Study of Green GDP Based on the Ecological Footprint Model

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Abstract. To explicitly assess the impact of the implementation of GGDP policies on global climate, this paper analyzes multiple manifestations of climate change. Using analytic hierarchy process, the significance of each manifestation was assessed, with carbon dioxide being the most significant. In this paper, "carbon emissions" is used as a research index, and the relation function y=68.56 + 0.002* investment in environmental governance + 0.004* investment in environmental degradation was obtained by fitting the carbon emission variation and the sum of investment in environmental pollution control and environmental degradation with least square method.   In addition, this paper introduces the "ecological footprint model", which uses the ecological footprint demand and ecological carrying capacity to jointly calculate the ecological damage level index of a country or region, to evaluate the sustainable development level and assist the carbon emission model to objectively evaluate the impact of the implementation of GGDP policies on the global climate. The advantages and disadvantages of the implementation of GGDP policy are also analyzed, the EKC curve is introduced, and suggestions for improvement are put forward for the possible fairness problems.

Keywords: GGDP, SEEA-2012, Climate Change, Ecological Footprint, EKC Curves.

1. Introduction

With the development and progress of the economy and society, the evaluation of the regional economic development only through GDP shows its limitations. Green GDP considering the negative impact on natural resources and the environment in the process of economic growth is proposed in this context. The green GDP accounting system calculates the resource loss value and the environmental governance loss value, which is conducive to the protection and improvement of the environment and plays a positive impact on the mitigation of climate change. Green GDP is an economic indicator designed to measure the economic growth of a country or region, taking into account the impact of environmental factors. The concept of green GDP was first put forward in the Manual of Comprehensive Environmental and Economic Accounting (SEEA) issued by the United Nations and was later revised by the United Nations in 2012 and 2013 to become a guiding document for the accounting of green GDP. [1][2]Domestic scholars have also carried out a lot of research on this: some researchers calculate green GDP from the SEEA-EA system [3][4]To improve on the field of accounting, Because in terms of the accounting methods, The calculation of green GDP needs to consider factors such as environmental resource consumption and pollution emissions, In order to more accurately assess the sustainability and environmental impact of economic growth; according to China's two-carbon agreement proposed at the United Nations in 2020, to study the effective path to achieve carbon peak starting from green GDP [5]; besides. There are also scholars committed to the research of green GDP at different provincial levels [4][6], In order to explore whether the green GDP between different provinces can promote the development of various fields and its development potential. It can be seen that at present, there is a relatively complete accounting system that can be used for the calculation of green GDP, and according to the different research objects, we can make some choices or changes in the accounting field according to the actual situation.[7] It can be seen that at present, there is a relatively complete accounting system that can be used for the calculation of green GDP, and according to the different research objects, we can make some choices or changes in the accounting field according to the actual situation. But in fact, despite the increasingly mature accounting system of green GDP, most countries still adopt the traditional GDP accounting method. Therefore, this paper will focus on the analysis of the necessity of using green GDP accounting, and the possible unfairness in using green GDP accounting, and give the corresponding policies or suggestions to reduce or eliminate the disadvantages generated in the adoption of green GDP.

2. The Global Climate Change Assessment

2.1. Analysis and selection of climate impact measures

2.1.1 Analysis of climate impact measures

To predict the impact on global climate, we chose climate change as our observation. There are many manifestations of climate change, such as temperature, ozone layer change, the amount of carbon dioxide in the atmosphere, precipitation, and the PH change of rainwater. We calculated the significance of these changes by drawing on the hierarchical analysis method to calculate the index weights.

2.1.2 Significance degree judgment matrix

The judgment matrix of analogy hierarchical analysis gives the judgment matrix of climate change significance. The judgment matrix of climate change significance is shown in Table 1.

Table 1: Significance judgment matrix

Index	Air temperature	Ozone	Carbon emission	Precipitation	PH of rainwater
Air temperature	1	1	0.143	0.333	3
Ozone	1	1	0.111	0.167	1
Carbon emission	7	9	1	5	7
Precipitation	3	6	0.2	1	5
PH of rainwater	0.333	1	0.143	0.2	1

The indicators in the table all indicate the corresponding degree of change to climate change. Results of the significance degree analysis.

2.1.3 Results of the significance degree analysis

Analogical hierarchy analysis results, significant significance analysis results. The significance results of each index are shown in Figure 1.

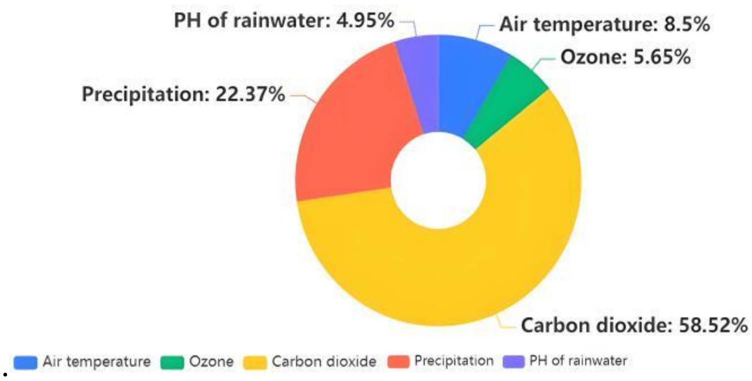

Figure 1: Significance analysis results

The maximum feature root was 5.289 with a CI value of 0.072.

2.1.4 Results of the consistency test

In the course of the significance analysis results, the value of the consistency index CI is presented, and the CR is obtained according to formula (1). The CR was 0.065, less than 0.1, so the consistency of the judgment matrix was considered acceptable without correction.

2.1.5 Consistency test result

In the process of significance analysis results, the value of consistency index CI is given, and CR is obtained according to Formula (9). CR is 0.065,less than 0.1, so it is considered that the consistency of judgment matrix is acceptable and does not need to be corrected. The consistency test results are shown in Table 2

$$CR = CI/RI \tag{1}$$

Table 2: Consistency Test Result

Maximum characteristic root	CI value	RI value	CR value	Consistency test result
5.289	0.072	1	0.143	Pass

The calculated results show that the significant index of temperature change degree is 8.504%, that of ozone change degree is 5.652%, that of carbon dioxide change degree is 58.524%, that of precipitation change degree is 22.372%, and that of rain PH change degree weight is 4.948%. The degree of change in carbon dioxide had the most significant effect. Therefore, when considering the impact of GGDP on climate change, we only consider the impact of GGDP on carbon emissions.

2.1.6 Selection of Index

Based on our significant degree analysis of the performance of climate change and the relevant indicators of GGDP accounting system, we choose carbon emission as the indicator to measure climate change and establish the model.

2.2. Least-squares fitting of carbon emissions

Based on the significance analysis of climate impact measurement indicators and the GGDP accounting method selected by us, we determined the following methods to measure climate impact: Through the known carbon emission, environmental pollution control investment and environmental degradation investment of a certain place in some years, the functional relationship between them is fitted to analyze the change of carbon emission caused by the change of environmental pollution control investment and environmental degradation investment under GGDP, so as to measure the climate impact of GGDP as the standard of economic health.

2.3. Least square regression

2.3.1 Determine the fitting curve

The independent variable is set as environmental pollution control investment and environmental degradation investment, and the dependent variable is carbon emission. The following fitting curve is established:

$$\hat{y_i} = kx_i + b \tag{2}$$

The fitting diagram is shown in Figure 2. The data sources used in the fitting are the Belt and Road ecological environment Big Data Service platform and Orient Wealth Network.

Figure 2: Fit the Effect Drawing

The residual sum of squares is calculated from the fitting results. The formula is as follows:

$$\sum {e_i}^2 = \sum (y_i - \hat{y_i})^2 \tag{3}$$

Where, $\hat{y_i}$ represents the value of the dependent variable obtained by fitting, i represents the type of the independent variable, x_i represents the value of the independent variable, and b represents the constant.

Because we want the sum of residual squares to be as small as possible, we take the partial derivative of the sum of residual squares and set it to 0. The formula is as follows:

$$\frac{\partial(\sum {e_i}^2)}{\partial k} = 0 \tag{4}$$

$$\frac{\partial(\sum {e_i}^2)}{\partial b} = 0 \tag{5}$$

2.3.2 Analysis of fitting condition

Through goodness of fit analysis, the fitting situation was calculated as follows:

$$R^2 = \frac{SSR}{SST} \tag{6}$$

$$\text{SSR}=\sum_{i=1}^{n} (\hat{y_i} - \bar{y})^2 \tag{7}$$

$$\text{SST}=\sum_{i=1}^{n} (y_i - \bar{y})^2 \tag{8}$$

SSR represents the regression sum of squares and SST represents the population sum of squares.

2.3.3 Linear regression analysis results

The results of linear regression analysis are shown in Table 3.

Table 3: Linear Regression Analysis Results

	Nonstandardized coefficient		**Standardization coefficient**	**VIF**	R^2	**Adjust** R^2	**F**
	B	Standard error	Beta				
Constant	68.56	7.845	-	-	0.804	0.755	F=16.385
IEP	0.002	0.001	0.402	1.935			
IED	0.004	0.001	0.569	1.935			

In the table above, IEP refers to investment in environmental pollution control, IED refers to investment in environmental degradation.

2.3.4 Fitting formula

$$\text{y} = 68.56 + 0.002 * \text{IEP} + 0.004 * \text{IED} \tag{9}$$

Assuming that the global consensus has been reached on using GGDP as a unified standard of economic measurement, all countries in the world are willing to divide the total amount of investment for environmental governance into m and the total amount of investment for environmental degradation into n from their financial resources.

$$\triangle \text{ Carbon emission } = 68.56 + 0.002 * \text{m} + 0.004 * \text{n} \quad (10)$$

In 2014, researchers in the United Kingdom used climate models of carbon emissions and global warming to show that temporary global warming is proportional to cumulative carbon emissions over decades to centuries.

This means that the carbon emissions we reduce under GGDP will directly alleviate the global greenhouse effect, thus lowering the sea level and weakening the threat of sea water inundation in coastal countries and regions. It can also slow down or avoid desertification and increase biodiversity.

2.4. Urban Ecological Footprint

On the basis of constructing the climate change model with carbon emission as the index, we introduce the ecological footprint model as the auxiliary measurement. Ecological footprint model is a quantitative method to measure regional sustainable development from the perspective of ecological discipline. We hope to build a national ecological damage level index based on ecological footprint requirements and ecological carrying capacity, so as to assess the level of sustainable development and assist in evaluating the impact of GGDP on climate mitigation.[8][9]

The types of land for production are shown in Figure 3.

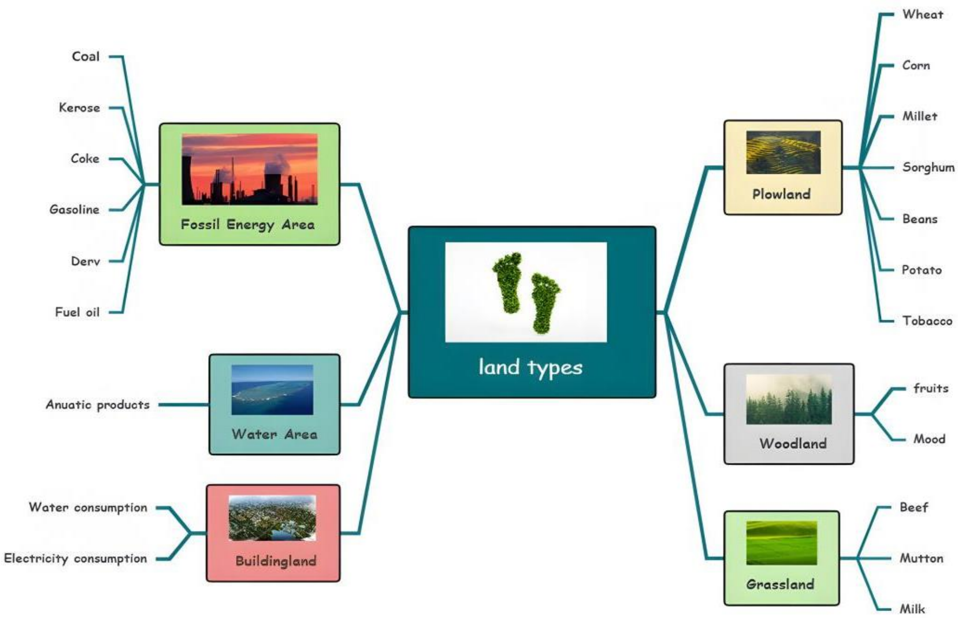

Figure 3: Productive Land Type

The calculation formula of ecological footprint demand is:

$$\text{EF}=\sum_{i=1}^{n}(E_i \cdot \frac{\text{A}_\text{i}}{\text{B}_\text{i}}) \quad (11)$$

Where EF refers to ecological footprint demand, E_i refers to equalization factor, A_i refers to per capita consumption of consumption items, B_i refers to corresponding project world average productivity.

The calculation formula of ecological carrying capacity is:

$$\text{EC}=\sum C_i D_i F_i \quad (12)$$

Where EC refers to ecological carrying capacity, C_i refers to various types of land area, D_i refers to equilibrium factor of carrying capacity, F_i refers to Yield factor.

Next, construct the ecological damage index:

$$ISD = \frac{EF-EC}{EC} \quad (13)$$

Where ISD refers to indicators of sustainable development.

This formula can be used to calculate the EF greater than EC. When the EF is less than EC, the corresponding area meets the standard of nature reserve.

ISD is the state of ecological destruction in an area. After analysis and comparison, the sustainable development level can be roughly divided into five levels. The five levels are shown in Table 4.

Table 4: Consistency Test Result

Grade	ISD	Sustainable development level
1	0-0.5	Moderately sustainable
2	0.5-1.33	Weak sustainability
3	1.33-3	Weak and unsustainable
4	3-8	Moderately unsustainable
5	8-	Strong and unsustainable

When carbon emission and SDI are known, SDI can be used as an aid to get the impact of GGDP on climate according to the fitting of carbon emission, environmental pollution control investment and environmental degradation investment.

3. Measure of GGDP

3.1. The Positive Impact of GGDP

3.1.1 Analysis of Accounting Index

The 15th Conference of the Parties to the United Nations Convention to Combat Desertification is held in Cote d 'Ivoire. The Drought Figures Report, released during the meeting, shows that the number and duration of droughts has increased by 29 per cent globally since 2000. It estimates that between 1998 and 2017 alone, drought cost the world $124 billion in economic losses. Drought affected about 1.4 billion people between 2000 and 2019. The measurement of water resources is conducive to the practice of the concept of water conservation and can help alleviate drought problems. The consideration of the cost of water pollution control is conducive to the technological upgrading of related industries, promoting scientific and technological innovation and productivity progress. The water body also has the function of regulating temperature, which contributes to maintaining temperature stability.

After the second Industrial revolution, human enter the era of electric appliances, and the development and utilization of energy reaches an unprecedented level. Until now, the crisis of energy shortage has appeared, and the greenhouse effect and ozone layer destruction caused by the use of coal and oil are also in urgent need of solution. The development of new energy can solve part of the problem of energy shortage, but it can not solve the problem of environmental damage and climate crisis. GGDP helps to improve energy efficiency and reduce pollution.

With the implementation of GGDP accounting index, people will have a deeper understanding of green and sustainable concepts. On this basis, the loss of environmental pollution control can be visualized by the calculation formula given, which is conducive to reducing the ungenerated environmental pollution and controlling the existing pollution.

3.1.2 Model Result Analysis

According to the climate mitigation model established with carbon emission as the index, after the implementation of the GGDP index, the countries accepting the index will make relevant policy adjustments and change the investment in environmental pollution control and environmental degradation. The reduction in carbon emissions that will result from such a change will help mitigate the climate crisis. At the same time, the ecological damage index used in the auxiliary measurement also decreased, indicating that the implementation of GGDP promotes the development of society in a sustainable direction.

3.2. The Negative Impact of GGDP

3.2.1 Environmental Kuznets Curve

The environmental Kuznets curve (EKC) [10] comes into view as we try to establish the relationship between the economy and the climate environment.

EKC curve was first proposed by American economists. The meaning of the curve is: with the growth of per capita GDP, the degree of environmental pollution rises first. After reaching a certain peak of pollution, the per capita GDP continues to grow and the degree of environmental pollution slowly declines. This peak is defined as the inflection point. We believe that when per capita GDP of a country reaches this inflection point, it means that the country has a certain economic basis to be more inclined to environmental protection in the development, that is to say, for such countries, it is easy to accept GGDP as a unified indicator. The EKC curve diagram is shown in Figure 4.

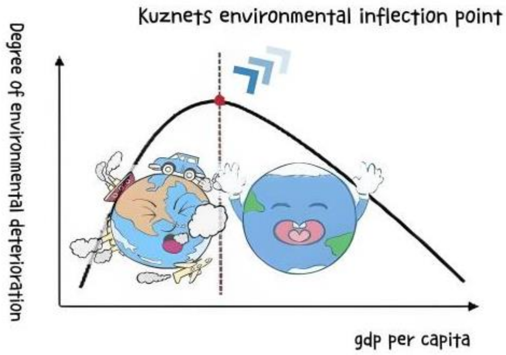

Figure 4: EKC Curve Diagram

Therefore, according to the different per capita GDP levels of each country, we re-divide each country under GGDP. We refer to the countries to the left of the inflection point as category a, those to the right as Category b, and those to the right as Category c.EKC curve classification is shown in Figure 5.

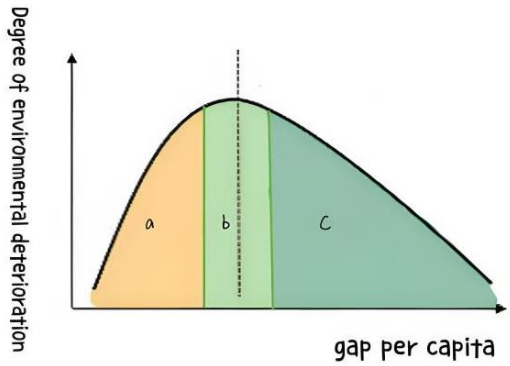

Figure 5: EKC Classification

For Class b and c countries, it is a general trend to benchmark national development level with GGDP, but for class a countries, it is obviously detrimental to their economic development to be required to take too much consideration of environmental factors. In this case, it is almost impossible for Class a countries to rapidly develop their economy through environmentally unfriendly forms. Accordingly, Plans for group a countries to catch up with Group b and Group c have also been dashed. Then, group c countries will always lag behind Group b and a countries. On this basis, the economic gap between less developed countries and developed countries will be further widened, which seriously affects the interests of less developed countries.

Here's what we can do about it:

1. Category b and c countries can provide certain technical assistance to Category a countries to help them make better use of environmental protection resources.

2. UN environmental organizations can provide some financial and human resources to Category a countries.

3. The countries concerned may, as appropriate, reduce or cancel the external debt of Category a countries with external debt.

Analyze the feasibility of such an effort: In the past, many countries have provided free economic aid to less developed countries. Moreover, under the overall goal of improving the global environment, the environment of every country and region will affect each other and form a community of shared future. Helping Category a countries is also helping ourselves. So, our efforts are achievable.

3.3. Global Analysis

By analyzing the benefits of climate change brought by using GGDP as an economic indicator and the current resistance, we believe that although Category a countries do not meet the defined economic standards at present, they can achieve when we help them adapt to the development under the indicator of GGDP through humanitarian assistance. Moreover, the benefits of environmental sustainability under the GGDP make this assistance more urgent and justified. Then the resistance we are considering from the class countries will be greatly reduced. Therefore, we think the span from GDP to GGDP is completely worthwhile.

4. Conclusions

Based on the negative impact on natural resources and environment in the process of economic growth, we have the green GDP policy to explore the impact of global climate, using the least squares method to explore the change of carbon emissions and environmental investment governance and the relationship between the sum of environmental degradation, borrow the ecological footprint model to assess the sustainable development level of countries or regions, the introduction of EKC curve improvement opinions, it is concluded that various countries should implement GGDP policy, and how to pay attention to environmental protection in different stages.

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