EGYPT GREEN GDP STUDY REPORT

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Foreword

There is a growing concern worldwide about sustainability and its implications to deal with environment considerations in context of economic development. As a result, Indicators that express the degree of sustainability of the development process in its relationship to the environment and natural resources are estimated.

The notion of “GREEN” is now intertwined with sustainability, and it is intended to express environment dimension in sustainability. Terms, such as green economy, green energy, green investments, and green budget, became dominating terminologies in the sustainability literature. Green growth is recently a prime goal of development policies in almost all countries, irrespective of their level of economic growth.

In Egypt, the government is committed to achieve the Sustainable Development Goals (SDGs) through the development of its own strategy “Egypt’s vision 2030”, where environment is one of its main pillars. The country is one of the first Arab countries in adopting Greening National Plan and Budget by expanding green investments and stimulating the private sector to invest in environmentally friendly projects. This is a step forward towards the preservation of natural resources and limitation of the harmful effects of climate change. Moreover, in May 2022, Egypt has declared its national strategy for climate change which aims at achieving low emission economic growth in various sectors by building resilience, adapting to and mitigating the negative impacts associated with climate change, and improving the governance and management of climate action and policies.

In the efforts of the Ministry of Planning and Economic Development to monitor the consistency of economic development with all dimensions of sustainability, the Institute of National Planning is commissioned to undertake a project to set the general framework and principles of estimating the green national accounts. This report is considered the first output of the project estimating the indicators of Green GDP in the framework of the United Nations System of National Accounts. This study constitutes a step forward towards determining the appropriate methodologies to estimate Green GDP for Egypt.

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List of abbreviations

ANS	Adjusted Net Savings
BTU	British Thermal Unit
CAPMAS	Central Agency for Public Mobilization and Statistics
CO2	Carbon Dioxide
COP	The United Nations Climate Change Conference of the parties
D&L	Damage and Loss
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEP	Gross Ecosystem Product
GOS	Gross Operating Surplus
INP	Institute of national Planning
NCAVES	Natural Capital Accounting and Valuation of Ecosystem Services
NPVM	Net Present Value Method
OAPEC	Organization of Arab Petroleum Exporting Countries
OECD	Organization for Economic Co-operation and Development
PM 2.5	Particulate Matter particles less than 2.5 micrometers in diameter
SEEA	System of Environmental-Economic Accounting
SNA	System of National Accounts
UNEP	United Nations Environment Programme
WASH	Inadequate Water, Sanitation, and Hygiene.
WB	The World Bank
WDI	World Development Indicators

Introduction

Sustainable development is becoming an increasingly important issue worldwide. There are currently numerous definitions of "sustainability" with varied degrees of validity, relevance, and consistency because the concept has extensively dominated public, political, and academic debates. All the definitions make it very evident that there is no legitimate distinction between the economy and the environment. Both are intricately and reciprocally connected. These connections may take the shape of opposing trade-offs or complementary synergies, but in order to be considered "sustainable," it is necessary to acknowledge that economic principles and the environment are interdependent and cannot be assessed separately. In recent time the growing risks of climate change and its mounting evidence of negative economic effects on growth, productivity, and destructive impacts on environment are of paramount concern worldwide. This necessitates adequate policies to achieve economic growth and sustainable development while at the same time combating climate change and preventing costly environmental degradation and the inefficient use of natural resources. These policies require adequate measures and metrics to be better developed and assessed.

Robust and easily understandable indicators are needed to provide signals and measure progress in achieving green growth. A great deal of work has been done and various indicators covering different aspects are developed, among which is Green GDP.

Conventional GDP has been used as a standard measure of an economy's size. However, it does not measure negative externalities. For example, carbon dioxide emission from economic activity is not considered when measuring GDP, nor the depletion of natural resources. Gross Domestic Product only describes the value of all finished goods produced within the economy over a period of time. Green GDP is a measure of GDP growth considering the environmental consequences of that growth.

The idea of Green GDP arose in the early 1990s in response to the flaws of the Conventional GDP scale for calculating certain types of economic (environmental) costs that affect human well-being. Basically, inspired by various international conferences in the early 1990s, such as the United Nations Conference on Environment and Development in Rio de Janeiro (1992), and the World Commission on Environment and Development (1993), the concept of sustainable social and economic development was introduced and gained global attention (Li and Lang, 2010).

Building a Green GDP indicator is important in giving a clearer perspective on the consequences of economic progress by introducing a new approach to determining the cost of environmental degradation. The present study is an attempt to estimate a Green GDP for Egypt upon request from the Ministry of Planning and Economic Development. The main objective of the study is to explore appropriate methodologies that can be applied to calculate Green GDP, as an indicator to monitor sustainability of actual development pattern in Egypt, and the extent of environmental degradation attributed to this pattern. This study gains its relevance in the occasion of Egypt hosting COP27 in November 2022, as the dissemination and opportunity of a wide discussions of the results may shed light on useful ideas to improve the estimation process of green growth indicators.

Structure of the Study

The study begins in Section 1 with reviewing the estimation methodologies of the Green GDP available in international institutions, with a special focus on methods of monetary evaluation of depletion of natural resources and costs of pollution. Section 2 reviews several countries experiences in estimating the Green GDP, as well as relevant lessons. Section 3 presents estimate of Egypt's Green GDP applying various methodologies. Moreover, it highlights data requirements and availability. Section 4 reviews interpretation of the results of the study and policy implications. The study concludes with results limitations, their relevance to policy makers and suggestions to improve the process of producing indicators for green growth and sustainability in Egypt.

1. Methodologies to Estimate Green GDP and Monetary Evaluation of Environmental Costs

In 1992, the Rio Summit called for the compilation of new accounts that expand the existing System of National Accounts (SNA), to integrate environment and social dimensions. In 1993, the United Nations published the Handbook of National Accounting: Integrated Environmental and Economic Accounting (https://seea.un.org/content/handbook-national-accounting-integrated-environmental-and-economic-accounting). It focused on monetary valuation of natural resources, allowing the cost of natural resource depletion and environmental degradation to be subtracted from gross domestic product. In particular, the handbook advocated for the compilation of an 'environmentally adjusted domestic product' known as **'Green GDP'**.

'Green GDP' accounting systems aim to provide a more accurate measure of welfare and to gauge whether an economy is on a sustainable development path. It is defined as Conventional GDP adjusted to exclude environmental costs that result from economic activities. These costs include depletion of natural resources and the environmental costs of air and water pollution. These variables must be converted from a physical unit to a monetary unit to calculate Green GDP. Terms of Green GDP and environmentally adjusted GDP are used interchangeably.

Data on environment variables are available in physical terms. The methodologies of calculating Green GDP focus mainly on methods of "pricing" environmental elements, i.e., evaluation of environmental costs in monetary terms. This section sketches potential methods of environmental valuation.

1.1. Methodology of the System of Environmental-Economic Accounting (SEEA) for Monetary Evaluation of Environmental Costs and Natural Resources

The System of Environmental and Economic Accounting (SEEA) is a statistical system that gathers economic and environmental information into a common framework to measure the environment's contribution to the economy, and the economy's impact on the environment. SEEA contains an internationally agreed set of standard concepts, definitions, classifications, accounting rules, and tables to produce internationally comparable statistics.

The SEEA Central Framework brings together, in a single measurement system, information on water, minerals, energy, timber, fish, soil, land and ecosystems, pollution and waste, etc.

The full system consists of three main sections, two of which can be implemented independently and the third is designed to integrate the first two with each other and with the SNA (System of National Accounts, 2012). The three sections consist of:

a) An extended form of supply and use tables capable of incorporating physical data alone or in addition to monetary data;

b) Elaborations of parts of the central framework of the SNA with some extensions; and
c) Consideration of extending the SNA to allow the effects of depletion and degradation to impact the macro aggregates such as GDP.

The depletion of environmental assets relates to the physical using up of environmental assets through extraction and harvest by economic units, including households, resulting in a reduced availability of the resource. Specifically, depletion, in physical terms, is the decrease in the quantity of the stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a pace greater than that of regeneration. Depletion in physical terms can be measured in monetary terms by valuing the physical flows of depletion using the price of the natural resource in its site.

For non-renewable natural resources such as mineral and energy resources, depletion is equal to the quantity of resource that is extracted, because the stock of these resources cannot regenerate on a human timescale. Increases in the stock of non-renewable natural resources (e.g., through discoveries) may permit the ongoing extraction of the resources.

Depletion is not recorded when there is a reduction in the quantity of an environmental asset owing to unexpected events such as loss and damage due to extreme weather or pandemic outbreaks. The methodology to evaluate depletion of natural resources in monetary units adopts the Net Present Value Method (NPVM) to value the stock and measure depletion of non- renewable resources. This method relies on the value of rent and the discount rate.

1.1.1. Calculating the Natural Resources Rent

In the SEEA returns are defined using the concept of economic rent. Economic rent is best considered to be the surplus value accruing to the extractor or user of an asset calculated after all costs and normal returns have been accounted for.

Resource rent and the net return to environmental assets can be derived within the national account's framework through a focus on the operating surplus of extracting enterprises. In this context, the operating surplus earned by an enterprise is considered to comprise a return for the investment in produced assets and a return to the environmental assets used in production.

Theoretically, there are three main approaches to estimating resource rent: the residual value method, the appropriation method, and the access price method. Among these methods SEEA suggests using residual value method to calculate resource rent. According to such method resource rent is estimated as Gross Operating Surplus (GOS) deducting specific subsidies and adding up specific taxes less user cost of produced assets. Estimates of the user costs of produced assets are composed of two variables: consumption of fixed capital of produced assets; and normal return on produced assets.

1.1.2. Calculating the Natural Resources Stock

The value of stock of the natural resource is estimated as the present value of future rents over the lifetime of the resource. For any given discount rate (r) and resource lifetime (T), the stock (V_t) can be generated through the following equation:

$$V_t = \sum_{t=1}^{T} \frac{RR_{1+t}}{(1+r_t)^t}$$

where, r_t is a nominal discount rate valid at time *t*, but not necessarily constant over time, and RR_{1+t} is the nominal value of expected future resource rent where; such rent can differ along the life span of the resource.

The aforementioned calculation depends on the following:

a) Growth rate of the quantity of natural resource extracted during the life span of the resources: the methodology presents two alternatives. The first one considers the recent quantity of extraction as the best indicator for the expected quantity in the future, while the second assumes a constant growth rate of extraction.

b) The growth rate of the price per unit of natural resource during the life span of the project: the methodology assumes that expected price is in line with expected inflation rate.

c) The nominal discount rate: the methodology estimates nominal discount rate from the relation between real interest rate and inflation rate (ρ_t), more clearly the following equation, which is derived from net present value equation, represents the inverse of real interest rate:

$$\frac{1+r_t}{1+\rho_t}$$

d) Time to exhaustion of the resource: the life span of a resource depends on several factors, including the total stock available, the rate of extraction of the resource and general market conditions.

1.1.3. Estimating the Value of Depletion, Discoveries and Losses for Non-Renewable Natural Resources

As mentioned above, natural resource depletion is calculated as the total physical changes in the non-renewable resource between the beginning and the end of the accounting period, considering the following:

a) Net Present Value Method doesn’t consider new discoveries and catastrophically losses in calculating natural resources stocks as its data are unknown at the beginning of the accounting period.

b) The methodology values the physical flows of depletion in monetary terms using the price of the beginning of the period, not the actual price.

Based on what is mentioned above, actual calculations of natural resources depletions require two adjustments:

a) Quantity Effect: Adjustments to quantity changes due to including actual data about new discoveries and catastrophic loss. This adjustment measures the change in the quantity of the resource valued at the price of the beginning of the period.
b) Revaluation Effect: captures the price change of the resource, multiplied by the quantity at the end of the period.

1.2. Methodology of World Bank to Estimate Environmental Costs

The World Bank estimates environmental costs in context of its concern to calculate the change in wealth in different countries of the world (World Bank, 2021). The purpose is to offer indicators that may guide policy makers to evaluate the sustainability of the economic growth process. The idea is that wealth of nations comprises all the available assets of all kinds of capital. These assets are the source of income for people in successive generations. Therefore, the increase of these assets (wealth) over time means that the growth process is sustainable. Otherwise, future generations would suffer a decrease or a stagnation of their sources of income and prosperity. In this context, the World Bank estimates the indicator "net adjusted saving", as national saving must exceed depreciation of all kinds of capital: produced capital, natural capital and includes government expenditure on education for human capital formation. So national saving must be netted of produced capital depreciation and depletion of natural resources used in production and degradation of elements of ecosystem such as pollution of air and water. Although the World Bank did not proceed to estimate Green GDP, but the monetary evaluation of natural resources depletion and costs of environment degradation can be used directly in calculating the Green GDP.

The World Bank methodology to evaluate environmental costs focuses on calculating two groups of costs:

a) The environmental costs due to the depletion of natural resources, including crude oil, natural gas, coal, mineral resources, and forests.
b) The costs resulting from environmental pollution incurred from air pollutants, such as carbon dioxide emissions, and particulates (PM 2.5).

1.2.1. Environmental Cost Related to Energy Resources Depletion

The World Bank's methodology for estimating the cost of energy depletion (crude oil and natural gas) in monetary terms is based on calculating the rent of these resources through the following formula:

*Rent of Energy Resources = Quantity Produced from Energy Resources ** (*World Price per Unit of Energy – Average Unit Production Cost of Energy*)

This methodology sheds the light on the following issues when applying the previous formula:

a) There is no single agreed global price for a unit of energy, as there are many international prices. The methodology indicated that it is better to rely on the average world prices when determining the unit price of energy.
b) It is preferable to have annual data on the production unit cost of energy, but if data are not available and at least one statement of this cost is available in one year, it can be relied upon since costs rarely change due to stability of technology for a large period of time.
c) In this case, it is possible to start from this value in estimating a time series of costs after considering GDP deflator.
d) In case of unavailable data, it is possible to rely on production costs for other countries as proxy, provided that those countries are similar to the country under study in the number of active excavators as well as geographical proximity to the country under study.
e) The rent of a unit of energy is calculated by subtracting production cost from the world price, however the result of this subtraction may be a negative value, meaning that the cost of extraction will exceed its world price. The methodology indicated that if this is accepted from a mathematical point of view, it is unacceptable from a realistic point of view, as this means that investment in energy extraction activities is economically unfeasible.
f) If there are missing values for some variables in some years, they can be estimated using statistical tools based on the four most recent available observations.

Another method of calculating the annual depletion of a non-renewable resource begins with a valuation of the resource stock, as in the following expression:

$$V_t = \sum_{i=t}^{t+T-1} \pi_i q_i (1+r)^{-(i-t)}$$

where $\pi_i q_i$ is the rent from the resource in year i, given by multiplying unit rents π_i by the quantity of production q_i. Unit rents are equal to the revenues less the production costs including a ‘normal’ rate of return on fixed capital and the consumption of fixed capital. The discount rate is r, set at 4 percent; and the time to exhaustion of the resource is T.

Since actual future rents are unknown, these are implicitly predicted by assuming zero growth in rents over the resource lifetime. Annual depletion (Dt) is given simply by dividing the present value of the resource stock (V_t) by time to exhaustion (T):

$$D_t = V_t / T$$

1.2.2. Environmental Cost Related to Metal Resources Depletion

The World Bank methodology calculates the costs of depletion for several metals: bauxite, copper, gold, iron, lead, nickel, phosphate, silver, tin, and zinc. The methodology is like energy resources depletion, it applies the following formula, which is known as the rent of metal:

*Rent of Metals = Quantity produced of metals * (world price per unit of metal - average production unit cost of metal).*

1.3. Depletion of Agricultural Land

Natural resources include important components other than energy and minerals, namely, cropland, pastureland, fisheries, forests etc.… Methodologies to evaluate the depletion and the degradation of these resources are more complicated and require extensive data.

As for the calculation of loss and damage in cropland and fisheries there are no available techniques in the World Bank calculations of wealth, it only estimates the net depletion of forests, which are not particularly prevalent in Egypt.

UNCCD defines land degradation as “any reduction or loss in the biological or economic productive capacity of the land resource base. It is generally caused by human activities, exacerbated by natural processes, and often magnified by and closely intertwined with climate change and biodiversity loss” (UNCCD, 2014).

1.3.1. Land accounts in SEEA central framework

Land accounts are one of the many types of accounts covered by the SEEA Central Framework. These accounts focus on assets and are recorded in physical terms and in monetary terms. Land and soil are separable assets; the soil resource provides the physical base for the growing of plants while the land defines the area of interest. This partitioning of land and soil allows the depletion and degradation of soil to be placed in a clear construct distinct manner as compared to land.

The quantitative dimension of soil is subject to depletion, being the loss of soil and the nutrients, it contains. Soil degradation represents the decline in the capital value of land over time caused by economic activity. This decline in value represents the fall in the future productive capacity of the land.

Losses in the productive capacity of land may be offset by land improvements that are regarded as capital formation in the SNA and the SEEA.

1.3.2. The Food and Agriculture Organization of the United Nations (FAO)

FAO developed a methodology to measure the Damage and Loss (DL) attributed to the agriculture sector caused by disasters. This methodology provides a process to evaluate the damage for the physical assets and the loss of economic flows due to disasters. It intends to measure impact of various disasters type such as climate-related events.

Impact to Agriculture = "DL(C) = Impact to crops" + "DL(L) = Impact to livestock" + "DL (FO) = Impact to forestry" + "DL (AQ) = Impact to aquaculture" + "DL (FI) = Impact to fisheries"

In each type of these components' estimations include production damage and loss, and also the damage in the assets of these components. Damage and loss are estimated in physical terms. Methodologies of pricing damage and loss to assign monetary values are not considered in FAO's work.

1.3.3. Economic of Land Degradation (ELD) Initiative & UNEP

It provided a methodology to estimate the economic costs of land degradation in an applied study on Africa (ELD Initiative & UNEP, 2015). The study considers land degradation and desertification due to climate change and poor management of agriculture, focusing on soil erosion and crop productivity on over 100 million hectares of crop lands across 42 African countries (Egypt included). The study predicts the cost of inaction in 15 years forward using the net present value technique, and cost-benefit analysis for quantifying the loss and assessing the cost of inaction, the cost of action, and benefits of action against land degradation.

Based on national level data from FAO, the World Bank, WOCAT, and the literature for 42 African countries, continental scale econometric models were developed of soil nutrient depletion and cereal crop production. The models were then used to estimate production losses per year due to erosion. The annual national level estimates of nutrient losses were valued using the replacement cost method, whereas the crop losses due to nutrient depletion were valued using the producers' prices of the crops, multiplying the marginal physical product of the environmental variable by the price of the market goods.

1.4. Evaluation of Economic Costs of Environment Pollution

This section investigates methodologies for estimating monetary value of the environmental degradation associated with economic activities to calculate the Green GDP, it focuses on the cost of air and water pollution**.**

1.4.1. Air Pollution

Daly defined air pollution as "Any substance emitted into the air from an anthropogenic, biogenic, or geogenic source, that is either not part of the natural atmosphere or is present in higher concentrations than the natural atmosphere and may cause a short-term or long-term adverse effect" (Daly, 2007; p3).

Air pollution has a wide range of harmful impacts on humanity and nature. WHO highlights the damaging effect of air pollution on human health in the form of lung disease, stroke, heart disease, and chronic bronchitis in case of short-term exposures. Long-term exposure could be manifested as cancer and damage to the immune, reproductive and neurological systems. In addition to impairing human health, air pollution can have several negative repercussions on the environment such as, acid rain, crop and forest damage, eutrophication, and haze.

The World Bank methodology estimates the environmental costs resulting from carbon dioxide (CO2) emissions through the following formula:

*Environmental costs of CO2 emissions = amount of emissions * marginal cost of emissions*

The adopted World Bank's methodology estimates the social cost of CO2 emissions at approximately $20 per metric ton of carbon. Whereas all pollutants have considerable effects on human health, particles are the most influential in terms of economic impact, as they can cause premature death and increase morbidity rates. Therefore, methodologies to evaluate costs of air pollution in context of estimating Green GDP, concentrate on costs induced by particulate matters which are discussed in the following section.

1.4.2. Health Effects of Particulate Matter Pollution (Ambient PM2.5)

Particulates are classified based on their size (aerodynamic diameter) into five types as follows: Particles less than 100 microns (PM10), Particles less than 4 microns, Particles less than 2.5 microns (PM2.5), and Particles less than 0.1 microns (PM0.1); they may be also classified according to their chemical composition (US-Environmental Protection Agency, 2022). The most harmful to mankind is (PM2.5).

The World Bank defines particulate emissions damage as the "damage due to exposure of a country's population to ambient concentrations of particulates measuring less than 2.5 microns in diameter (PM2.5), ambient ozone pollution, and indoor concentrations of PM2.5 in households cooking with solid fuels". Measurement data of concentration of different air pollutants are obtained from monitoring stations in different locations across the country.

Furthermore, the World Bank estimates the health impacts of Particulate Matter Pollution utilizing the result of the Global Burden of Disease Study (GBD), which is conducted by Institute for Health Metrics and Evaluation University of Washington, Seattle (Southerland, et al., 2022). The GBD estimates exposure to outdoor (ambient) air pollution, then evaluates relative risk (RR) function of contracting illnesses due to exposure to (PM2.5). RR is defined as risk of disease from ambient PM2.5 exposure relative to the risk if there is no PM2.5 exposure. The risks normally reflect long-term exposure to ambient PM2.5 (World Bank, 2019). Those risks can be translated into number of deaths due to exposure to this pollutant each year. The methodology used to evaluate the impact of exposure to particulates follows two steps:

Step (1) Estimating the mortality rate due to exposure to Particulate Matter:

Mortality rate due to exposure to Particulate Matter is not a straightforward data that can be obtained from vital statistics. These statistics presents data on mortality rates classified according to causes of death; this data set is defined as "baseline annual deaths". Mortalities due to illness that can be caused by particulates pollution are extracted and modified to be related to age group (25+), and then processed using relative risk function (RR). Institute for Health Metrics and Evaluation developed an integrated exposure-response (IER) parameter and attributable fraction (AF) to calculate the share of the population exposed to a particular PM2.5 concentration. Finally, numbers of deaths due to exposure to particulate matter in the age group (25+) are estimated. This methodology is used in Global Burden of Disease Study and estimates are produced for almost all countries of the world. The World Bank (2021) report of "Changing Wealth" use such estimates.

Step (2) Estimating the economic cost of exposure to Particulate Matter

The World Bank[1] takes two approaches to valuing the costs of premature mortality:

a) A welfare-based approach that monetizes the increased fatality risk from air pollution according to individuals' willingness to pay (WTP)[2]; and
b) An income-based approach that equates the financial cost of premature mortality with the present value of forgone lifetime earnings.

The income-based approach is more appropriate within the extended boundaries of the national accounts. Damages are calculated as foregone labor income due to premature death (World Bank, 2021):

*Economic cost of exposure to Particulate Matter = average income * number of deaths due to exposure to Particulate Matter*

1.4.3. OECD methodology for estimating health impacts of air pollution

Exposure to outdoor $PM_{2.5}$ is derived using pollutant concentration estimates. These use chemical transport models (which, in turn, rely on several emissions databases), satellite-based measurements of aerosol optical depth and measurements from ground stations. Hybrid approaches to measuring pollutant concentration present new opportunities to use different types of data from several different sources. This allows for more robust estimates of pollutant concentrations (OECD, 2017).

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[1] World Bank and Institute for Health Metrics and Evaluation. 2016. The Cost of Air Pollution: Strengthening the Economic Case for Action. Washington, DC: World Bank.

[2] The value of statistical life (VSL) is a welfare measure derived from individual willingness-to-pay (WTP) for a reduction in the risk of death. The VSL estimated for Egypt is LE 3.0 million based on a GDP per capita of LE 37,192 in 2016/17 according to MOF (2018) and the methodology for estimating the VSL in World Bank (2016) and World Bank and IHME (2016) *Source: Larsen, Bjorn. 2019. Egypt: Cost of Environmental Degradation: Air and Water Pollution. The World Bank.*

The cost of the health impact of air pollution is evaluated in terms of what the population at large would be "willing to pay" to avoid premature deaths. These welfare costs are calculated using estimates of the "Value of a Statistical Life". These, in turn, are derived from a meta-analysis of a large number of studies of individual willingness-to-pay to reduce the risk of premature mortality. Cost estimates represent the cost of premature mortalities. They exclude any morbidity impacts (labor productivity losses, treatment costs and willingness to pay to avoid pain and suffering from illness). They also exclude impacts other than those on human health (e.g., on built structures, agricultural productivity, ecosystem health).

1.4.4. Water Pollution

Water pollution valuation method also will depend on the health effects of inadequate water, sanitation, and hygiene (WASH). The valuation uses the same method presented for air pollution, with difference related to the diseases caused by water pollution. These diseases include diarrheal infections, typhoid/paratyphoid, schistosomiasis, acute lower respiratory infections (ALRI), intestinal nematode infections, and trachoma in addition to child mortality from poor nutritional status caused by inadequate water, sanitation, and hygiene. However, data on water pollution measurement are less available compared to air pollution.

1.5. Extended Measures of Green Growth

In the context of sustainability various indicators other than Green GDP have evolved over time. The development of measuring methodologies was induced by several factors such as the acceleration of climate change around the world, increasing scarcity of natural resources, and the progress in technologies for measuring different environment resources and phenomena. This led to the increase in data availability and data analytics. This section discusses various indicators and methodologies that arise in the literature.

1.5.1. The UN System for Environmental Economic Accounting (SEEA)

SEEA is a widely used accounting framework developed by the United Nations. It is an international statistical standard that integrates economic and environmental data using a systems approach to assess how much the environment contributes to the economy and how the economy affects the environment. To make it easier to create indicators and conduct analysis on the economy-environment nexus, the SEEA uses a structure and classifications that are compatible with the United Nations System of National Accounts (SNA). It provides the basis for a coherent dashboard of indicators, including indicators of efficiency and productivity (United Nations, 2022a).

There has also been a shift away from focusing on flow-type indicators such as Green GDP for measuring sustainable growth. Stock measures have become just as important, as sustainability depends on the ‘stock’ of natural assets and its ability to regenerate. The SEEA 2012 Central Framework shifted from the singular dominance of a flow indicator, towards a dashboard approach and stock indicators, featuring stock and flow accounts in both physical and monetary terms.

In 2021 the United Nations Statistical Commission adopted the SEEA Ecosystem Accounting (SEEA EA). It takes a capitals approach in portraying ecosystems as assets which provide humanity with vital ecosystem services (air filtration, carbon storage etc.). These ecosystem assets are measured in the SEEA EA in physical units and in monetary terms, using valuation principles consistent with the System of National Accounts. This framework enables to go beyond measuring just the negatives (degradation of ecosystems, depletion of natural resources, etc.) to also recognizing the positives (ecosystem services, restoration, etc.). An indicator for just the “positives” is currently being tested through a novel headline indicator called gross ecosystem product (GEP), which measures the sum of total ecosystem services produced and can be compared with GDP. The indicator is being tested in China.

1.5.2. Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES)

Launched in 2017, the project Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) aims to advance both the knowledge agenda and the development of policy-applications of environmental-economic accounting, and in particular for ecosystem accounting. The project initiated pilot testing SEEA Ecosystem Accounting (SEEA EA) in five participating partner countries, namely Brazil, China, India, Mexico, and South Africa.

These five countries were selected as strategic partners to the European Union, on account of the importance of their natural capital, their diverse ecosystems and biodiversity, along with their adherence to the commitments to the Convention on Biological Diversity (CBD).

The NCAVES project was funded by the European Union via a Partnership Instrument and has been jointly implemented by the United Nations Statistics Division and the United Nations Environment Programme, in collaboration with the Convention on Biological Diversity (CBD).

1.5.3. OECD Growth Indicators

Among indicators of green sustainable growth, the **“resource efficiency”**, is widely recognized, especially in Europe. According to the United Nations Environment Programme (UNEP), resource efficiency is about ensuring that natural resources are produced, processed, and consumed in a more sustainable way, reducing the environmental impact from the consumption and production of products over their full life cycles (Science Communication Unit, University of the West of England, Bristol 2013).

Two levels of indicators have been proposed regarding resource efficiency indicators:

a) ‘Resource Productivity’ to measure improving economic performance while reducing pressure on natural resources.

b) A series of complementary indicators on key natural resources such as water, land, materials and carbon, that will take account of the consumption of these resources.

The European Commission is using resource productivity as its lead indicator. This is calculated by dividing gross domestic product (GDP) by domestic material consumption.

OECD adopts the accounting framework of the System of Environmental and Economic Accounting (United Nations, 2014). It considers that green growth is not easily captured by a single indicator, and a ***small set*** of measures is needed. Therefore, four groups of indicators are developed (OECD, 2017):

a) Indicators monitoring the environmental and resource productivity of production and consumption;
b) Indicators describing the natural asset base;
c) Indicators monitoring the environmental dimension of quality of life; and
d) Indicators describing policy responses and economic opportunities.

1.5.4. Environmentally Adjusted Multifactor Productivity (EAMFP)

OECD further refined framework for measuring the environmentally adjusted multifactor productivity growth that seeks to incorporate environmental services in productivity analysis. Compared to standard productivity measurement, this framework allows accounting for the use of natural capital (currently including 14 types of fossil fuels and minerals) and the emission of pollutants as negative by-products (currently including 8 types of greenhouse gases and air pollutants). The indicators allow the sources of economic growth to be better identified, and growth prospects in the long run to be better assessed.

Growth in environmentally adjusted multifactor productivity (EAMFP) has been identified as a green growth headline indicator. It measures a country's ability to generate income from a given set of inputs, while accounting for the consumption of natural resources and production of undesirable environmental outputs. The framework for measuring the EAMFP provides opportunities to develop two related indicators that could be useful for green growth analysis. The first is the growth contribution of natural capital which measures how much current income growth depends on natural resource use. The second is the growth adjustment for pollution abatement which measures to what extent economic growth has been achieved at the expense of environmental quality (OECD, 2017).

1.5.5. Adjusted Net Savings (ANS)

Hamilton and Clemens (1999) developed the indicator of adjusted net savings (ANS), as a proxy for the change in wealth. ANS is measured as gross national saving minus depreciation of produced capital, depletion of subsoil assets and timber resources, and air pollution damages to human health, plus expenditures on education as it is considered an addition to human capital.

ANS is presented as a percentage of gross national income. A negative ANS value indicates that the country is consuming more than it is saving, which will undermine long term sustainability. Conversely, positive ANS value designates addition to wealth and future economic well-being.

1.5.6. Changing Wealth per Capita

The World Bank focuses on measuring wealth as GDP and wealth are considered as complementary indicators for measuring economic performance and provide a fuller picture when evaluated together. By monitoring trends in wealth, it is possible to see whether GDP growth is achieved by building capital assets, which is sustainable in the long run, or by liquidating assets, which is not. Wealth should be used alongside GDP to provide a means of monitoring the sustainability of economic development.

For countries with growing populations, it is not sufficient to maintain wealth. The World Bank (2021) considers that measuring the change in wealth per capita over time is perhaps the most important metric to consider in addition to GDP, and it provides an actionable way to track sustainability, as wealth creation must keep pace with population to reduce inequality. Growth must be sustainable and inclusive.

1.5.7. Global Green Economy Index

Global Green Economy Index is developed by Dual Citizen in 2010 and consists of 18 quantitative and qualitative indicators focusing on four key dimensions: climate change and social equity, sector decarbonization, markets and ESG (environment, social and governance) investment, and environmental health (Dual Citizen, 2022).

2. Countries' Experiences and Challenges in Estimating Green GDP

Several countries started the process of estimating Green GDP after the release of the 1993 SEEA, among them the United States, China, Norway, Australia, Canada, Indonesia and the UK. However, not all these countries kept on the process. Some countries, such as Norway, found that the non-market valuation techniques used to value environmental depletion and degradation were too experimental and inconsistent. In 1994, the United States estimated indicators showed that GDP numbers were overstating the impact of mining companies to the nation's economic wealth. Mining companies put pressures that led to stop working on revising the Green GDP. Recently the Bureau of Labor Statistics used to publish a “Green Goods and Services” survey, but it was discontinued in 2013 following budget cuts.

In China low numbers of Green GDP led to resistance from some local and regional governments, finally they stopped producing this indicator in 2005. However, China and other countries did not neglect green accounting, rather they shifted to indicators of green growth other than Green GDP as presented in the previous section. Recently more than 100 countries adopt SEEA, 82 of them are in stage 3, and 36 countries apply SEEA EA (UN 2021, Global Assessment Report).

This section presents the experiences of some selected countries that applied methodologies presented in Section (1) in estimating the Green GDP. This section attempts to highlight the differences in various aspects of implementation that may offer useful lessons for Egypt. Selected countries are China, Mexico, Ukraine and Thailand. After a brief note on each country, the main characteristics of their experiences are shown in Table (1).

2.1. Green GDP Accounting in China

China developed and imposed its own system of calculating GDP in 2003. It was one of the first countries to publish official reports on "Green GDP" at the national level in 2004. China adopted the United Nations System of Environmental and Economic Accounting (SEEA).

Recently, China is developing a new index based on ecosystem goods and service accounting (SEEA EA), known as **Gross Ecosystem Product (GEP)**, a measure that translates ecological contributions to the economy into monetary terms. GEP is defined as the monetary value of final ecosystem goods and services benefiting to people (Ouyang et al., 2020). The government of China is now actively working to develop and implement GEP starting at subnational levels in the context of NCAVES project. The physical and monetary accounting approach of the SEEA EA is used as the underlying statistical framework.

2.2. Green GDP Accounting in Mexico

Mexico was one of the first pilot countries for the implementation of SEEA Central Framework, taking 1988 as the base year and publishing its first report in 1991. Mexico is participating in NCAVES project and adopts SEEA EA accounting framework.

2.3. Green GDP Accounting in Ukraine

In Ukraine, experts have come up with some common approaches to calculating environmentally adjusted GDP, a set of which can be applied to practical calculations (United Nations, 2003). Damage from soil and water pollution, as well as biodiversity losses, has not been assessed due to lack of data, so the actual rate of negative effects of environmental degradation is underestimated.

2.4. Green GDP Accounting in Thailand

Thailand is concerned about sustainable development and has focused on the issue of natural resources and pollution since 1997. Green GDP is estimated in a study and not in an official institution. Calculating Green GDP in Thailand is based on the concept of “Hermann E. Daly” and is more complex in terms of natural cost estimation because it is based on different definitions (Sonthi, 2019). The results indicate that every production process produces good and bad outputs. In the case of Thailand, the results show that the discrepancy between GDP and Green GDP cannot be ignored especially regarding emissions.

Table 1
Green GDP accounting in selected countries

Countries	GREEN GDP			
	Environment Costs	Evaluation of Costs	Specialties	GDP-Green GDP
China	• Pollution of water resources • Air pollution • Placement of solid waste • Depletion of land resources	Net Present Value	Calculation of: • Fossil energy density (carbon) per GDP Consumption and carbon emissions with GDP growth. • SO_2 intensity per GDP • COD intensity per GDP.	7%
Mexico	Groundwater depletion, emissions, solid waste, water pollution, soil degradation and environmental protection expenditures, water, fisheries, and material flows.	Net Present Value	The use of satellite imagery, digital elevation models, topography (hydrography and transportation networks), Census geographies, geology.	3.5%
Ukraine	Reduction in natural capital, for example, due to the operation of the mining industry	Net Present Value	The increase in the stock of natural capital due to the discovery of new deposits of natural resources is considered. Deduction of the costs spent on combating environmental degradation.	5%
Thailand		Output distance function and its duality with revenue function is used relying on stochastic frontier analysis (SFA) for computing the shadow price of pollution		30%-40%

Source: Authors' compilation

3. Appropriate Methodologies for Egypt to Estimate Green GDP

As shown in previous sections there is one formula used to estimate Green GDP, in which environmental costs are deducted from Conventional GDP. However different methodologies are used for defining and pricing items of environmental costs, precisely depletion of natural resources and costs of different pollutants.

As known, there are differences in natural resources endowment in each country. Moreover, sources of pollution are not universally of the same relevance. Therefore, the choice of appropriate methodology depends in the first place on defining relevant natural resources that are exposed to depletion, and most influential pollutants. Shortage of detailed and reliable data is a problem in most countries, and Egypt is no exception. Fortunately, WB collects, processes and publishes considerable amount of data and indicators that could be used in environmental accounting and hence in the estimation of the Green GDP.

In the choice of the appropriate methodology to be applied in Egypt some practical issues should be taken into consideration, such as:

a) Limitations of data in terms of availability, accessibility, and completeness.
b) The methodology should be consistent with the system of national accounts adopted in Egypt, which is partially the SNA 2008 of UN.
c) The system of national accounts in Egypt is not fully implemented, especially of importance for estimating green accounts in general, is the wealth account (or balance sheet), which is concerned with assets and stocks accounts. Expertise with this type of accounts needs to be further developed.
d) The present study is a first step in the way to develop indicators for monitoring green growth in Egypt. Therefore, in searching for appropriate methodology for Egypt the focus is on some criteria, namely:
    - Referring to recognized international institutions who participated in developing the SNA (UN, WB, and OECD);
    - Simplicity of the adopted methodology with the inclusion of minimal number of variables; and
    - Compliance with relevant natural resources in Egypt and main sources of environmental degradation.

Deliberating on the above considerations, the World Bank methodology in estimating depletion of natural resources and costs of pollution is the most appropriate for Egypt in this stage, especially because of simplicity and data availability. According to WB estimations of shares of components of natural capital in Egypt, petroleum oil and natural gas have the biggest share, coal, forests, and fisheries are negligible, crop and pastureland have a growing share. The most growing share of natural capital in Egypt are the protected areas, as shown in Table (2).

Table 2
Shares of natural capital in Egypt

Share of Natural Capital	2013	2014	2015	2016	2017	2018
Natural Capital	100%	100%	100%	100%	100%	100%
Forests, timber	0%	0%	0%	0%	0%	0%
Forest, ecosystem services	0%	0%	0%	0%	0%	0%
Mangroves	0%	0%	0%	0%	0%	0%
Fisheries	0%	0%	0%	0%	0%	0%
Protected Areas	8%	8%	10%	12%	13%	14%
Cropland	20%	19%	20%	21%	21%	22%
Pastureland	17%	16%	16%	17%	18%	19%
Oil	37%	37%	35%	32%	32%	31%
Natural Gas	15%	16%	16%	15%	13%	11%
Coal (all grades)	0%	0%	0%	0%	0%	0%
Metals and Minerals	4%	3%	3%	3%	2%	2%

Source: World Bank Development Indicators (2021).

Based on previous data, oil and natural gas constitute more than 40% of natural capital in Egypt. Therefore, methodology of the World Bank in estimating cost of depletion of energy resources are suggested and used in this section.

3.1. First Scenario: Applying the World Bank Methodology and Data to Estimate Green GDP

The World Development Indicators (2021) provide annual time series data for different environmental costs in monetary terms. This data has been used directly to adjust GDP values to environmental costs in Egypt and estimate the Green GDP. Table (3) illustrates the time range for the environmental costs valued in monetary terms in Egypt according to World Development Indicators (WDI). The definition of the environmental costs' variables included in the estimation is as follows:

- **Energy Depletion** is calculated as the ratio of the value of the stock of energy resources to the remaining reserve lifetime (capped at 25 years), it covers crude oil, and natural Gas.

- **Mineral Depletion** is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime (capped at 25 years), it covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.
- **Net Forest Depletion** is calculated as the product of unit resource rents and the excess of round wood harvest over natural growth.
- **Carbon Dioxide Damage** is estimated to be $20 per ton of carbon (the unit damage in 1995 U.S. dollars) times the number of tons of carbon emitted.
- **Particulate Emission Damages** are calculated as foregone labor income due to premature death.

Thus, a general scheme of calculation is:

Green GDP = Conventional GDP – (Energy Depletion+ Mineral Depletion +Net Forest Depletion+ Carbon Dioxide Damage+ Particulate Emission Damages)

3.1.1. Required Data

To calculate Green GDP, annual time series data about Egypt in current US$ for GDP, energy depletion, mineral depletion, net forest depletion, and carbon dioxide damage and particulate emission damages are collected from World Development Indicators between 2010 and 2020.

As shown in Table (3) energy depletion on average between the years 2010 and 2020 contributed the largest share in the environment costs accounting for about 4.7% of GDP. However, it decreased significantly in 2020 (1.9%) this could be due to the effect of COVID-19 lockdowns. It is confirmed that during the pandemic economic activities that emit greenhouse gas (GHG) emissions has slowed down. The satellite pictures have revealed the dramatic fall in worldwide emissions because of decreased economic activity.[1] Particulate emission share is about 3.1% of GDP, while carbon dioxide (CO_2) emissions contributed with 3%, and net forest depletion shared with 0.2%. Mineral depletion is the smallest contributor to environment cost in Egypt reaching about 0.1% of GDP.

[1] https://www.weforum.org/agenda/2020/03/emissions-impact-coronavirus-lockdowns-satellites/

Table 3
Environmental Cost for Egypt (2010-2020)

Series Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
In Current Million US$											
Net Forest Depletion	485.8	553.8	601.4	527.5	839	758.3	586	730.5	383.3	514.1	460.8
Energy Depletion	13480	19040	19500	18650	16380	8569	6135	7916	12220	10820	6856
Mineral Depletion	182.4	580	912.6	313.2	183.9	130.9	254.4	280.2	15.59	NA	NA
Carbon Dioxide Damage	5642	6005	6642	6816	7305	7879	8387	8931	9648	10530	11270
Particulate Emission Damage	13330	8024	4472	8737	6559	9325	8595	338.5	7082	16680	13220
GDP	218983.7	235989.7	279116.7	288434.1	305595.4	329366.6	332441.7	235733.7	249713	303080.9	365252.7
in % of GDP											
Net Forest Depletion †	0.22	0.23	0.22	0.18	0.27	0.23	0.18	0.31	0.15	0.17	0.13
Energy Depletion †	6.2	8.1	7	6.5	5.4	2.6	1.8	3.4	4.9	3.6	1.9
Mineral Depletion†	0.083	0.246	0.327	0.109	0.06	0.04	0.077	0.119	0.006		
Carbon Dioxide Damage†	2.58	2.54	2.38	2.36	2.39	2.39	2.52	3.79	3.86	3.47	3.09
Particulate Emission Damage†	6.09	3.4	1.6	3.03	2.15	2.83	2.59	0.14	2.84	5.5	3.62
Total Costs	15.2	14.5	11.5	12.2	10.3	8.1	7.2	7.8	11.8	12.7	8.7

Source: World Development Indicators (2021). † authors' calculation based on WDI (2021).

3.1.2. Estimation of Green GDP

Following WDI and considering the general scheme of calculation of Green GDP the results obtained show that on average GDP in Egypt is overestimated by about 11.9% between the years 2010 and 2020.

Table 4
GDP and Green GDP in Egypt (2010-2020)

Series Name	GDP (current Million US$)	Total Environment Costs (current Million US$) †	Green GDP (current Million US$) †	Difference‡ (%)
2010	218983.7	33120.2	185863.5	15.1
2011	235989.7	34202.8	201786.9	14.5
2012	279116.7	32128	246988.7	11.5
2013	288434.1	35043.7	253390.4	12.1
2014	305595.4	31266.9	274328.5	10.2
2015	329366.6	26662.2	302704.4	8.1
2016	332441.7	23957.4	308484.3	7.2
2017	235733.7	18196.2	217537.5	7.7
2018	249713	29348.9	220364.1	11.8
2019	303080.9	38544.1	264536.8	12.7
2020	365252.7	31806.8	333445.9	8.7

Source: World Development Indicators (2021). † Author's calculations based on World Development Indicators (2021). ‡Difference = (GDP-Green GDP)/GDP

The differences in percentage between the value of GDP and the value of Green GDP for Egypt are ranging between 7.2% and 15.1% as shown in Table (4). Energy Depletion had the highest share in cost of environmental degradation from 2011 till 2014, and since 2015 pollution costs increased in higher rates (Figure 1).

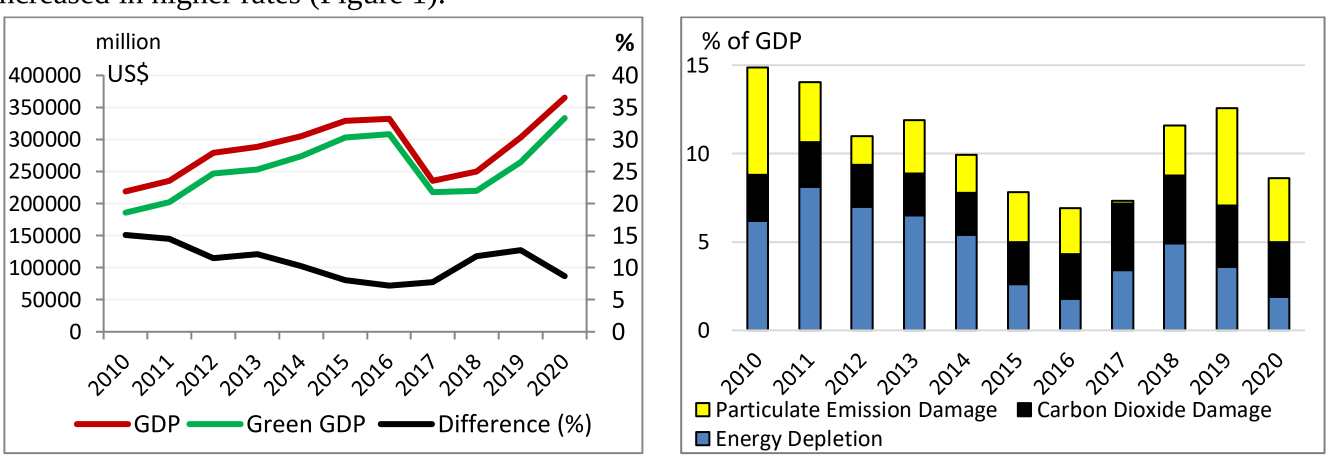


Figure 1: Trends of GDP, Green GDP, and the Difference in Trends (left panel) and Trends of Cost of Environmental Degradation (right panel) in Egypt
Source: Data of Table 3 and 4.

3.2. Second Scenario: Estimation of Green GDP Using Data from Local Sources

As depicted in the previous section, WDI provides annual time series data for different environmental costs that can be used directly to adjust GDP values in Egypt. Moreover, including carbon dioxide in environmental costs is debatable, as statistics of its emission in Egyptian sources show that they do not exceed limits defined by Egypt's Environment Law No (4) of 1994.

Alternatively, calculating estimates of environment costs using data from local sources may provide alternative insights. Therefore, data from local sources in Egypt are used to estimate depletion of energy sources according to the following formula:

*Depletion = Production volume * (International Price – average unit production cost)*

The time span for estimating energy depletion in Egypt, specifically crude oil and natural gas, covers the period (2010/2011 – 2019/2020).

3.2.1. Data requirements and sources

The required data include:

a) Oil and Natural Gas Production Volume
b) International Oil and Natural Gas prices
c) Oil and Natural Gas Unit Production Cost
d) Exchange Rates
e) Inflation Rates
f) GDP Values

Data were obtained from a variety of sources including OAPEC, Ministry of Petroleum, CAPMAS, Ministry of Planning and Economic Development, and Britain Bulletin Statistical Review. Table (6) summarizes the data characteristics.

3.2.2. Results for Adjusting GDP to Oil Depletion

The estimation involves the following steps:

a) Estimating Oil Unit Production Cost

Due to lack of published data about oil unit production cost for Egypt, data from Khalda Petroleum; one of the main oil producers; are used. [1] According to Khalda Petroleum the cost of oil production in Egypt is around 5 US dollar/barrel in the year 2015/2016[2]. Oil unit production costs for the other years are estimated using the World Bank approach assuming that the production costs in the single year remained constant in real terms, while in nominal terms inflation rates should be considered.

[1] Is a joint venture company between Egyptian General Petroleum Corporation (EGPC) and Apache Corporation. The company main work area is located in Egypt's western Desert where the main activities of operations are implemented. The activities include drilling, production, process of oil and gas and shipment as well.

[2] https://egyptoil-gas.com/tag/oil-production-cost/

Therefore, the unit production costs for oil in Egypt during (2010/2011 - 2019/2020) are estimated by adjusting the value in 2015/2016 using the annual inflation rates. The resulting data are illustrated in Table (6). It shows that the value of oil unit production cost in Egypt ranges between 3.1 US Dollar and 8.5 US Dollar for the time span 2010/2011 - 2019/2020

Table 5

Characteristics of the Required Data for Estimating Energy Depletion Costs

	Variable	Source	Data availability	Units of Measurements	Data periodicity
Production	Oil Production	Annual reports form Ministry of Petroleum	Unpublished	Thousand Tons	Annually
	Natural Gas Production	Annual reports form Ministry of Petroleum	Unpublished	Thousand Tons	Annually
Prices	International Oil Prices	OAPEC Annual Statistical Report	Published	Average Price for OAPEC Basket in US dollar / Barrell	Annually
	International Natural Gas Prices	Britain bulletin statistical review	Published	US Dollar/ Million BTU	Annually
Production Cost	Oil and Natural Gas production Cost	Estimated	Unpublished	US dollar / Barrell for Oil & US Dollar/ BTU for Natural Gas	-
Economic Variables	Exchange rates	Central Bank of Egypt (CBE)	Published	LE/US dollar	Monthly, quarterly, and annually
	Inflation Rate	CAPMAS	Published	%	Monthly, quarterly, and annually
	GDP	Ministry of Planning and Economic Development	Published	Real Prices in LE	Quarterly, and annually

a) Standardization of Measurement Units

International price and production cost of oil are available in barrel, while production data of oil is recorded in tons, standardizing the units of measurements for the variables included is required. The standardization process is applied using the following conversion factor:

1 metric tons of oil = 7.33 barrel [1]

[1] OAPEC, Annual Statistical Report, available online at: https://oapecorg.org/

Table 6
Estimation of the annual cost for crude oil unit production in Egypt

Year	Inflation rates (%)[a]	Unit Cost for Oil Production US Dollar/ Barrel[b]	Oil Production (Millions of tons)[c]	Oil Production (Millions of barrels)[d]	International Oil Price US Dollar/ Barrel[e]
2011/2010	11.3	3.1	34.8	255.1426	77.45
2012/2011	10.06	3.3	34.9	255.5458	107.46
2013/2012	7.11	3.6	34.4	252.2766	109.07
2014/2013	9.47	4	34.7	254.3877	105.45
2015/2014	10.07	4.4	35.2	258.016	96.71
2016/2015	10.37	5	34.6	253.618	49.49
2017/2016	13.81	6.5	32.2	236.026	40.76
2018/2017	29.51	7.4	32.1	235.293	52.34
2019/2018	14.4	8.1	32	234.4354	69.78
2020/2019	9.15	8.5	31	226.9295	64.04

Sources: [a] CAMPAS, Annual Statistical Yearbook, Different Issues. [b] Authors' Calculations. [c] Annual statistical reports, ministry of petroleum, different reports, unpublished data. [d] Authors' calculation based on conversion factor, 1 metric tons of oil= 7.33 barrel. [e] OAPEC, Annual Statistical Report, available online at: **https://oapecorg.org/**

b) Estimation of Crude Oil Depletion

After obtaining the required data and standardization process, the final step is to apply the World Bank formula to estimate the value of oil depletion in Egypt. The results showed that, on average, Egyptian economy has incurred about 17.8 billion US dollar as environmental costs of crude oil depletion, which is equivalent to about 170 billion LE between the year 2010/2011 and year 2019/2020 (Table 7).

The cost of total oil depletion fluctuated in Egypt during the period (2010/2011 -2019/2020) as shown in Figure (2). The data used reveals that the magnitude and fluctuations of oil prices are the most influential. The costs increased between the year 2010/2011 and year 2014/2015 due to increase in international oil prices. Whereas depletion cost declined in the year 2015/2016, as a reflection of a sharp decline in crude oil prices. Starting from the year 2015/2016 oil depletion cost is back up again driven by increasing international oil prices. In contrast, exchange rates and unit cost of oil production are relatively smooth and thus have no impact on depletion cost fluctuations in Egypt.

The environmentally adjusted GDP (Green GDP) that accounts for oil resource depletion showed that GDP is overestimated by about 5% on average between the year 2010/2011 and year 2019/2020.

Table 7
Crude oil depletion in Egypt

Year	Conventional GDP (Constant Billion LE) †	Oil Depletion (Billion LE) ‡	Oil Depletion/ GDP (%)‡	Exchange Rate (LE/US Dollar) §
2011/2010	2844.75	112.5	4.0	5.9
2012/2011	2908.08	161.2	5.5	6.1
2013/2012	2971.63	182.8	6.2	6.9
2014/2013	3058.28	182.7	6.0	7.1
2015/2014	3191.99	183.2	5.7	7.7
2016/2015	3330.73	113.1	3.4	10.0
2017/2016	3470	143.8	4.1	17.8
2018/2017	3654.4	187.9	5.1	17.8
2019/2018	3857.5	242.5	6.3	16.8
2020/2019	3995.2	198.6	5.0	15.8
Average		170.8	5.1	5.1

Sources:† Ministry of Planning and Economic Development, unpublished data. ‡ authors' calculation § Central Bank of Egypt, https://www.cbe.org.eg/ .

3.2.3. Results for Adjusted GDP to Natural Gas Depletion

The estimation of Adjusted GDP to natural gas depletion in Egypt follows the same steps as for crude oil postulated in the previous section.

a) Estimating Natural Gas Unit Production Cost in Egypt

Similar to oil, there is a lack of published data about natural gas unit production cost. Therefore, a proxy is used based on an announcement from the chairman of the Chamber of Petroleum Industry and Mining at the Federation of Egyptian Industry in a scientific seminar held at INP in 2022. According to his announcement the unit production cost of natural gas is around 2.75 US dollar/ Million BTU in 2019/2020. Natural Gas unit production costs for the other studied years are estimated by adjusting the value of 2019/2020 using the annual inflation rates as shown in Table (8). The results show that the estimated values of natural gas unit production cost after considering inflation rates in Egypt are ranging between 1 US Dollar/ Million BTU and 2.75 US Dollar/ Million BTU.

While the international price and the production cost of natural gas are provided in British thermal unit (BTU), and natural gas production is available in tons, the standardization process is applied using the following conversion factor:

1 million tons oil equivalent = 39.6832 trillion BTU[1]

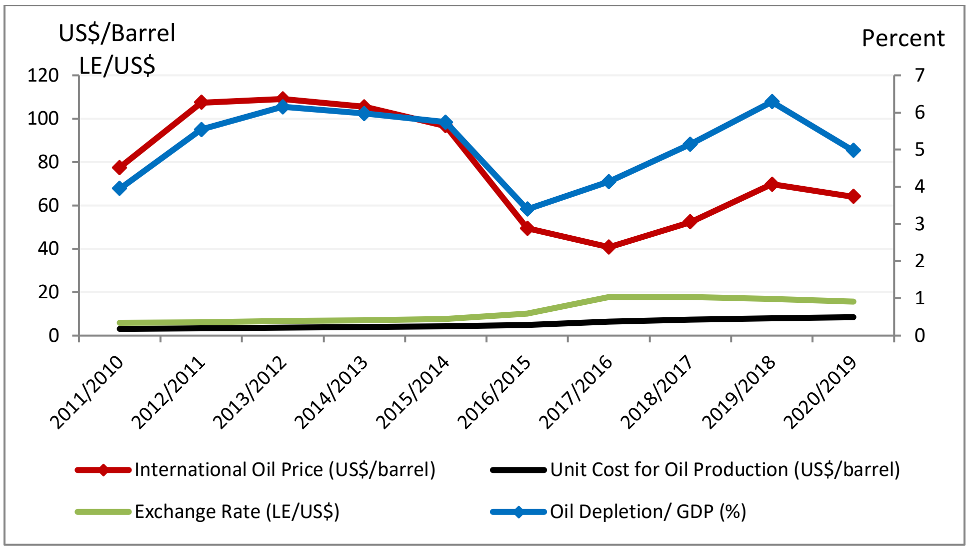


Figure 2: Trends of Factors Affecting Oil Depletion Costs
Sources: authors' calculation using data from Tables 7

a) Adjusting GDP in Egypt to Natural Gas Depletion

After obtaining the required data and standardization process, the final step is to apply the World Bank formula to estimate the value of natural gas depletion in Egypt. The results showed that, on average, the Egyptian economy has incurred about 10.3 billion US dollar as environment cost resulting from natural gas depletion, which is equivalent to about 94.4 billion LE between the year 2010/2011 and year 2019/2020.

The adjusted version of the Gross Domestic Product (GDP) of Egypt that accounts for natural gas depletion shows that GDP is overestimated by about 2.9% on average between the year 2010/2011 and year 2019/2020. The results above demonstrate that depletion of energy resources in Egypt from both crude oil and natural gas accounts for more than 7% of GDP. This means that Egypt is still heavily relying on nonrenewable fossil energy.

[1] OAPEC, Annual Statistical Report, available online at: https://oapecorg.org/

Table 8
Natural Gas production in Egypt

year	Inflation Rate (%)[a]	Unit Production Cost of Natural Gas (Dollar/MBTU)[b]	Natural Gas Production (Million tons)[c]	Natural Gas Production (Billion BTU)[d]	International Natural Gas Price (Dollar/MBTU)[e]
2011/2010	10.1	1.00	46.3	1837.9	7.7
2012/2011	7.1	1.07	46.1	1827.9	10.5
2013/2012	9.5	1.17	44.2	1754	10.7
2014/2013	10.1	1.29	39.2	1557	11.1
2015/2014	10.4	1.42	35.2	1396.8	10.1
2016/2015	13.8	1.62	31.3	1242.1	6.3
2017/2016	29.5	2.10	31.9	1265.9	4.7
2018/2017	14.4	2.40	41	1627	5.7
2019/2018	9.2	2.62	49.7	1971.2	7.3
2020/2019	5.0	2.75	47.5	1883.2	5.5

Sources: [a] CAPMAS, annual Statistical Yearbook, Different Issues. [b] Authors' calculation. [c] Annual statistical report, different issues, Ministry of Petroleum, in addition follow up reports, different issues, ministry of planning and economic development. [d] Authors' calculation based on conversion Factor 1 million tons oil equivalent = 39.6832 trillion BTU. [e] OAPEC, Annual Statistical Report, available online at: https://oapecorg.org/

Table 9
Natural Gas Depletion

Year	Conventional GDP (Billion LE)	Natural Gas Depletion (Billion LE)	Natural Gas Depletion/ GDP (%)
2011/2010	2845	73.01	2.6
2012/2011	2908	103.87	3.6
2013/2012	2972	114.76	3.9
2014/2013	3058	108.03	3.5
2015/2014	3192	93.11	2.9
2016/2015	3331	58.89	1.8
2017/2016	3470	59.38	1.7
2018/2017	3654	96.50	2.6
2019/2018	3858	154.84	4.0
2020/2019	3995	81.54	2.0
Average		94.39	2.9

Source: Authors' calculation

The costs of natural gas depletion seem to be influenced by all factors and not just by international prices, as the case of oil depletion (Figure 3). Similarly, to oil, the international prices of natural gas are likely to be the main influential factor in explaining fluctuations of natural gas depletion cost in Egypt.

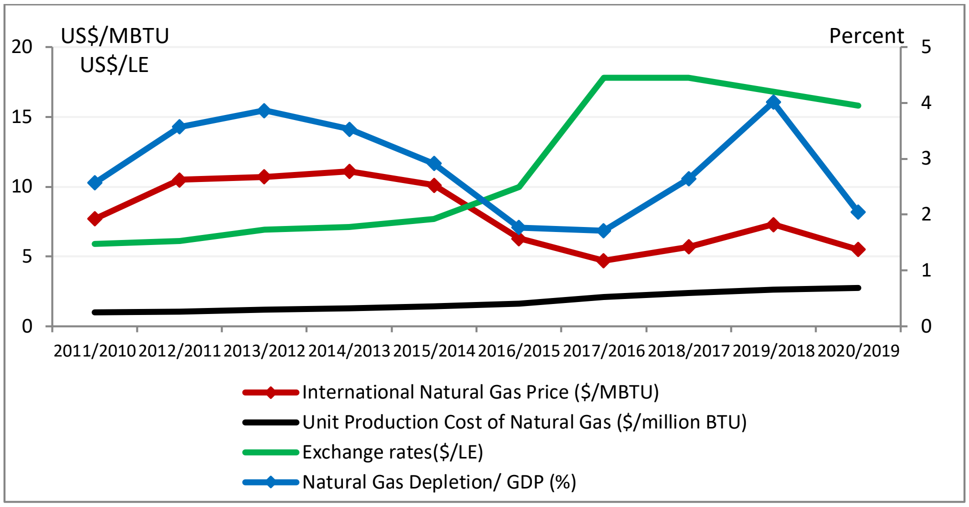


Figure 3: Trends of Factors Affecting Natural Gas Depletion Costs

Data Source: Central Bank of Egypt, **https://www.cbe.org.eg/**. Yearbook, Different Issues. International Natural Gas, Britain bulletin statistical review.

3.2.4. Comparison of Results of the Two Scenarios

Comparing the estimated value of total energy depletion based on the World Bank data, and the estimation using Egyptian local authorities data, showed that the estimated values vary between the two approaches. In more details, the decline in GDP due to the environmental adjustments to energy depletion using the World Bank data (4.25%) is lower than the decline when using data from local data sources in Egypt (8%) (Table 10).

Using local data in the second scenario results in higher energy depletion estimates as compared to the World Bank data during the same time period, except in the first year. Although the same methodology of the World Bank is applied in the second scenario, the varying results exhibited in both scenarios may be due to the variation in employed data especially inclusion of additional variables such as exchange rate and inflation rate. Moreover, variations of conventional GDP between the World Bank and the Ministry of Planning and Economic Development (MOPED) data may partly explain variations in energy depletion rates to GDP (Figure 4).

Table 10
Total Energy Depletion

Using Data from Local Sources				Using World Bank Data	
Year	GDP (Billion LE)	Total Energy Depletion (Billion LE)	Energy Depletion/ GDP (%)	Year	Energy Depletion/ GDP (%)
2011/2010	2844.75	185.51	6.5	2010	8.1
2012/2011	2908.08	265.07	9.1	2011	7
2013/2012	2971.63	297.56	10.0	2012	6.5
2014/2013	3058.28	290.73	9.5	2013	5.4
2015/2014	3191.99	276.31	8.7	2014	2.6
2016/2015	3330.73	171.99	5.2	2015	1.8
2017/2016	3470	203.18	5.9	2016	3.4
2018/2017	3654.4	284.4	7.8	2017	4.9
2019/2018	3857.5	397.34	10.3	2018	3.6
2020/2019	3995.2	280.14	7.0	2019	1.9

Source: authors' calculation

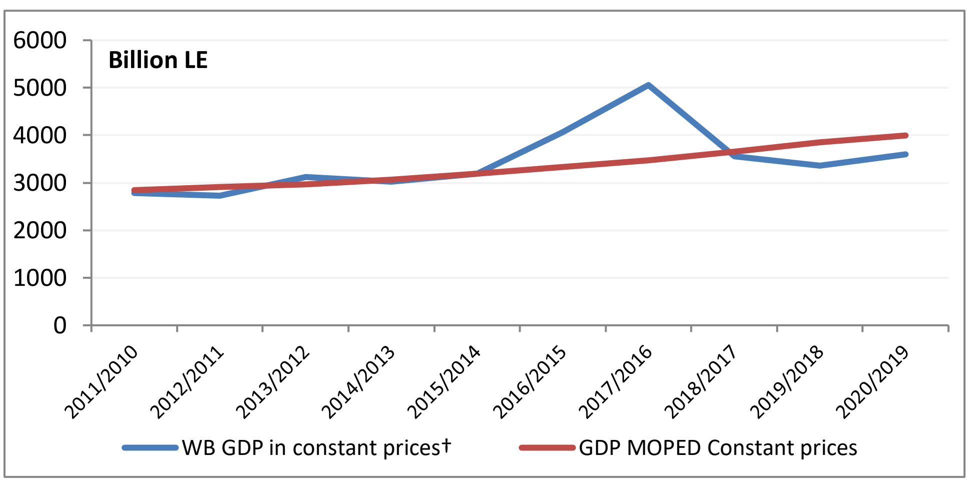


Figure 4: World Bank (WB) versus Ministry of Planning and Economic Development (MOPED) Gross Domestic Product (GDP)

Data Sources: World development Indicators (2021), and MOPED (2022)

†World Bank numbers were converted to LE by using exchange rates and converted to constant prices using GDP deflator computed from data of GDP in MOPED, and then converted to fiscal years by computing averages of each two successive calendar years.

The high magnitude of the adjustment demonstrated in both scenarios reflects the importance of incorporating the depreciation of natural resources and environmental degradation into the conventional indicators used to measure the country's economic activity, which reflects the importance of estimating the Green GDP.

3.2.5. Estimation of Costs of Pollution

<u>3.2.5.1</u> <u>Air pollution</u>

The major cause of environmental degradation in Egypt is air pollution. Six main pollutants are selected as indicators of the condition of ambient air quality in Egypt. According to the guidelines stated in the Egyptian environment law, these pollutants are Sulfur Dioxide (SO_2), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ozone(O_3), Particulate Matters (PM), and Lead (Arab Republic of Egypt, 1994). It should be noted that the World Health Organization (WHO) permissible limit for ambient air pollution differs from the limits set by the Egyptian Law which may call for a revision (WHO, 2006).

According to Egypt's State of Environment Reports, Particulate Matter (PM10 and PM2.5) are the only pollutants that exceeded the limit under the Egypt's Environment Law No (4) of 1994. The other pollutants are within the acceptable range. Therefore, the study will concentrate on the cost of Particulate Matters emission damage due to the wide range and the magnitude of its effect on Egyptians' health. The valuation approach will focus mainly on the impact cost of this pollutant on health.

Table 11
Air emission in Egypt

Pollutants	Monitoring stations	Result	
Sulphur Dioxide	51	The annual average in urban or industrial areas did not exceeding the legally defined maximum limit	
Nitrogen Dioxide	40	The annual average in urban or industrial areas did not exceeding the legally defined maximum limit	
Carbon Monoxide	8	The measurements recorded a relative compatible with the legally defined maximum limit in most of the observational periods.	
Ozone	11	The average measurements did not exceed the legally defined maximum limit	
Particulate Matter (PM10)	72	The annual average at Greater Cairo and the Delta exceeded the legally defined standard by nearly 71%.	
Particulate Matter (PM2.5)	26	The annual average exceeded the legally defined maximum limit by approximately 28%.	

Source: EEAA (2020)

The data required to apply the methodology of the World Bank consists of number of deaths in age group 25+ annually due to exposure to particulate matters. The vital statistics available in CAPMAS display the number of deaths due to different causes of death. Those data need to be adjusted according to Relative Risk function and Attributable Fraction. These parameters are not available, but the mortality rate due to exposure to particulate matters in Egypt can be obtained from the Global Health Data Exchange platform offered by the Institute for Health Metrics and Evaluation (Southerland et al., 2022) (Table 12).

The economic cost of exposure to Particulate Matter is estimated using income-based approach. According to this approach the economic cost is estimated as:

The average income * number of deaths due to exposure to Particulate Matter.

Average annual wage rate is used to represent the average income to calculate the economic cost.

Table 12
The estimated annual cost of health effects due to exposure to Particulate Matter (PM) in Egypt

Year	Mortality due to exposure to PM (person) †			Year	Average Annual Wage Rate	Estimated Mortality Due to Exposure to PM‡	Economic Cost of Exposure to PM‡
	Average Value	Upper	Lower				
2009	81067.58	93455.33	69388.58		**(LE)**	**(person)**	**(Million LE)**
2010	79445.74	91409.26	67841.89	2011/2010	25298	80428	2035
2011	81409.32	94024.61	69440.76	2012/2011	30550	82542	2522
2012	83675.61	96573.02	71300.18	2013/2012	36452	83747	3053
2014	83818.37	96853.11	71418.62	2014/2013	40742	83054	3384
2013	82289.84	94912.75	70001.1	2015/2014	44278	85521	3787
2015	88752.04	102829.7	75266.3	2016/2015	47814	88679	4240
2016	88605.34	106907.6	72283.52	2017/2016	51792	88013	4558
2017	87420.17	110698.6	67317.1	2018/2017	56004	88140	4936
2018	88859.09	113884.7	65707.55	2019/2018	62062	89746	5570
2019	90632.03	116904.9	66869.89	2020/2019	65644	91226	5988

Source: †The Global Health Data Exchange platform, https://ghdx.healthdata.org/. Based on the Southerland, et al. (2022). ‡Authors' calculation

3.2.5.2 Water Pollution

Impact of water pollution on health is measured in the same way as air pollution, i.e., in forgone income due to premature death arising from illness incurred by this pollution. Estimated deaths due to exposure to water pollution are shown in Table (13).

3.2.6. Green GDP Estimation in Egypt (2010/2011 – 2019/2020)

Taking into consideration all estimated environmental costs, which include energy depletion and costs of air and water pollution, Green GDP for Egypt can be calculated by deducting all environmental costs from conventional GDP. Results are displayed in Table (15).

Table 13

The estimated annual cost of health effects due to exposure to water pollution (WP) in Egypt

Year	Mortality due to exposure to WP (person) †			Year	Average Annual Wage Rate‡	Mortality Due to Exposure to WP‡	Cost of Exposure to WP‡
	Average Value	**Upper**	**Lower**				
2009	10837.29	15593.51	7034.86		**(LE)**	**(person)**	**(Million LE)**
2010	11311.55	16193.74	7576.587	2011/2010	25298	10937	277
2011	10563.41	15378.67	6949.958	2012/2011	30550	10437	319
2012	10309.99	14833.08	6750.621	2013/2012	36452	10301	375
2013	10291.78	14983.18	6691.233	2014/2013	40742	9896	403
2014	9499.725	14232.19	5956.409	2015/2014	44278	9177	406
2015	8854.521	13257.47	5600.358	2016/2015	47814	7933	379
2017	7012.177	10552.81	4268.806	2017/2016	51792	7382	382
2016	7752.364	11699.28	4800.729	2018/2017	56004	7048	395
2018	6343.118	9677.745	3710.302	2019/2018	62062	6083	378
2019	5823.332	8921.616	3346.51	2020/2019	65644	5684	373

Source: † The Global Health Data Exchange platform, https://ghdx.healthdata.org/. Based on the Southerland, et al. (2022). ‡Authors' calculation

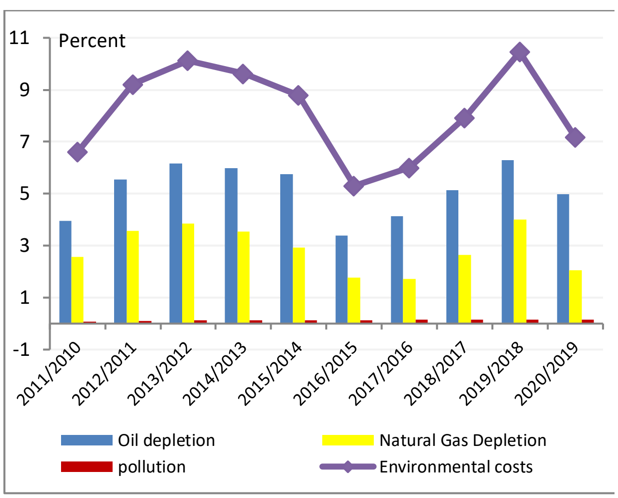
By applying the World Bank Method and using data from local sources to estimate Green GDP that accounts for energy depletion and pollution in Egypt, the results reveal that on average conventional GDP is overestimated by about 8.1% between the years 2010/2011 and 2019/2020 (Figure 4). Results obtained using local data are lower than the results obtained using the World

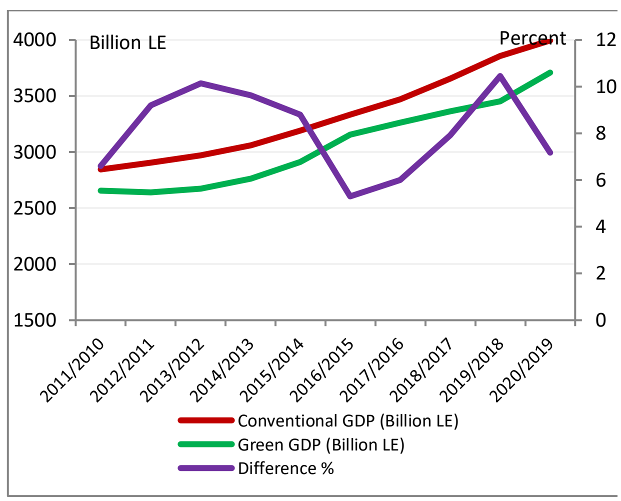
Bank data (about 10%). This difference arises from the exclusion of the costs of CO2 emissions and the disparity in the estimation of the cost of particulate matters.

Table 14
Conventional GDP and Estimated Green GDP

Year	Conventional GDP (Billion LE)	Oil depletion/ GDP (%)	Natural Gas Depletion/ GDP (%)	Cost of air pollution %GDP	Cost of water pollution %GDP	Green GDP (Billion LE)	Difference %
2011/2010	2844.75	4.0	2.6	0.07	0.01	2656.9	6.6
2012/2011	2908.08	5.5	3.6	0.09	0.01	2640.2	9.2
2013/2012	2971.63	6.2	3.9	0.10	0.01	2670.6	10.1
2014/2013	3058.28	6.0	3.5	0.11	0.01	2763.8	9.6
2015/2014	3191.99	5.7	2.9	0.12	0.01	2911.5	8.8
2016/2015	3330.73	3.4	1.8	0.13	0.01	3154.1	5.3
2017/2016	3470	4.1	1.7	0.13	0.01	3261.9	6.0
2018/2017	3654.4	5.1	2.6	0.14	0.01	3364.7	7.9
2019/2018	3857.5	6.3	4.0	0.14	0.01	3454.2	10.5
2020/2019	3995.2	5.0	2.0	0.15	0.01	3708.7	7.2
Average	-	5.1	0.0	0.12	0.01	-	8.1

Sources: Authors' Calculation





A. .. **B.**

Figure 5: Cost of Environmental Degradation and Trends of GDP and Green GDP

Source: Authors' Calculation

The results obtained by using data from local sources reveal the large environmental costs associated with energy depletion cost (Oil and Natural Gas), accounting for around 8% from GDP, which means that almost all environmental costs are related to energy depletion. This result should not be considered decisive given that the applied calculations did not include all environmental costs in Egypt, of which the most significant is the degradation of agricultural land. As shown previously in Table (2) cropland and pastureland constitute around 40% of natural resources in Egypt.

3.3. Third Scenario: Estimating Green GDP Adjusted to Energy Depletion and Pollution Costs and Carbon Dioxide Damage

According to Egyptian law of environment CO2 emissions in Egypt do not exceed the defined limits by the law. Taking into consideration the rising CO2 emissions concern worldwide and commitments to reduce it to zero level (Net-Zero-Emissions), it could be worthy to estimate environment costs of CO2 emissions in Egypt in context of the calculations of Green GDP. The World Bank Indicators include economic costs of damage due to CO2 emissions in Egypt. As previously mentioned, it is estimated at 20 dollars per metric ton of carbon (the unit damage in 1995 U.S. dollars) times the number of tons of carbon emitted. It is worth noting that some experts evaluate the social cost of carbon higher than 20 dollars (OECD 2021).

Table 15

Greenhouse Gases (GHG) Emissions in Egypt (equivalent to CO2 metric tons)

Sector	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Total including LUCF	351.9	345.0	338.6	325.6	318.3	312.1	306.3	309.4	298.6	289.7
Total excluding LUCF	351.7	344.8	338.4	325.4	317.3	311.1	305.4	308.4	297.7	289.9
Energy	260.7	257.5	249.3	235.2	229.7	224.4	219.2	221.0	211.4	205.0
Electricity/Heat	112.8	108.7	106.3	99.34	96.97	92.34	88.29	87.83	81.55	77.99
Transportation	55.27	55.19	57.06	58.77	56.3	54.86	52.61	52.11	47.88	45.89
Manufacturing/Construction	39.29	40.77	34.85	27.1	28.67	28.89	31.66	28.25	31.86	31.84
Fugitive Emissions	33.18	32.63	31.02	29.84	28.19	29.13	28.02	29.91	26.83	26.41
Agriculture	32.45	28.25	30.23	31.24	30.7	30.73	30.71	31.29	31.11	29.28
Industrial Processes	30.03	31.02	31.45	32.16	30.65	30.26	30.21	31.47	31.11	32.02
Waste	28.54	27.97	27.4	26.84	26.27	25.73	25.2	24.66	24.12	23.58
Building	17.42	17.5	17.24	17.15	16.74	16.26	15.86	15.76	15.97	15.75
Bunker Fuels	2.82	2.61	2.35	1.57	2.25	2.72	2.65	3.82	3.78	4.07
Other Fuel Combustion	2.71	2.7	2.88	3.02	2.9	2.96	2.84	7.18	7.33	7.18
Land-Use Change and Forestry	0.18	0.18	0.18	0.18	0.92	0.92	0.92	0.92	0.92	-0.17

Source: https://www.climatewatchdata.org/data-explorer/historical-emissions

3.3.1 Calculating the Costs of Carbon Dioxide Damage

In calculating the costs of CO2 damage in this third scenario the value of 20 dollars is applied. GHG emissions data in metric tons CO2 equivalent are extracted from the climate watch data explorer. The CAIT dataset, which covers all industries and gases, is chosen since it is the largest one available on Climate Watch. It does not use the official inventories that each country submitted to the UNFCCC to emphasize the comparability of data between countries. The timeframe is up to 2019 due to a 3-year lag in the dataset. Calculating the costs of CO2 damage, the total emissions including Land-Use Change and Forestry (LUCF) data are utilized.

Table 16

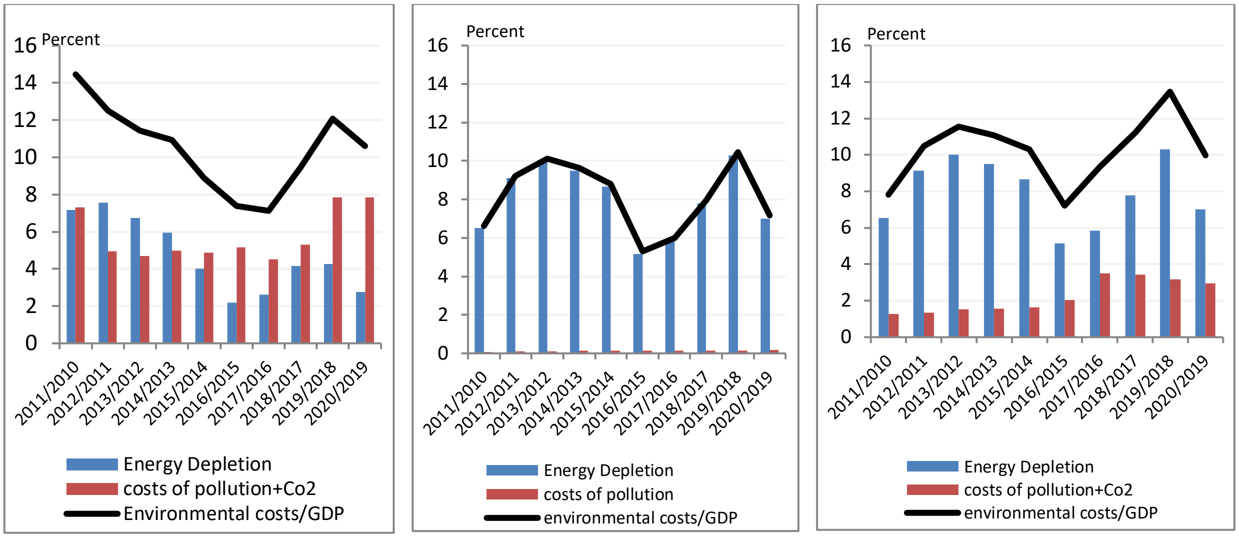
Environmental Costs Including Carbon Dioxide Damage and Corresponding Green GDP

Year	Conventional GDP (Billion LE)	Oil depletion/ GDP (%)	Natural Gas Depletion / GDP (%)	Cost of air pollution %GDP	Cost of water pollution %GDP	Co2 damage/GDP	Green GDP (Billion LE)	Diff-erence %
2011/2010	2844.75	3.95	2.57	0.07	0.01	1.20	2622.7	7.8
2012/2011	2908.08	5.54	3.57	0.09	0.01	1.25	2603.7	10.5
2013/2012	2971.63	6.15	3.86	0.10	0.01	1.42	2628.3	11.6
2014/2013	3058.28	5.97	3.53	0.11	0.01	1.44	2719.8	11.1
2015/2014	3191.99	5.74	2.92	0.12	0.01	1.51	2863.4	10.3
2016/2015	3330.73	3.40	1.77	0.13	0.01	1.91	3090.4	7.2
2017/2016	3470.00	4.14	1.71	0.13	0.01	3.34	3145.9	9.3
2018/2017	3654.40	5.14	2.64	0.14	0.01	3.30	3244.1	11.2
2019/2018	3857.50	6.29	4.01	0.14	0.01	3.01	3338.2	13.5
2020/2019	3995.20	4.97	2.04	0.15	0.01	2.78	3597.4	10.0
Average	-	5.1	0.029	0.12	0.01	2.12		10.2

Source: Author's calculations

The results show that adding CO2 damage to the environmental costs in the third scenario raises the cost of environmental degradation to an average of 10.2% of GDP (Table 16).

Comparing results of the three scenarios (Figures 6) reveals that environment degradation costs (pollution + CO2 damage) are undermined in scenarios depending on local data sources. The World Bank Indicators assign higher weights for pollution costs and CO2 damage compared to depletion of energy resources, which is not the case in the other two scenarios.

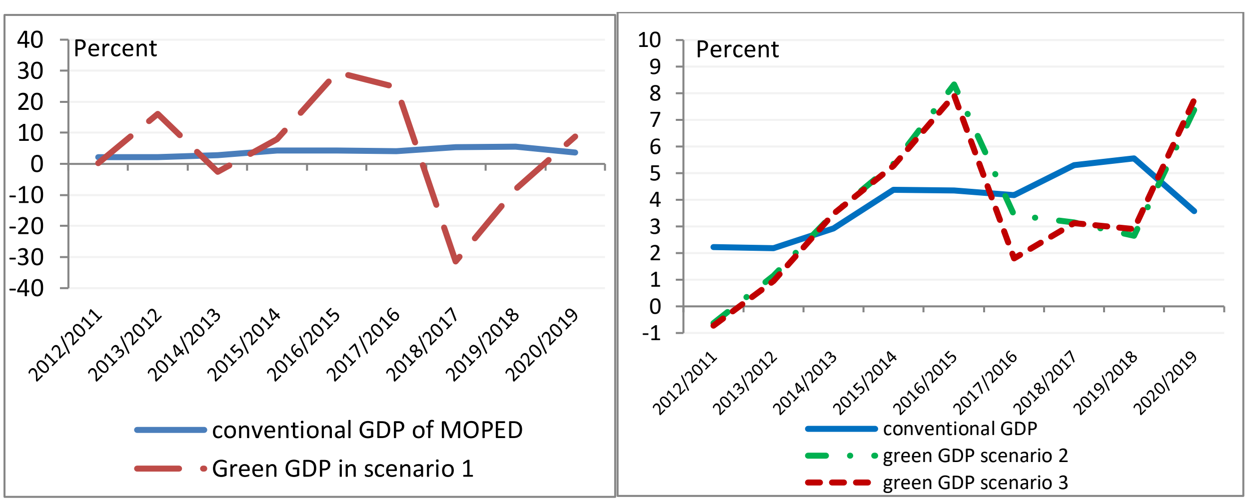


A. Scenario 1 B. Scenario 2 C. Scenario 3

Figure 6: Cost of Environmental Degradation as a Percentage of Egypt GDP

3.3.2 Growth Rates of Conventional GDP and Green GDP

Considering growth rates of Green GDP compared to conventional GDP, Figure (7) gives some insights. Green GDP growth rate, calculated using the World Bank data, is extremely fluctuating (Figure 7.A). It reflects fluctuating conventional GDP in the World Bank Indicators. The results also reveal that there is no consistent pattern of the Green GDP growth rate in both scenarios using local data (Figure 7.B). However, this is an expected outcome as the calculated Green GDP is totally dependent on fluctuating oil and natural gas prices.



A. Scenario 1 **B. Scenario 2 and 3**

Figure 7: Conventional GDP and Green GDP Growth Rates

Source: Authors' calculation

The negative growth rate of Green GDP in the year 2011/2012 is a reflection of the considerable increase in cost of oil depletion driven by a surge in oil prices to 107 dollar/barrel from 77 dollar/barrel in 2010/2011. During the period 2013/ 2014 to 2015/2016, the growth rate of Green GDP exceeded the growth rates of Conventional GDP. The main reason was the negative growth rate of energy depletion cost, which constitutes the largest share in total environmental cost. In contrast, the period 2016/2017 to 2018/2019 registered higher growth rates for conventional GDP compared to Green GDP due to the positive growth rate of energy depletion cost.

3.4. Methodology for Estimating the Costs of Agricultural Land Degradation in Egypt:

Estimation of the cost of agricultural land degradation in Egypt is of great importance, not only because of its high share in natural capital, but also because of the threats of climate change that can exert huge damages to agriculture, which is the main source of food. Shortage of data is a major obstacle to the estimation of this indicator.

Estimations of areas of degraded land in Egypt can be achieved through National Authority for Remote Sensing and Space Sciences and Desert Research Center. Through remote sensing they can observe and spot the changes in agricultural areas and magnitude of encroachment or degradation.

Using satellite images, it is depicted that during the 2011 revolution and later, large areas of agricultural land were encroached. It is estimated that during the period 2011-2018 around 84939 feddans were encroached (i.e., around 12000 feddans yearly).[1]

Estimation of the cost of soil depletion of the violated agricultural land requires information about the crops and/or animal husbandry that were produced in each of these areas, and the market values of these products (or rental value of each feddan as an alternative, that is not very adequate). This kind of data may be available in certain departments of the Ministry of Agriculture and Land Reclamation. Nonetheless, data are unpublished. Therefore, cooperation between CAPMAS, the Ministry of Agriculture and Land Reclamation and the Ministry of Planning and Economic Development as well as a team of experts is key to produce adequate estimations. Deducting the costs of agricultural land degradation in Egypt in Green GDP calculations will lead to further decrease in its value compared to conventional GDP.

3.5. Environmental Costs and Finance Gap

Natural resources are considered as capital assets and constitute a part of the wealth of the country. Therefore, depletion of natural resources must be replaced by investment in new assets, the same way as for consumption of fixed produced capital, to avoid reduction in the wealth stock.

[1] (https://m.akhbarelyom.com/news/newdetails/3832880/1/).

Investments for the recovery of environment degradation are vital to preserve the ecosystem and biodiversity.

The estimated amount of environmental costs indicates the financing requirements to recover these costs. Financing these investments depends on saving capacity of the country. Domestic saving should finance investment to create new capital assets to enhance economic growth, replacing consumption of fixed capital and replacing depletion of natural resources and environment degradation. Gross domestic saving rate in Egypt ranges between 3% and 13% from 2010/2011 to 2019/2020, with an average around 7% (Table 17). After considering requirements to replace capital depreciation, which is reflected in the rate of fixed capital consumption (about 6% on average), the average rate of net domestic saving is reduced to 1.3%, and in some years, it falls to negative rates.

Table 17
Domestic Saving Rate Compared to Environmental Costs

	Gross Domestic Saving Rate †	Consumption of Fixed Capital ‡ (% of GDP)	Net Domestic Saving Rate	Environmental Costs/GDP %
2011/2010	12.98	6.28	6.70	7.80
2012/2011	8.11	5.54	2.56	10.47
2013/2012	7.87	5.12	2.76	11.55
2014/2013	5.21	5.28	-0.06	11.07
2015/2014	5.81	5.25	0.56	10.29
2016/2015	5.48	5.67	-0.19	7.21
2017/2016	3.09	6.27	-3.19	9.34
2018/2017	6.20	6.12	0.08	11.23
2019/2018	9.73	6.07	3.66	13.46
2020/2019	6.19	6.22	-0.03	9.95
Average	**7.10**	**5.80**	**1.30**	**10.20**

Source: Author's calculations**,** †MOEPD, ‡https://databank.worldbank.org/source/world-development-indicators.

Results of the study show that the estimated environmental costs represent about 10.2% of GDP on average, which reveals the existing gap between gross domestic saving and environmental costs (Figure 8). The gap widens when considering the net domestic saving.

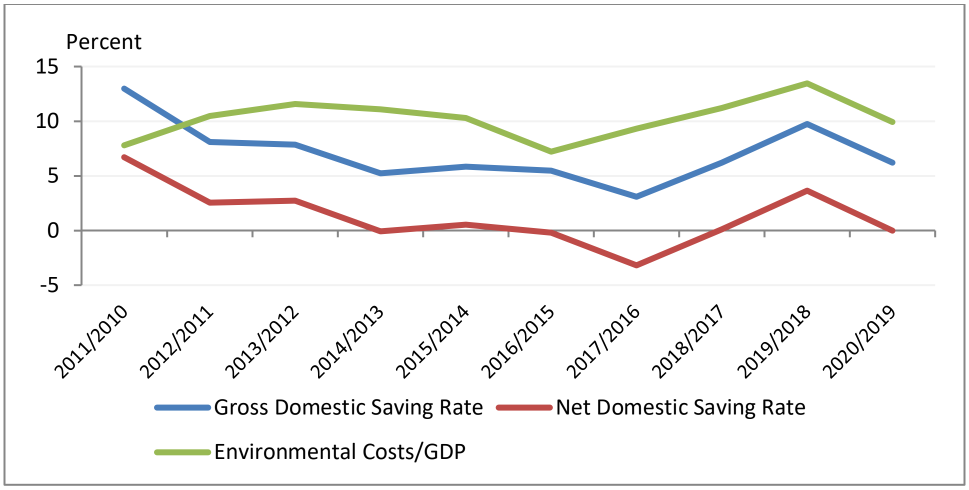


Figure 8: **Saving Gap**

Source: Author's calculations using data of Table 17.

This section of the study demonstrates the importance of the analysis of the availability of financing requirements to implement adequate policies and actions to ensure sustainability of growth process.

4. Interpretation of the Results and Policy Implications

4.1. Interpretation of the Results

The estimation results of the Green GDP in different scenarios reveal that thee cost of environmental degradation associated with economic growth process are substantial but not comprehensive. Shortage of data, and lack of practical methodologies for monetary evaluation impeded the inclusion of some relevant factors to the estimation such as cost of degradation of agricultural land and waste.

Three alternative scenarios are presented in the study. The first scenario is based on unexplained fluctuating GDP in the World Bank indicators, considerable differences are observed between GDP published by the Ministry of Planning and Economic Development, thus further investigation is called for. The second and third scenarios are based on data from local sources. Extensive data gaps are encountered and proxies are used. Carbon Dioxide damage is excluded in the second scenario based on the Egyptian Law of Environment, and the cost of environmental degradation took only Particulate Matter (PM2.5) and water pollution into consideration. The results of this scenario reveal that the costs of these two types of pollutants have almost no effect on total environmental costs, compared to that of energy resources depletion. The third scenario might be more appropriate as it considers costs of carbon dioxide damage and adopts the price of 20 dollars per metric ton, assigned by the World Bank. Adding the cost of carbon dioxide damage raises costs of pollution from about 0.12% of GDP in the second scenario to about 2.5% on average in the third scenario.

The costs of energy resources depletion are the same in the second and the third scenario (8% on average) and are higher than the costs estimated by the World Bank (4.7%). The latter shows declining trend in the last years, in contrast to estimations based on local data in spite of using the methodology of the World Bank. Including factors such as exchange rates and inflation rates in formulae based on local data may explain some of the divergence, along with wide variations in figures of GDP.

Sharp fluctuations of international oil and natural gas prices exert big impact on estimations of energy resources depletion and on Green GDP. This fact implies the importance of research on alternative methodologies for more accurate estimations. Affording required data may enable using methodology suggested in SEEA, which is based on data of gross operating surplus, consumption of fixed capital and normal rate of return on capital and other specific data related to taxes and subsidies.

In spite of all the above considerations that may cast doubt on accuracy of results obtained on Green GDP and its components of environmental costs, these results may be indicative about the magnitude of impact of economic activity on environment, and hence on sustainability of economic growth process. The analysis of the components of environmental costs, reflected in resources depletion and costs of different pollutants, are of great importance as they may point to relative weights of these components. This may be useful in deciding priorities of action and allocation of expenditures on improving and protecting the environment. Comparison of environmental costs and domestic saving reveals the level of available financing capacity and its impact on possibilities of implementing appropriate policies.

4.2. Policy Implications:

Green GDP may be used with other indicators to monitor the sustainability of the economic growth path, and the efficiency of natural resources management. This must be reflected in the process of policy making to define the appropriate decisions. Shortage of finance capacity is a major obstacle facing implementation of adequate policies to reduce environmental costs. This shortage will become deeper when considering the increase in economic costs attributed to expected climate changes.

Policies and actions for increasing domestic savings are needed, however economic crises due to pandemic of covid-19 and then the Russian-Ukrainian war and their ramifications would hamper these policies. External financial resources are urgent in condition to avoid increasing burden of external debt. Policies concerning data and developing expertise in the field of green accounting are important specially to enable the estimation of capacity to finance mitigation and adaptation measures to curb the expected climate change impacts.

Conclusions and Main Messages

- Green GDP is an important indicator for sustainable development. It should not be used as a single indicator, but in complementarity with other indicators in context of extended environmental accounting.
- Methodologies for estimating Green GDP are available in details in different sources, the main problem lies in monetary evaluation of environment variables that are usually measured in physical units.
- Available data in Egypt barely permit to calculate the depletion of energy resources, in spite of the lack of data on cost of production. As for pollution costs, data on air pollution are available as they can be collected from monitoring stations, but considering their health impacts detailed data on mortality and morbidity are incomplete. This call for more collaboration between CAPMAS and the Ministry of Health and Population to provide such data.
- To promote the development of a “green” economy, consideration of environmental parameters in the system of macroeconomic indicators should become mandatory, and should be a component of a balanced social, economic and political decision-making process, enhancing its integration with environmental policy.

- To ensure that Egypt is on the correct path of sustainable development, the appropriate indicator must be reliable and available for tracking progress. Limitations arise in estimating various types of pollution. There is still pollution in solid waste, chemicals, and hazardous waste, which are difficult to include in the calculation. More in depth research into the cost of depleting natural resources is required.
- The data task requires institutional strengthening and cooperation due to overlapping institutional roles and responsibilities. CAPMAS should work in close collaboration with a group of institutions including ministries of environment, petroleum, agriculture and health, in addition to research institutions.
- Green GDP indicator, initiated in 1993, is no longer used as single indicator to take into consideration the environmental costs associated with economic development process. Driven by development of accounting frameworks, specifically SEEA, and technologies to collect and process required data, a dashboard of a variety of indicators are suggested and implementing in increasing number of countries around the world. These indicators are designed to satisfy the needs of policy makers to be informed on the effective actions to be taken to sustainably manage the natural resources, to maintain ecosystem services and biodiversity, and avert impacts of climate change alongside with economic growth process. The production of such indicators requires considerable amount of data and statistical expertise.
- In the case of Egypt estimation of Green GDP should be considered as an exercise to gain experience in interpreting data on environment variables and analyzing their interconnections with economic variables. It may also help in defining data gaps required to produce a dashboard of more sophisticated indicators.
- Green GDP in Egypt can be directly estimated using the World Bank data. As depicted in the present study, partially available local data can be used to replace some of WDI data. An analysis of the results should be conducted and gaps in required data should be defined as well as measures to work on filling those gaps.
- A necessary step that should precede the task to produce indicators to monitor green growth and sustainability, is to implement the accounting framework SEEA. Implementation should be gradual. Starting with land, energy and water accounts is suggested. Analysis of physical data must be a starting point to define priorities and the path to go further in updated versions of SEEA Central Framework and then SEEA ecosystem services.
- Many developing and developed countries make use of the technical and the financial support of international institutions, such as the World Bank, UNEP, OECD, and the European Union. Projects and initiatives are acting in different countries; Egypt may communicate with these institutions and benefit from available technical and financial support.

- One of encouraging matters that may help in acquiring data and technical methodologies and models for measurement and estimations of variables and parameters is the increasing global sharing platforms for sharing knowledge, models and experiences in the area of estimating green growth indicators in its broader sense. Some of these platforms are initiated by UN and its related programs and agencies, such as UNEP Live Knowledge Platform launched to fill gaps between data Providers and consumers, Green Growth Knowledge Platform (GGKP), and ARIES for SEEA Ecosystem Accounting.

References

- ARIES (Artificial Intelligence for Environment & Sustainability) (2022). ARIES for SEEA: a web-based application for automatic yet fully transparent compilation of SEEA Ecosystem Accounts.
- Arab Republic of Egypt (1994). Environmental Law. Law 4/1994 and its Executive Regulations (ER).
- Climate Watch Data (2022). https://www.climatewatchdata.org/data-explorer/historical-emissions Visited on August 22th, 2022
- Daly, A. and P. Zannetti. (2007). An introduction to air pollution – definitions, classifications, and history. Chapter 1 of ambient air pollution (P. Zannetti, D. Al-Ajmi, and S. Al-Rashied, Editors). Published by The Arab School for Science and Technology (ASST) (http://www.arabschool.org.sy) and The EnviroComp Institute (http://www.envirocomp.org/).
- Dang, T. and Mourougane, A. (2014). Estimating Shadow Prices of Pollution in Selected OECD Countries. OECD Green Growth Papers, No. 2014–02, OECD Publishing, Paris.
- Dual Citizen (2022). The Global Green Economy Index (GGEI) https://dualcitizeninc.com/global-green-economy-index/ Visited on August 22th, 2022.
- EEAA (2020) Egypt's State of Environment Report 2019 [In Arabic] https://www.eeaa.gov.eg/portals/0/eeaaReports/SoE-2019/final%20EgyptSOE2019.pdf Visited on August 22th, 2022.
- ELD Initiative & UNEP (2015). The Economics of Land Degradation in Africa: Benefits of Action Outweigh the Costs. Available from www.eld-initiative.org.
- Filson Maratur Sidjabat, Asyifa Apsari, (2020). The Green GDP Implementation in Country-Based Environmental Management System: A Review, Serambi Engineering, Volume V, No. 4, October 2020.
- Islam and Asaad (2021). Forecasting GDP and Green GDP of South Asian Country for Sustainable Development. Himalayan Journal of Economics and Business Management | Volume 2, Issue 5, Oct. 10. https://himjournals.com/article/articleID=344
- Kirk Hamilton and Michael Clemens (1999). Genuine Savings Rates in Developing Countries. The World Bank Economic Review. Vol. 13, No. 2 (May, 1999), pp. 333-356. Published By: Oxford University Press.
- Kultida, et al. (2017). Thailand Green GDP assessment based on environmentally extended input-output model, Journal of Cleaner Production. Volume 167, 20 November 2017, Pages 970-977. https://doi.org/10.1016/j.jclepro.2017.02.106
- Li, V.; Lang, G. (2010). China's 'Green GDP' Experiment and the Struggle for Ecological Modernisation. Journal of Contemporary Asia, Vol. 40, No. 1, pp. 44-62.

- Listra, Andistya Oktaning, 2020, Evaluation of Green GDP Measurement in Indonesia Using Grey System Approach**.** Journal of Indonesian Applied Economics ISSN: 2541-5395 (ONLINE) Vol. 8, No. 1, February 2020, page. 24-31
- Larsen, Bjorn. 2019. Egypt: Cost of Environmental Degradation: Air and Water Pollution. The World Bank.
- MOPED (2022). https://mped.gov.eg/GrossDomestic?lang=en Visited on August 22th, 2022.
- NBS China 2021. Ecosystem Accounts for China. Results of the NCAVES Project.
- OECD 2014. Towards Green Growth: Monitoring Progress - OECD Indicators.
- OECD (2017), Green Growth Indicators 2017, OECD Green Growth Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264268586-en.
- OECD 2021. Effective Carbon Rates 2021 Pricing Carbon Emissions through Taxes and Emissions Trading. https://www.oecd-ilibrary.org/sites/0e8e24f5-en/index.html?itemId.
- Rauch, J.N; Chi, Y.F. (2010). The Plight of Green GDP in China**.** Consilience: The Journal of Sustainable Development, Vol. 3, No. 1, pp. 102-116.
- Samuelson, P.A.; Nordhaus, W.D. (2014). Should We ‘Green’ Gross Domestic Product? Environment and Energy Bulletin 6(2): 01-05.
- Saša et al. (2019) Green GDP: An Analyses for Developing and Developed Countries, DOI: 10.15240/tul/001/2019-4-001
- Saša, et al., (2017). A new approach to measuring Green GDP: a cross-country analysis**.** June 2017 Journal of Entrepreneurship and Sustainability Issues 4(4):574-590
- Science Communication Unit, University of the West of England, Bristol (2013). Science for Environment Policy in Depth Report: Resource Efficiency Indicators Report produced for the European Commission DG Environment, February 2013. Available at: http://ec.europa.eu/science-environment-policy.
- SEEA (2021). Global Assessment Results. System of Environmental Economic Accounting. https://seea.un.org/news/aries-seea-rapid-generation-natural-capital-accounts
- Shlapak & Veklych (2013) Green GDP as an Indicator of Environmental Cost of Economic Growth in Ukraine, Institute of Environmental Economy and Sustainable Development of National Academy of Science of Ukraine. https://archive.org/details/GreenGdpAsAnIndicatorOfEnvironmentalCostOfEconomicGrowthInUkraine/page/n7/mode/1up
- Sonthi, C., (2019) Concepts and empirical calculation of the Green GDP for Thailand, International Journal of Green Economics · January https://www.researchgate.net/publication/335134255
- Southerland, V. A et al. (2022). Global Urban Temporal Trends in fine particulate matter (PM2·5) and attributable health burdens: Estimates from Global Datasets. The Lancet Planetary Health, 6(2), e139–e146. https://doi.org/10.1016/s2542-5196(21)00350-8.

- The System of Environmental Economic Accounting (2012). United Nations.
- United Nations (2003). Integrated Environmental and Economic Accounting, Studies in Methods, Handbook of National Accounting. https://unstats.un.org/unsd/environment/seea2003.pdf
- United Nations (2014). System of Environmental- Economic Accounting 2012— Central Framework.
- United Nations (1993) Integrated Environmental and Economic Accounting, Interim Version, Department for Economic and Social Information and Policy Analysis, Statistical Division, United Nations, New York. https://seea.un.org/content/handbook-national-accounting-integrated-environmental-and-economic-accounting.
- United Nations (2022a). The Rise, Fall and Rethinking Green GDP. https://seea.un.org/news/rise-fall-and-rethinking-green-gdp. Visited on August 22th, 2022
- United Nations (2022b). UN Global Platform. https://unstats.un.org/bigdata/un-global-platform.cshtml Visited on August 22th, 2022
- United Nations (2022c). ARIES for SEEA. https://seea.un.org/content/aries-for-seea Visited on August 22th, 2022
- UNCCD 2014. 2014 World Day to Combat Desertification. https://www.unccd.int/events/other/2014-world-day-combat-desertification.
- US-Environmental Protection Agency. (2022, July 18). Particulate Matter (PM) Basics. US-EPA. Retrieved August 15, 2022, from https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#effects
- World Bank. 2021. The Changing Wealth of Nations 2021: Managing Assets for the Future. Washington, DC: World Bank. World Bank. https://openknowledge.worldbank.org/handle/10986/36400 License: CC BY 3.0 IGO."
- World Bank (2002). Manual for calculating adjusted net saving, Environmental Department.
- World Health Organization, 2006. WHO Air quality guidelines for Particulate matter, Ozone, Nitrogen dioxide and Sulfur dioxide, Global update 2005, Available at ⟨http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf⟩ (last access 28 September 2021).
- World Bank. (2021). World Development Indicators database. Available from https://databank.worldbank.org/source/world-development-indicators. Accessed July 2022.