A Study on Global Climate Mitigation and National Resource Management Based on the Green GDP Accounting Model

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Abstract. This article investigates the potential of Green GDP (GGDP) to replace conventional GDP as a global economic metric. By accounting for environmental degradation and natural resource depletion—factors typically excluded from traditional GDP calculations—GGDP offers a more comprehensive measure of long-term economic performance. Utilizing a linear regression model, this study examines the relationship between economic activity and climate change, with a focus on carbon emissions and water consumption. The findings reveal an inverse correlation between GGDP and rising global temperatures, suggesting GGDP’s potential to mitigate climate change by integrating the environmental costs of economic growth. A case study of China further illustrates how adopting GGDP could lead to improvements in air quality, more efficient resource management, and alignment with the country’s environmental objectives, including its commitments under the Paris Agreement. Although the transition from GDP to GGDP may face resistance, particularly in nations heavily reliant on fossil fuel consumption and resource exploitation are significant. This study underscores the necessity of incorporating environmental considerations into economic evaluations to foster a sustainable future, where economic growth can be achieved in harmony with ecological preservation. GGDP thus provides a more holistic and sustainable framework for assessing global economic performance.

Keywords: Green GDP (GGDP), Climate Change Mitigation, Environmental Economics, Sustainable Developmen, Carbon Emissions and Resource Management.

1. Introduction

The shortcomings of conventional GDP in accounting for environmental degradation and resource depletion have resulted in the formation of Green GDP (GGDP) as a more accurate indicator of economic success. According to Stiglitz, Sen, and Fitoussi (2010), GDP often misses the environmental costs of economic expansion, resulting in a misleading assessment of long-term sustainability [1]. GGDP provides a more complete picture of economic success by accounting for environmental harm and resource usage. As Xu (2024) argues, traditional GDP does not factor in the depletion of natural resources or the environmental costs of production, such as pollution and degradation, leading to an incomplete and misleading economic evaluation. GGDP, on the other hand, subtracts the costs of environmental degradation from GDP, providing a more comprehensive and sustainable measurement of economic growth.

In recent years, research has increasingly backed the use of GGDP to balance economic development with environmental sustainability. For example, Cheng (2024) highlights how China's clean energy programs, especially in metropolitan areas, have effectively decreased carbon emissions while sustaining strong economic development [2]. This twin accomplishment illustrates the potential of GGDP to enhance sustainable development by tracking the environmental repercussions of economic activity. Li (2024) stresses the significance of improving water resource management in China, demonstrating how proper allocation may balance economic requirements and ecological protection [3].

Furthermore, the function of GGDP in climate change mitigation is becoming more widely acknowledged. Chen (2024) emphasizes the need of optimizing water resources for sustainable development under stringent regulatory frameworks to reduce overconsumption and environmental stress [4]. By including both carbon emissions and water resource usage into economic calculations, GGDP provides vital insights into the link between economic activity and global temperature change. Zheng, Ding, and Liu (2023) highlight that by incorporating carbon trading mechanisms and pollution control costs into GGDP, policymakers can more accurately link economic activity with its environmental impact, thereby creating stronger incentives for sustainable practices.

To summarize, the extant evidence supports the emerging agreement that GGDP is a more comprehensive and sustainable economic statistic. Accounting for environmental costs allows for a more fair evaluation of long-term economic success, bridging the gap between economic expansion and climate change mitigation efforts. This article expands on previous research by investigating GGDP's potential to replace conventional GDP and its function in supporting sustainable resource management.

2. Research on the Impact of GGDP on Global Climate

The shift from traditional GDP to Green GDP (GGDP) is critical for understanding the true environmental costs of economic activities [5]. Conventional GDP, which primarily measures economic output, often overlooks externalities like carbon emissions and resource depletion, leading to a skewed understanding of economic progress and its long-term sustainability. By contrast, GGDP incorporates these environmental factors, offering a more accurate and comprehensive metric that aligns economic growth with environmental sustainability (Stiglitz, Sen, & Fitoussi, 2010). By promoting resource efficiency and reducing environmental degradation, Green GDP enables a more sustainable approach to economic development. This shift is particularly important in the context of global climate change, where the balance between economic growth and environmental preservation is increasingly vital.

To empirically test the relationship between GGDP and climate variables, we applied a linear regression model to evaluate how GGDP alternatives impact global climate. Specifically, the model investigates the relationship between GGDP and global average temperatures, with a focus on identifying the most significant independent variables. In our initial model, we considered seven independent variables, including carbon dioxide emissions, solid waste storage, sulfur dioxide emissions, and water resource consumption. Zhou (2020) highlights that local governments face substantial challenges in managing emissions and resource usage, particularly due to financial and governance constraints. These challenges must be accounted for when developing models that test the impact of GGDP on climate change. The standardized regression coefficients reveal varying degrees of influence for these variables, providing insight into which factors most significantly affect the global climate. Therefore, according to the standardized regression coefficients, the influence of the seven independent variables on the dependent variable varies from small to large, as shown in Figure 1:

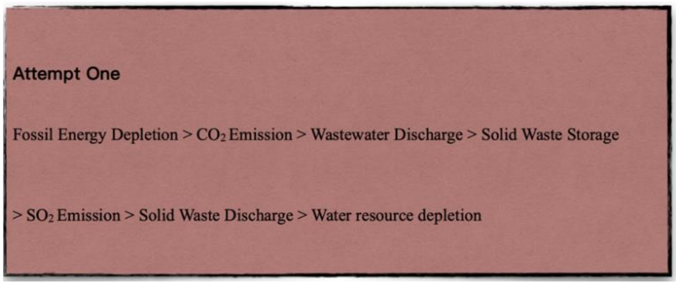

Figure 1. Influence Degree of Seven Variables

However, due to multicollinearity issues among some of the independent variables, the first model proved statistically insignificant. Multicollinearity occurs when two or more independent variables are highly correlated, leading to unreliable estimates of their individual effects on the dependent variable, in this case, global average temperature. To address this issue, stepwise regression was employed to refine the model by systematically removing variables that contributed to multicollinearity. This method allowed us to isolate the variables that had the most significant impact on climate outcomes, ultimately reducing the number of independent variables from seven to four as shown in the figure 2 below:

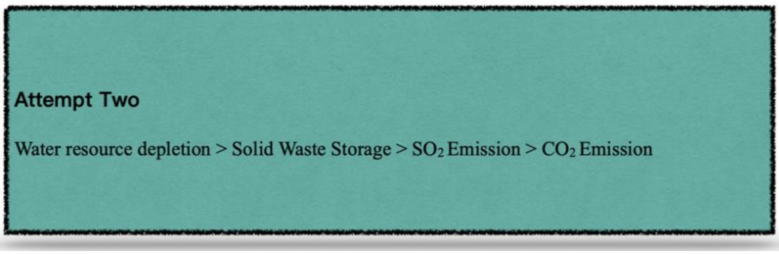

Figure 2. Influence Degree of Selected Variables

By eliminating the strongly collinear variables in the first attempt, the range of independent variables selected is narrowed to the following as shown in the figure 3:

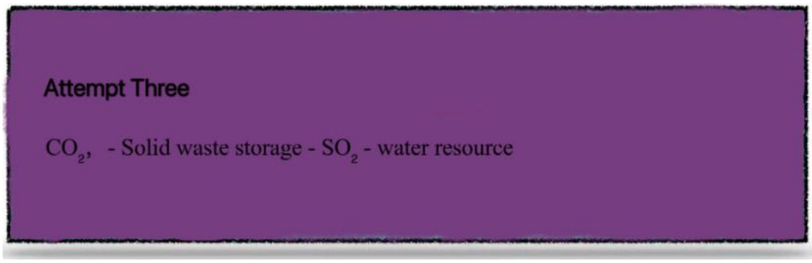

Figure 3. Influence Degree of Selected Variables

Since the beta of CO2 in the first model is the highest among the four non-multilinear variables, and the beta of water resource is the highest among the four variables in the second model. In this way, carbon dioxide emissions and water resources consumption will be used as two focused variables to test the effect of GGDP.

2.1. Model Establishment

Based on the selection of high correlation factors, the new derivative model of GGDP model (1) only considers independent variables GDP, qco, qw, α, Pw. The formula of model is shown below:

$$\frac{dGGDP}{dt} = \frac{dGDP}{dt} - \frac{d}{dt}(q_{co}\alpha + q_w P_w) \tag{1}$$

Take the derivative of sum of qcoα and qwPw,

$$\frac{dGGDP}{dt} = \frac{dGDP}{dt} - \left(\frac{d\alpha}{dt} q_{co} + \alpha \frac{dq_{co}}{dt}\right) - \left(q_w \frac{dP_w}{dt} + P_w \frac{dq_w}{dt}\right) \tag{2}$$

This model of the relationship represents the effect of carbon dioxide emission rate of cost and global water consumption rate of cost in Global Green GDP.

2.2. Model Results

The derivative of a single variable is calculated respectively, and then the Grey model is used for prediction. The variable data of the model is as follows Fig 4-6:

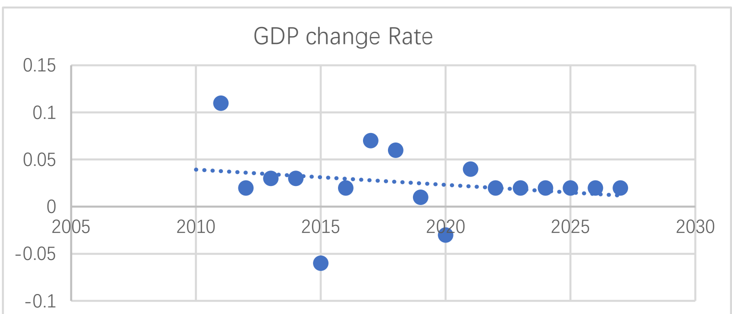

Figure 4. Global GDP Change Rate (2011-2027)

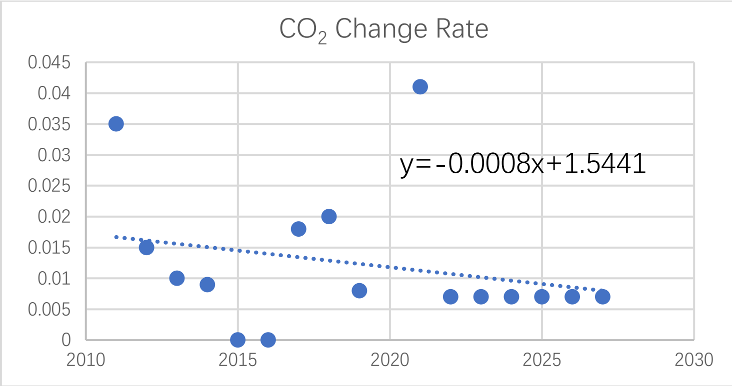

Figure 5. Global Carbon Dioxide Emission Change Rate (2011-2027)

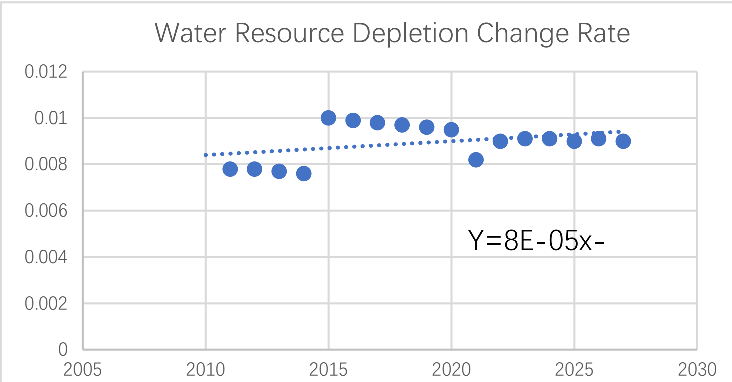

Figure 6. Global Water Resource Depletion Change Rate (2011-2027)

Based on limited data and large economic elasticity of purchasing power, the rate of change of global green GDP can be roughly reverted to the following trend graph by assuming conversion factor α=1 and average water price Pw=1, as shown in Figures 7 and 8:

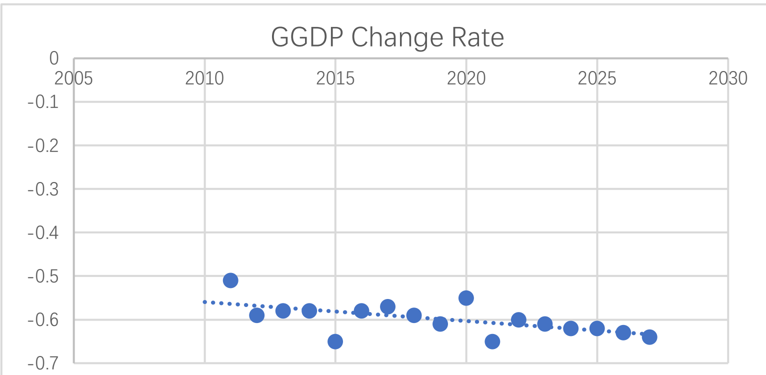

Figure 7. Global Green GDP Change Rate (2011-2027)

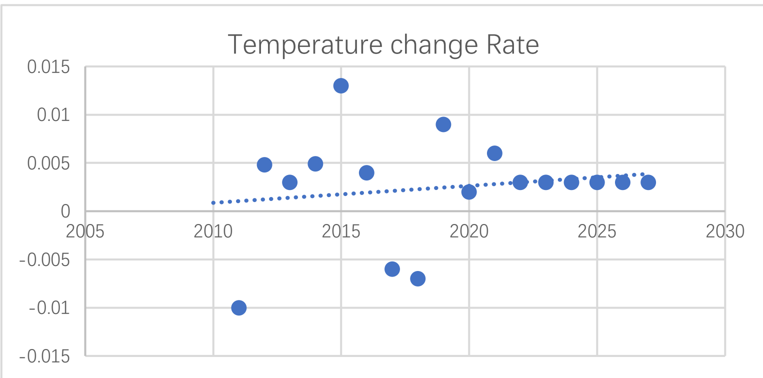

Figure 8. Global Average Temperature Change Rate (2011-2027)

2.3. Results Analysis

Feng, Ruiqi, and Junyao (2020) report that from 2010 to 2017, the change rate of certain environmental indicators was 12.2%. Additionally, data from Wikipedia (2022) shows that the global average water price increased by 3.91% between 2010 and 2022. Based on Figure 8, which presents the linear regression analysis of the GGDP and global average temperature from 2011 to 2027, the results show a negative growth rate for GGDP, with its second derivative also remaining negative. This indicates a continued decline in GGDP. In contrast, global average temperatures exhibit a positive growth rate, with a second derivative greater than zero, signifying an upward trend.

The negative correlation between GGDP and global average temperature highlights the limitations of using traditional GDP metrics to assess climate impacts. Traditional GDP calculations show a positive correlation with rising temperatures, making it difficult to link economic activities directly to climate change. However, the GGDP model, by accounting for environmental costs such as pollution control and resource depletion, provides a more accurate representation of how human activities affect climate mitigation.

3. Research on the Impact of Rising Temperatures on Climate Change

The logic behind the relationship between rising temperatures and climate change is well-established in the scientific community. As the Earth's temperature increases, it leads to changes in weather patterns, sea levels, and other factors that can significantly impact the environment. One fundamental way rising temperatures lead to climate change is through melting ice caps and glaciers. As temperatures rise, the ice at the Earth's poles and in mountainous regions begins to melt at an accelerating rate. This meltwater then flows into the ocean, causing sea levels to rise.

Table 1. Grey Predict Model (2012-2027)

Year	GDP (billion $)	GGDP (billion $)	Temperature (°C)
2012	8532	-902.736	9.4
2013	9570	-1072.637	9.6
2014	10480	-956.811	10.2
2015	11060	-971.701	10.5
2016	11230	-2072.281	10.4
2017	12310	-2547.259	10.4
2018	13890	-2950.075	10.1
2019	14280	-3551.018	10.3
2020	14690	-4215.787	10.3
2021	17730	-4951.162	10.5
2022	17615	-5764.64	10.5
2023	18700	-6664.518	10.6
2024	19808	-7659.971	10.6
2025	20949	-8761.152	10.7
2026	22125	-9979.289	10.7
2027	23337	-11326.803	10.8

From Table 1 One of climate change's impacts is its effect on the economy. Rising temperatures and changes in weather patterns can lead to crop failures, reduced yields, and lower-quality produce. This can result in higher food prices, food scarcity, and food insecurity, leading to economic losses for farmers and businesses in the food industry. For example, climate change may affect the production of maize (corn) and wheat as early as 2030 under a high greenhouse gas emissions scenario, according to a new NASA study published in the journal, Nature Food. As a result, maize crop yields are projected to decline by 24%, while wheat could grow at about 17% [6]. (Jägermeyr et al., 2021).

Referencing Statista and China Statistical Yearbook from 2012 to 2017, the table above has been created. Using Grey Predict Model (GMP), data on the predicted annual average temperature in China, the expected value of GDP from 2022 to 2027 in China, and value of GGDP from 2018 to 2027 are predicted.

From results based on GMP, a double y-axis graph shows the relationship between the annual average temperature in China, the expected value of GGDP, and GDP has been created as shown in Figure 9:

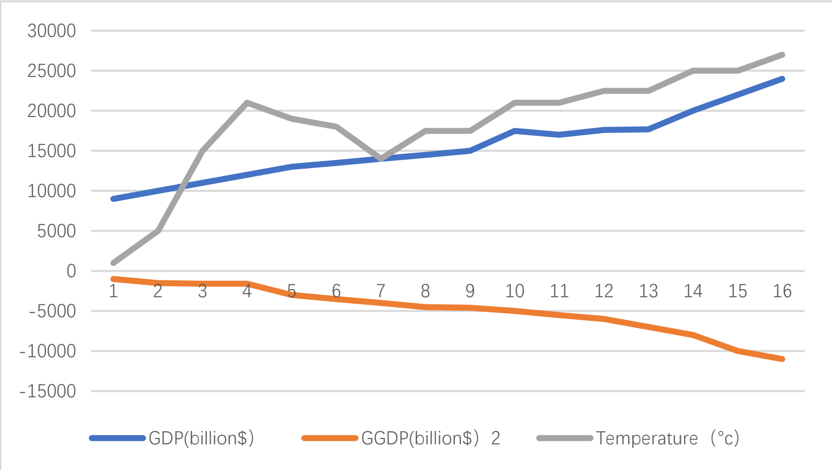

Figure 9. Double y-axis line changing model (2012-2027)

Since the relationship between GDP and the annual average temperature in China is positive, it suggests that as GDP increases, the temperature also increases. Pursuing economic growth at the cost of the environment can result in negative consequences for the long-term sustainability of the economy.

Under the concept of a Green economy, which emphasizes the importance of sustainable development, economic growth is achieved while preserving and enhancing the natural environment. In other words, economic growth and environmental protection are not mutually exclusive. Instead, they can be complementary and mutually reinforcing. When the relationship between GGDP and temperature is negative, GGDP's consideration of environmental costs becomes even more critical. If increasing temperatures negatively impact economic growth, it becomes even more critical to ensure that economic growth is sustainable and does not come at the expense of the environment. GGDP's inclusion of environmental costs ensures that economic growth is sustainable and considers the environmental impact of that growth.

If China adopts GGDP instead of GDP, several demographic benefits and environmental improvements could be realized. One notable outcome would be improved air quality, an issue China has long grappled with, particularly in urban areas. For instance, in January 2013, PM2.5 levels in some cities reached over 700 micrograms per cubic meter, 28 times higher than the WHO's recommended levels (Lu, 2015) [7]. Since 2021, China has intensified its efforts under the Paris Agreement, increasing its nationally determined contributions and focusing on carbon neutrality. Consequently, carbon dioxide emissions per unit of GDP in 2021 were 3.8% lower than in 2020 and 50.8% lower than in 2005 (Annual Report on Actions to Address Climate Change, 2022). Using GGDP instead of GDP would provide a clearer reflection of these environmental efforts, reinforcing China’s commitment to mitigating pollution.

Water resources are important in calculating GGDP since their quality and availability have a substantial impact on economic activity and public health. In 2017, China updated its "Water Pollution Prevention and Control Law," which strengthened environmental protection and enforcement, allowing the nation to better manage its water resources. By adding water management into GGDP, China may more properly represent the economic costs of water depletion and pollution, ensuring that the environmental consequences of water consumption are taken into account in economic evaluations. Research emphasizes the need of improving water resource allocation in order to achieve sustainable development. Advanced methodologies, such as system dynamics and multi-objective decision-making models, have been used to increase water usage efficiency in a variety of industries, enabling for more efficient allocation of scarce resources (Li, 2024). Furthermore, the "strictest water management system," as proven in Zhongshan City, offers a framework for ensuring balanced water distribution while taking into account ecological, economic, and social concerns (Chen, 2024). Such integrated water management techniques are consistent with the GGDP's goals, demonstrating how sustainable water usage and pollution control contribute directly to economic development and environmental sustainability. By including these tactics into GGDP, China may better assess the real costs of development on its natural resources [8].

Additionally, GGDP accounts for the environmental costs associated with fossil fuel consumption, which greatly impacts the overall GGDP calculation. China's introduction of a pilot carbon trading system in various provinces, with plans for a national rollout, demonstrates its commitment to reducing emissions. This system, which places a price on carbon, covers more than 1,700 companies and approximately 40% of the nation's emissions (OECD, 2022). This market-driven approach not only encourages businesses to lower emissions but also improves the overall GGDP by accounting for reduced environmental damage.

Historically, China's administration has stressed its residents' well-being, which is profoundly founded in Confucian ideals that promote social harmony and public good. Confucianism has had a significant impact on Chinese policy-making, with the ruler's obligation to ensuring the people's needs are satisfied, indicating a long-standing cultural approach to governance that is also consistent with current sustainable development objectives (Ames & Jr., n.d.). These ideals are reflected in China's continuing transition to the Green GDP (GGDP), which aims to balance economic development with environmental sustainability. By include environmental costs, GGDP provides a more realistic measure of development that takes into account both social and environmental well-being, and it is a significant step toward enhancing the nation's living standards while tackling environmental concerns (Wang and Zhao, 2022).

The change to GGDP is consistent with China's overall environmental policy aims, which have developed in response to local and global sustainability challenges. Recent initiatives, such as the introduction of stronger environmental rules and carbon trading systems, demonstrate China's commitment to decreasing pollution and supporting green technology innovation (Wang et al., 2022). These policy efforts align with Confucian concepts of responsible governance and demonstrate the government's commitment to balancing economic advancement and environmental sustainability. The inclusion of environmental costs in GGDP represents a major step forward in policymaking, since it ensures that long-term economic policies take into account resource depletion and pollution, both of which are key challenges in China's continued growth trajectory.

China's adoption of GGDP reflects its worldwide leadership in climate action. By include environmental deterioration in economic success criteria, China not only addresses internal sustainability challenges but also contributes to global climate change mitigation efforts. As the country continues to build its GGDP framework, it has the potential to serve as a model for other nations looking to balance economic development with environmental preservation [9, 10].

4. Conclusion

In conclusion, using GGDP instead of traditional GDP gives China a more accurate instrument for assessing sustainable development. GGDP includes environmental expenses including pollution, resource depletion, and the detrimental effect of fossil fuels, which are sometimes disregarded in standard GDP estimates. By including these aspects, GGDP shows the true economic consequences of human activities on the environment, allowing for more effective policy choices. China's contributions to the Paris Agreement, such as carbon neutrality and carbon trading systems, are better captured by GGDP, emphasizing progress in lowering carbon emissions and improving air and water quality. Furthermore, GGDP corresponds with China's objective to balancing economic development with environmental sustainability, providing a more direct way to solving important challenges such as pollution and climate change. The historical legacy of Confucian ideals, which promote social harmony and population well-being, lends credence to the adoption of GGDP as a statistic that emphasizes long-term social and environmental wellbeing. Finally, GGDP fosters long-term growth while retaining economic competitiveness, safeguarding China's future prosperity and environmental responsibility.

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