Problem Chosen	2023 MCM/ICM Summary Sheet	Team Control Number
F		**2317176**

GGDP, or Green Gross Domestic Product, is a measurement of a country's GDP taking in account its environmental impact such as CO2 emission, water pollution, depletion of natural resources, etc.. GDP, Gross Domestic Product, does not consider the environmental damage and cost of a nation. Because of climate change, technological advancements, Earth's rapidly changing environment, etc., GDP is no longer an accurate measure of a nation's economic health. In the past few decades, economists and environmentalists have come up with models to calculate a country's GGDP by considering economic output and environmental input. In this paper, we selected the best model to calculate GGDP in Japan and modified the formula based on its relevant environmental issues that could be applied generally to other nations. In this paper, we calculated the cost of CO2 emissions and the cost of energy production and we found the data of GDP of Japan between 2010-2020 to compare GDP and GGDP to show the impact of the country's economy.

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Introduction

Based on the UN, since the 1970s, one of the main criticisms of GDP has been that it completely ignores environmental damage and resource depletion. Alternatively, it may consider environmental deterioration and depletion to be economic productivity. For instance, although having a terrible impact on long-term well-being and economic growth, clearing a rainforest and selling the lumber will raise GDP. These traditional measurements, according to some popular criticisms, do not account for non-valued factors including income distribution, asset depreciation, the non-market economy, and environmental problems like pollution, ecological degradation, and resource depletion. As a result, the GDP, for instance, says nothing about growth and development that is sustainable and/or equitable. It becomes even worse when we compare it amongst nations because many of them attain economic expansion through environmentally harmful techniques.

An alternative measure of economic growth called "green GDP" takes into account environmental effects of that expansion, such as resource depletion and environmental deterioration. Because of the "threshold effect," economic expansion typically has a negative impact after a certain point, even when it initially enhances quality of life. When this threshold is crossed, future economic growth may turn negative.

With declining leisure time, increased income inequality, and depletion of natural resource quality of life, national accounting techniques or the Green GDP measure could be used to identify these problems.

How to calculate green GDP

To calculate green GDP, a variety of models can be utilized, each having advantages and disadvantages of its own. Life Cycle Assessment, Ecological Footprint, Input-Output Analysis, and Genuine Progress Indicator are all helpful tools for assessing various facets of environmental impact and sustainability. The ideal model to employ for estimating green GDP would depend on the precise objectives and context of the analysis. Each model has strengths and limitations of its own. An effective approach for assessing the economic interdependence of various economic sectors and its effects on the environment is input-output analysis. It might be beneficial for figuring out how different sectors in a nation or region affect the environment as well as for finding ways to lessen that impact. Also, by examining the direct and indirect effects of climate mitigation measures on the economy and environment, input-output analysis can be used to determine the anticipated global impact of those policies.

Here are the general steps involved in calculating GDP:

1. Set the parameters for the analysis: Choose the relevant geographic areas and economic sectors for the analysis, as well as the relevant climate strategies or measures such as gas emissions, renewable energies, climate change effects, programs, etc.
2. Put together an input-output table creating an economic transaction and relationship matrix for the locations and industries that have been chosen. This matrix depicts the movement of products and impacts between industries and geographical areas and can be used to calculate the financial effects of environmental measures.
3. Estimating economic impacts: Use the input-output table to estimate the direct and indirect economic impacts of each climate effect on the economy. Direct impacts are

those that occur within the policy sector itself, such as changes in output or employment. Indirect impacts are those that occur in the supply chain, such as changes in consumer spending.

4. The direct and indirect effects on the economy of each climate effect can be determined using the input-output table. Direct consequences are those that occur immediately within, such as modifications to production. Any effects that occur sooner or later in the supply chain are referred to as indirect effects.
5. Multipliers are calculated by using the input-output table to account for the indirect effects each climate effect has on the economy and the environment. By accounting for both direct and indirect effects, these multipliers can be used to calculate the overall economic and environmental impact.
6. Examining the anticipated global impact of climate effects using the predicted economic and environmental impacts and multipliers. This analysis can help determine which effects are most impactful, as well as which effects may have unexpected consequences.

The results of input-output analysis should be carefully understood because of its assumptions and limitations. The quality and availability of the data, as well as the assumptions that were made when building the input-output table, all play a role in how accurate the results are. Input-output analysis, however, can offer a practical technique for calculating the anticipated worldwide impact of climate mitigation strategies.

Environmental Problems in Japan

Japan is a very technologically advanced country. The Global Innovation Index (GII) ranked Japan in 13th place (out of 132) in technological advancement and innovation in 2022, moving up 3 spots since 2020 (Japan). And within South East Asia, East Asia, and Oceania it ranked fourth (Japan). With this being said, Japan has the potential of causing or being the product of a lot of damage in terms of environmental effects. Japan, as being a part of the Paris agreement, a treaty between nations "to combat climate change and adapt to its effects" (The Paris Agreement), has a duty to work toward sustainability and its nations environmental policy. Climate change, air quality, waste management, and the fishing industry are all problems Japan currently faces.

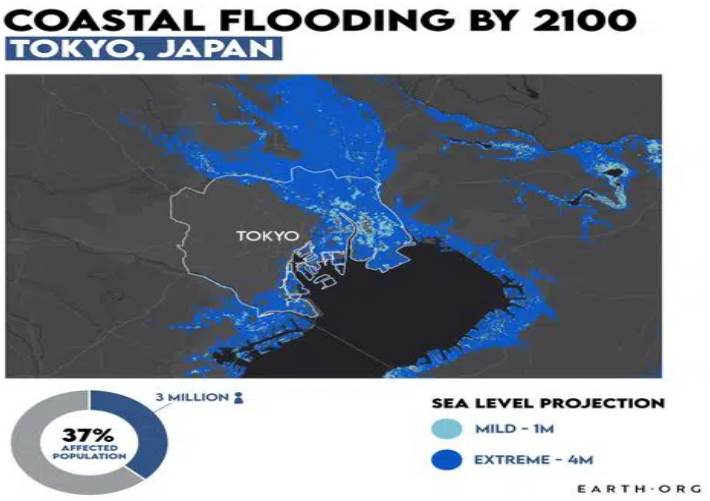
Because Japan is an island, a big way climate change presents itself is through rising sea levels and extreme destructive weather. With potential flooding caused by these, Japan's city layout may be affected along with a resettlement of citizens. In addition to flooding, Japan, along with many countries, experiences an increase in temperature causing heat strokes for their older citizens, food insecurity, and a destruction of coral reefs.

One of Japan's biggest environmental issues is air quality being "one of the most air-polluted countries in the world" (Koons). The cause is simply "vehicle emissions and industrial production," (Koons) a cause of fossil fuel combustion. The number of air-pollution-related deaths is increasing annually in Japan, with 2019 alone having over 42,000 cases.

Another huge environmental problem Japan faces is waste management because of its limited space as an island. Because Japan doesn't have "landfill space and long-term waste storage, which are common solutions in most developed countries," it relies on "waste

incineration" (Koons). This causes a release of greenhouse gasses which negatively impacts communities. In addition to an unsuitable removal of waste, Japan "has the lowest recycling rate of the countries in the Organisation for Economic Cooperation and Development (OECD)" (Koons).

As an island, the fishing industry should not be ignored when discussing the environmental problems of Japan. Japan's overfishing along with uncontrollable climate change has an effect on the country's fishing industry by damaging coral reefs and diminishing "fish stock replenishment rates." An unsustainable fishing industry has caused an "exploitation of a significant portion of Japan's fisheries" which "between 1985 and 2017, Japan's seafood production fell by 66%" (Koons).



Climate change, air quality, waste management, and the fishing industry are some of Japan's biggest environmental destructors. As an island, things such as waste management and climate change have a huge yet uncontrollable effect on Japan's environment. In combination with air quality produced by production and an unsustainable fishing industry, Japan's Green GDP is in trouble.

Japan's GDP grew "1.04% annually on average between 1995 and 2020 when accounting for its progress on reducing carbon emissions" which is "nearly double the average real GDP growth per year over the same period if emissions reductions were not considered, which is calculated at 0.57%".

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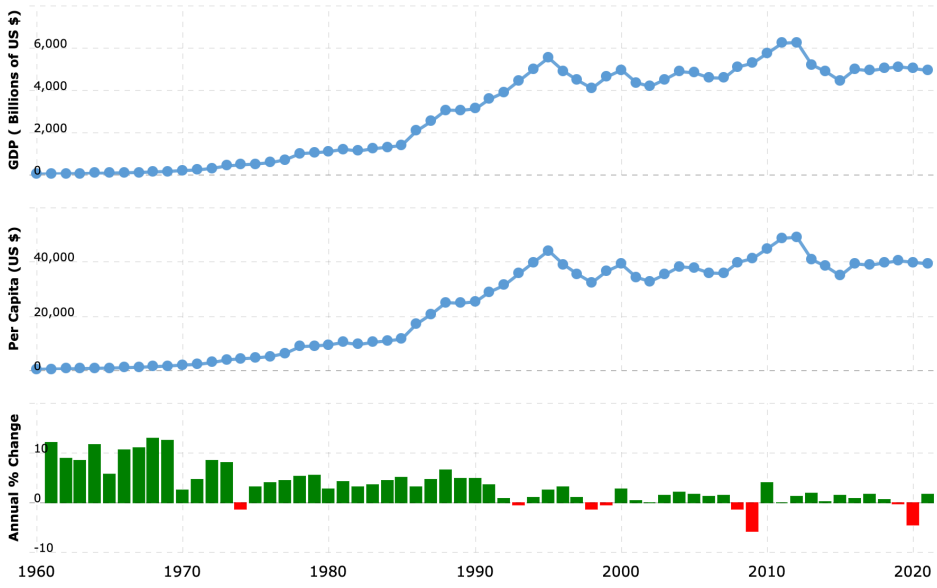
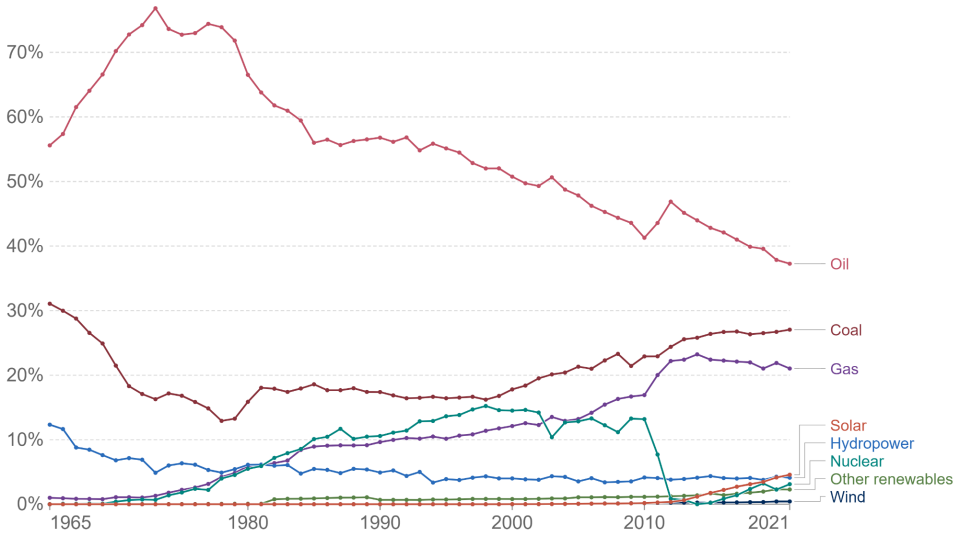


Share of energy consumption by source, Japan

To convert from primary direct energy consumption, an inefficiency factor has been applied for fossil fuels (i.e. the 'substitution method').



Source: Our World in Data based on BP Statistical Review of World Energy (2022)

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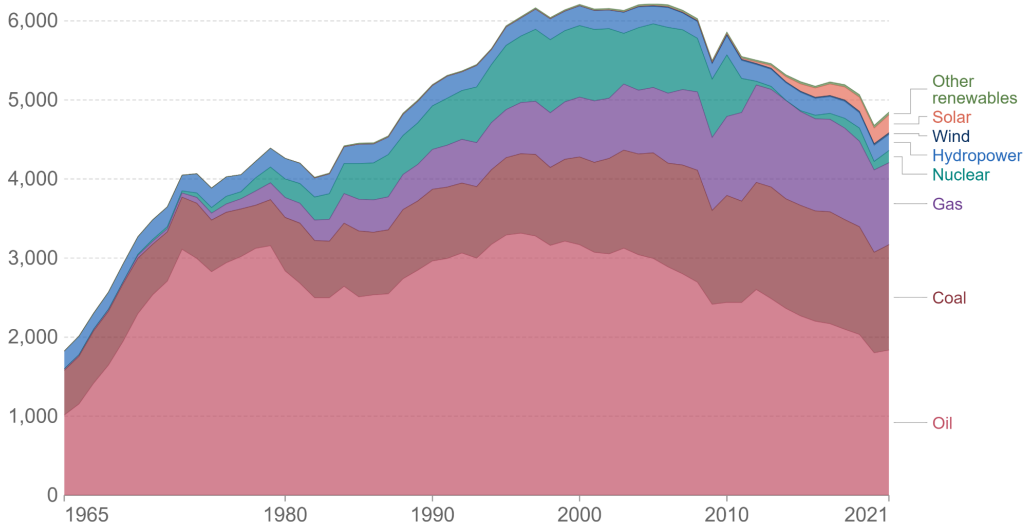
Energy consumption by source, Japan

Primary energy consumption is measured in terawatt-hours (TWh). Here an inefficiency factor (the 'substitution' method) has been applied for fossil fuels, meaning the shares by each energy source give a better approximation of final energy consumption.



Source: BP Statistical Review of World Energy

Note: 'Other renewables' includes geothermal, biomass and waste energy.

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Energy is essential for our daily living and social activities. However, Japan is a country with a low energy self-sufficiency ratio considerably low level compared with other OECD countries. Thereafter, it decreased substantially due in large part to the shutdowns of nuclear power plants, but started to increase gradually in recent years. The major reason for this low self-sufficiency ratio is that energy resources are scarce in Japan. Japan depends largely on fossil fuels such as oil, coal and liquefied natural gas (LNG), most of which are imported from overseas. Having experienced oil crises in the 1970s, Japan reduced its dependency on fossil fuels to a certain extent. However, since the Great East Japan Earthquake in 2011, thermal power generation has increased with dependency on fossil fuels in FY2019.

In recent years, attention is focusing on energy from natural sources such as renewable energy. However, solar and wind power are influenced by natural conditions, making it difficult to obtain a stable supply. In order to utilize these energy sources, technology for storage batteries is essential. And building storage batteries needs rare metals. For instance, in lithium-ion batteries, which are used for electrified vehicles, rare metals such as lithium, cobalt and nickel are used. Japan depends almost 100% on imports for such mineral resources. There will be increasing demand for power generation facilities using renewables and electrified vehicles. Therefore, it is necessary to secure a stable supply of mineral resources such as rare metals which are expected to play a more important role in the future.

An illustration of GDP vs Green GDP

Illustrating the difference between GDP and Green GDP by taking the example of a pharma company. The production has clear benefits to society and contributes positively to GDP and Green GDP. However, chemical synthesis relies on energy-intensive processes, and the

associated combustion of fossil fuels leads to the emission of air pollutants. In some cases, we can compensate for some of the negative externalities - for example, by treating people for health problems, potentially using drugs whose production partly contributes to the issue - or repairing buildings where the stonework has been degraded by air pollutants. In this case, overall welfare hasn't increased, at best it has stayed the same.

Nonetheless, the healthcare expenditure and other investment involved would translate into an increase in GDP or value added to the economy. By contrast, by using Green GDP, these expenditures would, in theory, equalize the external costs, meaning Green GDP would stay constant. Similarly, if no measures were taken to compensate for the negative impacts, GDP would stay the same but Green GDP would decrease.

Calculating Green GDP in Japan

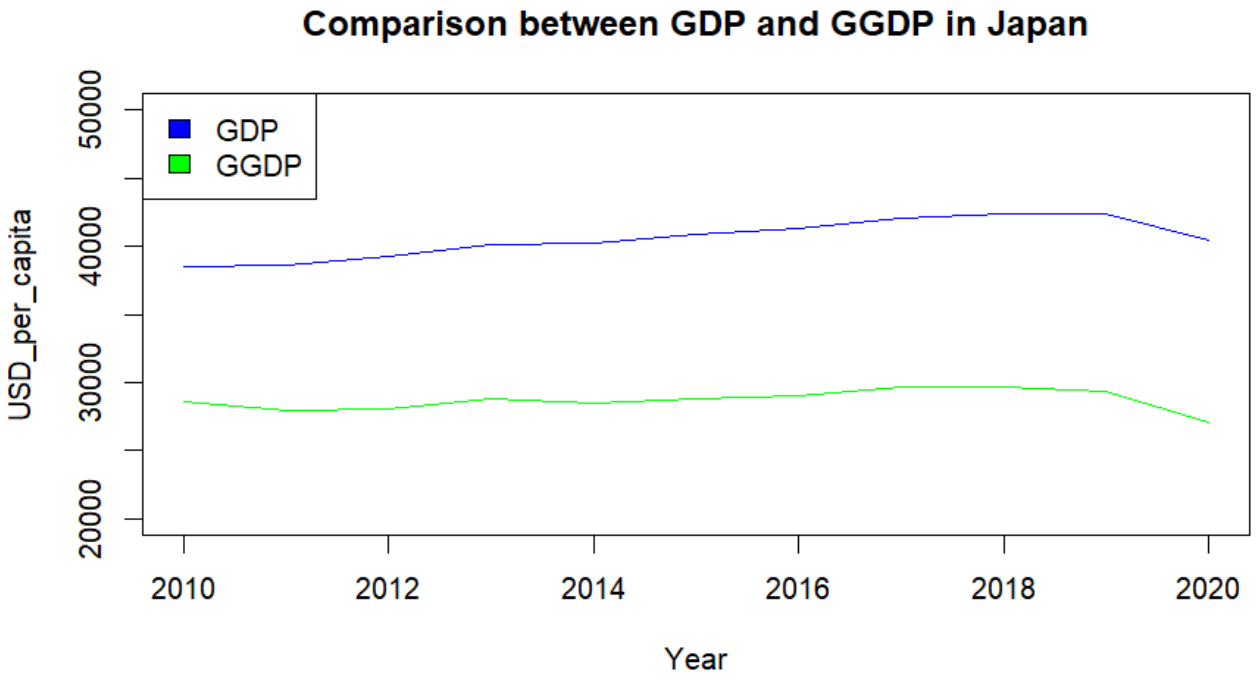
Using all this information and based on the environmental problems in Japan the best formula to calculate GDP in Japan would be:

$$Green\ GDP = GDP - Cost\ of\ Environmental\ Pollution - Cost\ of\ Resource\ Depletion$$

1. Environmental pollutions
    - Air Pollution
        - CO2 emission pollution
        - SO2 emission pollution
        - NOx emission pollution
    - Wastewater pollution
2. Resource depletion
    - Fossil energy depletion

- Water resource depletion
- Forest resource depletion
- Energy consumption value

In this formula, the green GDP in Japan can be determined using input-output analysis. Data on the economic and environmental effects of several sectors in Japan are needed for this model. This could include information on each sector's economic output and value added, as well as information on its energy use, greenhouse gas emissions, water use, land use, and other environmental indicators. Then, utilizing the information gathered to demonstrate the interdependence of various sectors of the Japanese economy, we must create an input-output table. The direct and indirect effects of each sector on other economic sectors should be shown in the input-output table. The next step is to determine each sector's environmental impact. This could entail calculating the CO2, SO2, and NOx emissions, and cost of water pollution using some available data available on https://stats.oecd.org/. So that we can determine the economic costs of these impacts once the environmental impacts have been estimated, we then need to quantify the economic costs of environmental damage and loss of resources such as water resources, forest, fossil fuel and energy consumption. And finally we need to Adjust GDP for environmental impacts using the general traditional formula for calculating Green GDP which is “GDP - The cost of natural resource consumption- The costs of environmental depletion”.



In the graph above, we found the cost of Japan's CO2 emissions and the cost of energy production between the years 2010-2020. We subtracted this from Japan's GDP in these years to calculate GGDP. This is a sample model showing the difference of GDP versus GGDP in Japan by taking in account only the two variables CO2 emissions and energy production. As it is shown, it is important to consider the environmental cost of a nation to analyze a country's economy.

Japan's national accounting system now uses green GDP accounting. We deduct the environmental costs from the GDP when calculating the general calculation for green GDP. Whereas environmental costs cover the expenses related to waste disposal, air and water contamination, and the degradation of natural resources. Based on the extent of environmental harm and the price of alleviating that harm, these costs are estimated. Japan's green GDP offers a more accurate picture of the nation's economic performance that takes into consideration the

impact of economic activity on the environment by deducting these environmental costs from the regular GDP calculation. Japan's economy and environment could be significantly impacted by the switch from GDP to Green GDP.

Potential impacts from shifting GDP to GGDP in Japan

1. Economic impact: Japan is a highly industrialized economy with a heavy reliance on manufacturing, construction, and transportation sectors. Shifting to a Green GDP could impact these sectors as they may be required to adopt more environmentally-friendly practices and technologies, which could increase costs and potentially reduce output. However, this could also create opportunities for new green industries and jobs, such as renewable energy and energy-efficient technologies.
2. Environmental impact: Japan has been facing significant environmental challenges, including air and water pollution, climate change, and loss of biodiversity. Shifting to a Green GDP could help to mitigate some of these challenges by incentivizing more sustainable practices and technologies. This could include reducing carbon emissions, promoting circular economy principles, and encouraging the use of renewable resources. However, it is also important to note that the transition to a Green GDP may not be smooth, and there may be trade-offs between economic growth and environmental protection.
3. Policy impact: Shifting to a Green GDP would require significant policy changes, including the development of new metrics for measuring economic activity and environmental impact, and the implementation of new regulations and incentives to promote more sustainable practices. This could involve significant political and social

changes, including the involvement of various stakeholders, such as industry groups, environmental NGOs, and government agencies.

Overall, shifting to a Green GDP in Japan could lead to a more sustainable and resilient economy, but it will also require careful planning and implementation to balance economic growth and environmental protection.

Non-technical report

Calculating Green GDP in each region and country in the world may differ. The most important thing that we need to consider in modeling the formula for green GDP is the environmental problems and the possible costs that these problems can cause to that nation. In this paper we came up with a model to calculate Green GDP in Japan based on the most important environmental issues that they are dealing with. So in our suggested model, we need to subtract the cost of each possible pollution such as air pollution, water pollution and also we need to consider the loss of all natural resources like water resources, forest resources, fossil fuel , and energy consumptions. So the result would be Green GDP of that country. And the whole point of doing that is because GDP itself may not be the best indicator of the health of a nation's economy since it does not consider the environmental costs that every nation is facing every year. On the other hand Green GDP can take care of those other costs that GDP does not cover.

Conclusion

Adopting GGDP as a measure of economic health could have significant positive impacts on how Japan uses its natural resources and also climate mitigation. For example, GGDP takes into account the value of natural resources such as forests and wetlands, which provide ecosystem services such as carbon sequestration and water filtration. Under a GGDP-based system, there would be more of an incentive to preserve and restore these natural resources, rather than exploiting them for short-term economic gain. However, this shift would also require careful planning and support for workers and communities that are most affected by the transition. For several decades, numerous methodological and conceptual approaches have been carried out to conceptualize green GDP for the transition towards a circular bioeconomy and sustainability, such an indicator became necessary because ever since its development in the twentieth century.

Reference list

GDP per capita (current US$) - Japan. *Data*. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2015&locations=JP&start=2000. Accessed 20 February 2023

Gross domestic product (GDP) QMI. *Gross domestic product (GDP) QMI - Office for National Statistics*. https://www.ons.gov.uk/economy/grossdomesticproductgdp/methodologies/grossdomesticproductgdpqmi#:~:text=Gross%20domestic%20product%20(GDP)%20measures%20total%20domestic%20economic%20activity%20and,approach%20and%20the%20income%20approach. Accessed 20 February 2023

Jackson, F. (2022, August 18). Japan introduces a new way to measure growth, green GDP. *SG Voice*. https://sgvoice.energyvoice.com/policy/4630/japan-green-growth-measurement/. Accessed 20 February 2023

Japan takes step into green GDP research. (2022, August 5). *The Japan Times*. https://www.japantimes.co.jp/news/2022/08/05/business/kishida-green-gdp/. Accessed 20 February 2023

Japan. *wipe.int*. https://www.wipo.int/edocs/pubdocs/en/wipo_pub_2000_2022/jp.pdf. Accessed 20 February 2023

Koons, E. (2023, January 12). Environmental issues in Japan and solutions. *Energy Tracker Asia*

https://energytracker.asia/environmental-issues-in-japan-and-solutions/#:~:text=Air%20Quality%20–%20Air%20Pollution%3A%20Japan's,air%20pollution%20are%20increasing%20annually. Accessed 20 February 2023

The Paris Agreement: What is the Paris Agreement. *Unfccc.int*. https://unfccc.int/process-and-meetings/the-paris-agreement?gclid=Cj0KCQiArsefBhCbARIsAP98hXQUOxhyU2VDbVcgSOLgGakkO8zSg_zG1szD8rpOms9p-CDb8zrfhpQaAh4wEALw_wcB. Accessed 20 February 2023

Prakash^, A., Sarkar^ , K. K., & Kumar^, A. Estimation of green GDP for India article - rbidocs.rbi.org.in. *rbidocs.rbi.org.in*. https://rbidocs.rbi.org.in/rdocs/Bulletin/PDFs/2ESTIMATIONGDPFORINDIA65C6FCD18BA940D5B33130942352CAE6.PDF. Accessed 20 February 2023

The rise, fall and rethinking of green GDP | system of environmental economic accounting. *United Nations*. United Nations. https://seea.un.org/news/rise-fall-and-rethinking-green-gdp. Accessed 20 February 2023

Ritchie, H., Roser, M., & Rosado, P. (2022, October 27). Japan: Energy country profile. *Our World in Data*. https://ourworldindata.org/energy/country/japan. Accessed 20 February 2023

Stjepanović, S., Tomić, D., & Škare, M. (2017, February 25). A NEW APPROACH TO MEASURING GREEN GDP: A CROSS-COUNTRY ANALYSIS. *etalpykla.lituanistikadb*.

https://etalpykla.lituanistikadb.lt/object/LT-LDB-0001:J.04~2017~1564990977139/J.04~2017~1564990977139.pdf. Accessed 20 February 2023

Stjepanović, S., Tomić, D., & Škare, M. GREEN GDP: AN ANALYSES FOR DEVELOPING AND DEVELOPED COUNTRIES. *core.ac.uk*, 4–17. https://core.ac.uk/download/pdf/295597367.pdf. Accessed 20 February 2023

Tsai, W.-H., Lee, H.-L., Yang, C.-H., & Huang, C.-C. (2016, November 28). Input-output analysis for sustainability by using DEA method: A comparison study between European and Asian countries. *MDPI*. Multidisciplinary Digital Publishing Institute. https://www.mdpi.com/2071-1050/8/12/1230. Accessed 20 February 2023

Thurm B., Burgin S., Widmer J. (2022, September 21). Let's replace GDP by introducing the Green Domestic Product. *IIMD*. https://www.imd.org/ibyimd/sustainability/lets-replacegdp-introducing-the-green-domestic-product/. Accessed 20 February.

2021 - Understanding the current energy situation in Japan. (2022, August 12). METI. https://www.enecho.meti.go.jp/en/category/special/article/detail_171.html. Accessed 20 February.