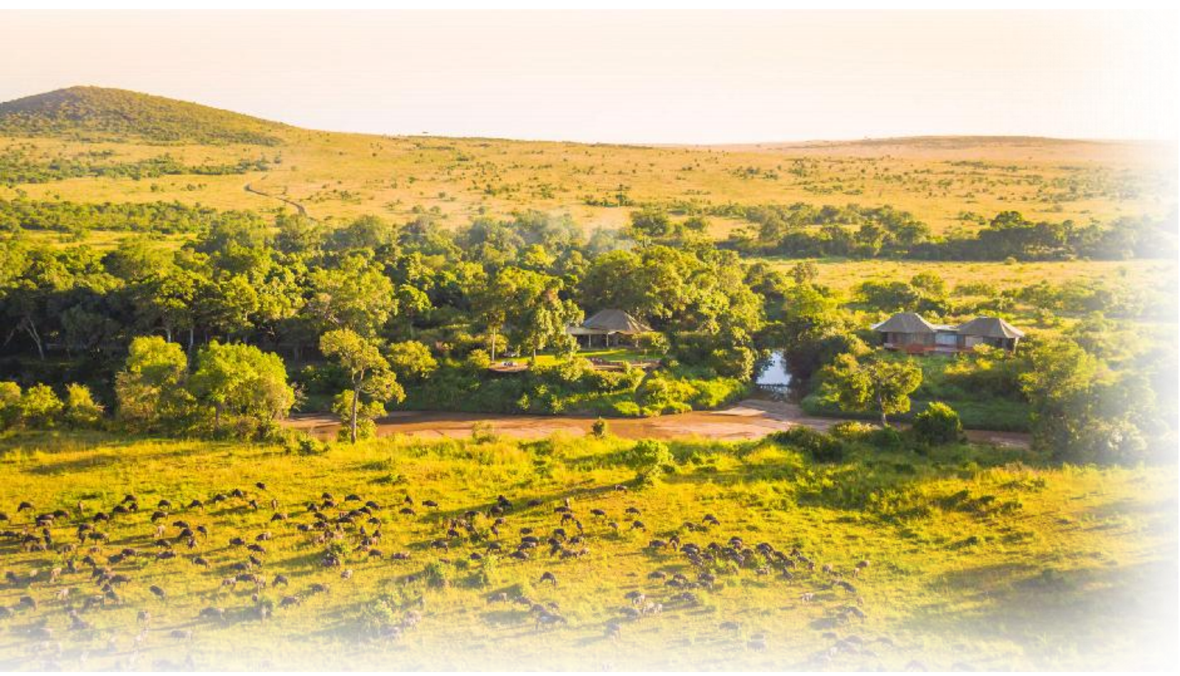
Known for the diversity of its wildlife, the Masai Mara National Reserve is East Africa's premier safari location. With the cumulative impact of human factors, the ecological environment of the Masai Mara National Reserve has undergone some changes. Although the Kenyan government has issued relevant policies, the effect has not been significant. This report mainly aims at the specific situation of MMNR. Suggestions and plans with certain reference.

Cause of conflict

Due to the generally lower level of socio-economic system development in the Masai Mara Nature Reserve than in other areas, there is a large number of poor people and poverty, who can only survive on traditional cultivation and grazing. The area of cultivated land has increased year by year, leading to a reduction in the range of a large number of animals and a surge in conflicts between humans and animals.

Thus, the root of the problem is economic development. It is suggested that national and local governments can introduce poverty alleviation measures to increase residents' income, thus promoting local industrial transformation and slowing down farmland development. Once the living conditions of the residents change and become increasingly affluent, I can radically weaken and eliminate the negative entropy flow expenditure of the forest ecosystem in the reserve.

The above policy suggestions for the two regions will obviously contribute to the development of agriculture and animal husbandry, increase residents' income, and play a positive role in ecological protection, which is also good for national development. The positive effect on region B, namely MMNR, is also self-evident.



Specific Measures

First of all, if the land around the reserve can be rented, it will not only expand the freedom of wildlife, but also enable tourists to visit more areas, enrich the attractions and activities of MMNR, which will help attract people from all over the world and increase the income of the nature reserve.

Secondly, if sufficient ecological corridors are established, it will be a beautiful scenery line. Importantly, the conflict between animals and herders will be reduced, which will reduce the management expenditure of nature reserves in this regard

Last but very effective is to raise the awareness of residents on ecological protection and popularize the relevant legal provisions of nature reserves. If local people can do this, the wildlife in the area will be well protected, and the nature reserve will be less able to cope with emergencies because of the help of nearby residents. Once the quality of residents improves, it is believed that more and more people will travel to the Masamara region.

According to the data, 60% of the income of this place comes from tourism, so it can be said that tourism keeps people alive here. The development of tourism will be greatly promoted in the above description, so it has an irreplaceable role in the economic development of this place.

（Editor: Team #230974)

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Appendices

Appendix 1
Introduce: Tools and software
Paper written and generated via Office 2023. Graph generated and calculation using MATLAB R2022a.

Appendix 2
Introduce: Code

```
import numpy as np
import pandas as pd
import math

def ewm(df):
    df = df.apply(lambda x: ((x - np.min(x)) / (np.max(x) - np.min(x))))
    rows, cols = df.shape
    k = 1.0 / math.log(rows)

    p = df / df.sum(axis=0)
    lnf = -np.log(p , where = df!=0 )*p*k

    d = 1 - lnf.sum(axis=0)
    w = d / d.sum()

    w = pd.DataFrame(w)
    w = w.round(5)
    w.index = df.columns
    w.columns =['weight']
    return w
```