ECONOMIC ENVIRONMENTAL EQUILIBRIUM

Creating an Innovative Digital Twin Model of the Global Ecosystem to Achieve Sustainable Growth at Equilibrium Point Using Predictive Analysis through Socio-tech Entrepreneurship and Exponential Synergistic Architecture

Ravikumar Gajbiye

Thakur Institute of Management Studies & Research, Mumbai, Maharashtra, India

Published November 2026

Abstract

This paper explores the feasibility impact of Digital Twins Technology of Industry 5.0 on the global economic-environmental ecosystem for achieving sustainable growth. The researcher proposes an innovative econometric model based on natural resource infrastructure using Predictive Analysis embedded in the human-focused, sustainability, and resiliency aspects of the fifth Industrial revolution. The research combines seamlessly the Socio-tech Entrepreneurship of Industry 4.0 and the Exponential Synergistic Architecture of Industry 5.0. The researcher additionally aims to propose a new indicator of economic growth for the world economy, introduce a wealth redistribution model for sustainable development, and emphasize the role of our nation, India, as a global leader for promoting inclusive growth for all the nations of the world in the New Industrial 5.0 era and beyond.

Keywords: Digital twins technology; econometric model; predictive analysis; socio-tech entrepreneurship; wealth redistribution model; Industry 5.0

1 Introduction

- Digital Twin Modelling
- Using Predictive Analysis
- Digital Twins Technology of Industry 5.0

1.1 Terminology used

- Economic-environmental ecosystem
- Sustainable growth
- Innovative econometric model based on natural resource infrastructure
- Predictive Analysis
- Fifth Industrial Revolution
- Socio-tech Entrepreneurship of Industry 4.0
- Exponential Synergistic Architecture of Industry 5.0
- New indicator of economic growth
- Wealth Redistribution Model (WRM)

- India, Global Economic Leader

1.2 Aim of the research

- Propose a new indicator of Economic Growth for the Global Economy
- Introduce a Wealth Redistribution Model for Sustainable Growth
- Emphasize the role of India as a Leader of Global Inclusive growth in the new Industrial Era.

1.3 Research questions

1. How to replace defunct GDP as an Economic Growth Indicator?
2. Why are Resource-rich nations economically poor?
3. Is the Statistical data of the World Economy reliable or accurate?
4. Have global organisations like the UNO and WB outlived their purpose?

1.4 Hypotheses and assumptions

- GDP is not a correct indicator of economic growth
- Sustainable growth requires Wealth redistribution
- Global economic leadership needs an Indian face
- Minerals are the DNA of Economic Activity.
- Common Price of Natural Resources prevents Economic downturns
- Minerals and agricultural products are common property of mankind
- Wealth created out of Economic activity is the common property of mankind

This research work explores the impact of Digital Twins Technology of Industry 5.0 on the global economic-environmental ecosystem for sustainable growth.

Three key pillars define Industry 5.0:

These are (1) human focus, (2) sustainability and (3) resiliency.

An econometric model based on resource infrastructure and the embedded intelligent upgrade for equipment is a Digital Twin's primary condition. Digital Twins can provide automated real-time process analysis between connected machines and data sources, speeding up error detection and correction.

In addition, Digital Twins can bring obvious efficiency improvements and cost. Digital Twins reflects its potential application value and subsequent potential value in Industry 5.0 in the Industrial X.0 era.

2 Research design

2.1 Type of research

It is an exploratory type of research using secondary data from panel data framework which makes it possible to allow for differences in the form of unobservable individual country effects and ability to control for individual heterogeneity. Panel studies are able to control for state and time-invariant variables. Method of sampling used is non-probability, judgment, convenience sampling.

2.2 Research flow plan

This study follows the guidelines proposed by Durach et al. (2017), Okoli and Schabram (2010), and Webster and Watson (2002) for a systematic literature review. According to Durach et al. (2017), the usual steps include "(1) defining the research question, (2) determining the required characteristics of primary studies, (3) retrieving a sample of potentially relevant literature, (4) selecting the pertinent literature, (5) synthesizing the literature, and (6) reporting the results" (Durach et al., 2017). Okoli and Schabram (2010) also suggest that the researchers train in literature search before starting the analysis, particularly when the work is done in parallel by multiple researchers, while Webster and Watson (2002) provide essential suggestions for structuring the study and conducting a concept-centric analysis.

The first stage (planning) defined our goal of understanding the role of DTs in the emerging needs of Industry 5.0, the literature survey, and the synthesis protocol by two reviewers.

Bibliometric network analysis preceded the second stage (selection) to identify relevant keywords and clusters in the main pillars of Industry 5.0.

In the selected context, human and technology dimensions are deeply intertwined. Among the several possible theoretical lenses for understanding the phenomena, strong structuration theory (Stones, 2005) stands out.

According to this theory, systems that include the behaviour of the actors at the micro (e.g., individual), meso (e.g., organization), and macro (e.g., country or region) levels, and structure (resources and rules that are used and created by humans) are inseparable (Giddens, 1984). Structures support society's actions and are shaped by the results of these actions.

More recently, strong structuration theory has appeared to clarify the duality of structure, providing a theoretically helpful lens for understanding technology developments, which have already been adopted in critical settings such as healthcare and management (Greenhalgh and Stones, 2010; Jack and Kholeif, 2007).

Stones (2005) posits that structure and patterns of action should be studied through hermeneutics, suggesting the identification of position-practice networks (ontology-in-situ) involving humans and non-human agents (e.g., technology).

Four main components must be addressed in studies adopting the theory, called the quadripartite nature of structuration:

1. external structures (forces that affect agents' behaviours independently of their will);
2. internal structures of agents (knowledge or agent roles);
3. active agency, referring to the types of actions performed; and
4. outcomes of actions, where structures can remain the same or change (Greenhalgh and Stones, 2010; Stones, 2005).

Figure 1 shows the use cases of digital twins in Industry 5.0.

Table 2
Use cases of DTs in Industry 5.0

I5.0 Pillar	Context	References
Human-centric	Human health and safety Work assistance and error reduction Training Fair decision making	Wang et al. (2022), Pang et al. (2023), Choi et al. (2022), Ruppert et al. (2022), Ignatius and Bahsoon (2023), Haoqi Wang et al. (2023b)
Sustainability	Environmental protection Energy optimization Waste reduction	Rios et al. (2023), Guruswamy et al. (2022), Choi et al. (2022)
Resilience	Health monitoring and disaster prevention Supply chain continuity Manufacturing flexibility Secure data storage	Rios et al. (2023), Choi et al. (2022), Minca et al. (2022), Zhang et al. (2021), Dewangan and Chandrakar (2023)

Figure 1. Use cases of digital twins in Industry 5.0.

2.3 Variables used in the research design

2.3.1 Factors of economic production used in the study

The four basic parameters that define a nation's economy are:

1. **Land:** As it remains constant, and produces resources to run the economy
2. **Population:** As a multiplicative factor being consumer base in economy.
3. **Agriculture (supra-soil asset base):** Satisfies basic need of hunger
4. **Minerals (sub-soil asset base):** Valuation necessary for trade of resources

2.3.2 Operationalisation of factors of production

(i)GDP: GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single-year official exchange rates.

Population: Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.

Note: Population of a nation is taken as a multiplicative factor as it adds up to the economic wealth of a nation by actively participating in the economic process as consumers/end-users.

Land area: Surface area is a country's total area, including areas under inland bodies of water and some coastal waterways.

Land Revenue: It is the sum of the sub-soil and supra-soil assets revenue base.

- Sub-soil asset base is the Mineral revenue.
- Supra-soil asset base is the Agriculture revenue

Agriculture Revenue: Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

Mineral Revenue: It is the revenue derived from the minerals in the soil, as a product of the quantity of that mineral extracted in a given year and its price.

Table 1 presents the list of primary variables and secondary (derived) factors.

Table 1. List of primary variables and secondary (derived) factors.

Primary factors	Secondary factors
1. GDP	1. Conversion Factor
2. Population	2. Common Pricing Mechanism
3. Agriculture Revenue	3. Wealth Redistribution Model
4. Mineral Output	4. Economic-Environmental Equilibrium Point

2.3.3 Relationships between variables/constructs used in the model

2.3.4 Explanation of the variables

Independent variables: the variables that decide the value of the dependent variable-

- Land revenue consisting of agriculture revenue and mineral revenue
- Population

Dependent variable: the variable whose value is to be calculated

UGNRP: economic potential based on valuation of natural resources

Intervening variable: Influences the independent variables affecting value of dependent variable.

SNA transparency is the level of accuracy and reliability of the economic accounting data at national level of aggregation

2.3.5 New economic concepts introduced in the research study

An economic indicator is a statistic about the economy (Moffatt, 2009). By studying the correlation between a developing country's GDP and its environmental quality, central concepts of environmental economics like market failures and externalities can be analysed.

GNRP (Gross Natural Resource Product): GNRP of a nation is the cumulative worth of all its resources. Mathematically it is the product of land revenue and a population factor.

UGDP (Universal Gross Domestic Product): It is the cumulative economic performance of all nations.

Normally, GDP (Gross Domestic Product) is the monetary value of all goods and services, including all private and public consumption, government outlays, investments and foreign trade in a country.

Mathematically, for any nation, GDP is given by Equation (1):

$$GDP = C + G + I + NX \quad (1)$$

Similarly, the cumulative actual economic worth (achieved performance) of all nations is proposed as Universal GDP.

Land Revenue: It is the sum total of the mineral revenue and agricultural revenue for a nation in a given time period (business cycle).

Mineral revenue: It is the valuation of the raw resources of economy based on a common price mechanism. It is an aggregation of the quantity of natural resource multiplied by its price.

UGNRP (Universal Gross Natural Resource Product): The Cumulative GNRP of the World is calculated at the beginning of the economic cycle of world trade. It is the sum of the GNRP of all the nations of the world.

Mathematically, UGNRP is represented by Equation (2):

$$GNRP_{cum} = GNRP_1 + GNRP_2 + GNRP_3 + \ldots + GNRP_n \quad (2)$$

where 1, 2, 3, …, n denote nation 1, nation 2, nation 3, …, nation n.

Note: The cumulative GNRP of the world (GNRPcumulative) is calculated at the beginning of the economic cycle.

3 Conceptual framework

The basic conceptual premise on which the research rests is:

Resource Utilization (Environmental Decline) must equal Economic Growth.

This section gives a brief idea of the working of the statistical methods utilized for arriving at the solutions proposed.

3.1 Solutions proposed in the research study

The innovative solutions proposed in the research are:

1. Concept of GNRP
2. Concepts of UGDP and UGNRP
3. Wealth Redistribution Model
4. Economic Environmental Equilibrium Point

3.2 Data compilation

- Data Collection Method:
- Sampling Method
- Sample Size
- Database of Nations
- Database of Minerals

3.3 Stages in the research working process

The research process is carried out in three stages:

- **Stage 1:** Define and Calculate GNRP
- **Stage 2:** Deriving Wealth Redistribution Model

- **Stage 3:** Forecasting the Equilibrium Point

3.4 Stage 1: define and calculate GNRP

3.4.1 Highlights of GNRP calculation

- Common Pricing of Minerals
- Conversion mechanism
- Production database of Minerals
- Economic worth of nations (mineral value)

This economic worth based on mineral valuation is the critical element in calculating the proposed Gross Natural Resource Product (GNRP)

3.4.2 Working for GNRP derivation

This is a simple two-step mechanism

Step 1: Land Revenue = Mineral Value + Agriculture Revenue

Step 2: GNRP = Land Revenue * Population factor (pop. in bn)

3.5 Stage 2: deriving the wealth redistribution model

3.5.1 Defining UGNRP, UGDP and excess wealth

- **UGNRP:** Expected cumulative wealth potential of all nations calculated at the beginning of the economic cycle, the sum of GNRP of all nations.
- **UGDP:** Cumulative economic wealth at the end of the economic cycle.
- Excess Wealth = GDP – mean UGDP.
- **Difference between UGNRP and UGDP:** (UGDP – UGNRP)
- **If positive:** Wealth redistribution is necessary
- **If negative:** Natural resource utilization is to be reduced
- **If zero:** The Economic-Environmental-Equilibrium Point.

3.5.2 Working principle behind the wealth redistribution model

The excess wealth for a nation is ploughed back into the economic potential valuation (UGNRP) of the successive business cycle until UGNRP equals UGDP, and there is no excess wealth created.

3.5.3 Operationalising the wealth redistribution model

The method to operationalize WRM is given below step-wise.

1. Check the difference between the GDP and the mean UGDP for a nation for a particular year for the nation/economy (GDP – mean UGDP).
2. If the difference is a positive value, the difference (excess GDP) is to be added to the GNRP of that nation in the subsequent year (INJECT).
3. If the difference is a negative value, no action is to be taken for subsequent year.
4. The addition of excess GDP to the GNRP of that nation to ensure excess wealth created is ploughed back into the nation's economy for the next year.

3.5.4 Logic behind the methodology

- This will inflate the nation's wealth and subsequently get added to the Common Wealth Pool (UGNRP) of the next year.
- This will ensure further disincentivization for unplanned and unwanted economic growth and ensure redistribution of created wealth.

3.6 Stage 3: forecasting the equilibrium point

This section involves Trend Analysis and Forecasting of the Equilibrium Point based on the forecasts for the year 2017 and 2022.

The process of forecasting is achieved in five steps:

1. Trend Analysis
2. Forecast Analysis
3. Projections based on forecast
4. Achieving zero difference
5. Interpretation of the Results

Step 1: Trend Analysis

Trend Analysis based on the forecast is graphically depicted using

- Moving Average Trend
- Linear trend

After adjusting for UGNRP (original) with the excess growth factor, the difference between UGNRP (Revised) and UGDP is seen to be reduced drastically over successive years. It may reach zero level of macro-constancy at equilibrium point if proper measures are taken.

Step 2: Forecast Analysis

1. The forecast value of GDP (nominal) for the years 2017 and 2022 are considered
2. Value of UGDP forecast is calculated for the given nations for 2017and 2022
3. Growth Rate for prediction values based on forecast is calculated
4. Using the growth rate, UGNRP is calculated for the year 2017 and 2022
5. Difference between forecast UGDP and derived UGNRP for 2017 is obtained
6. Difference between forecast UGDP and derived UGNRP for 2022 is obtained.

Note: The final aim of the research is to achieve zero difference between UGDP and UGNRP values, projected for the year 2022.

Step 3: Projections based on forecast

Graphically, the linear trend value for UGDP can be devised for the years 2018 to 2021. Accordingly, the UGNRP can be adjusted to reach zero difference.

Step 4: Achieving Zero difference

The target of "Zero difference" between UGNRP and UGDP can be achieved in two ways:

- **Method 1:** UGDP value in 2022 equals the UGNRP value
- **Method 2:** UGNRP in year 2022 must be equal to the planned UGDP value

Step 5: Interpretation of the Results/Conclusion

At this point, we can conclude that equilibrium point of sustainable growth has been achieved.

4 Statistical framework of research

This section gives a brief idea about the statistical methodology used in the derivation of the proposed new economic growth indicator, the wealth redistribution model methodology, and the process of arriving at the economic-environmental equilibrium point for sustainable growth.

4.1 Statistical methods used

1. Regression analysis is the method adopted to reflect correlation between GDP growth and various factors of production.
2. Correlation analysis is used for inferring correlation between GDP (dependent variable) and Land, Agriculture, Population, and Minerals (independent variables).

Note: The researcher has highlighted these methods in the research paper titled "Derivation of Constant UGDP using Econometric Models; Calculating Real GDP using Valuation of Key Natural Resources" and presented at the 4th IRC at IIM-Ahmedabad- 'ICADABAI- 2015 by the researcher.

1. Trend Analysis and Forecast Analysis are used for predicting the values of GDP for a 5-year period.
2. Simple mathematical calculations are used to deduce growth rate based on which proposed GNRP value is derived.

4.2 Summary of the wealth redistribution mechanism

1. At the initial evaluation of natural resources, the cumulative economic potential (UGNRP) is calculated.
2. UGNRP is compared with cumulative wealth generated (UGDP). If the two values are unequal, we conclude that there is economic disequilibrium.
3. The GDP of each nation is compared with mean UGDP. If the GDP is more than mean GDP, the difference is added to the GNRP of that nation in next business cycle.
4. The UGNRP is compared with UGDP in next cycle. The steps are repeated till the stage when both the values are equal. i.e. UGDP = UGNRP

This distribution ensures equal growth opportunity and optimizing usage of natural resources in the subsequent economic cycle, based on sufficing requirement for growth.

4.3 Statistical derivation of GNRP, UGNRP and UGDP

4.3.1 Part A: steps in calculating GNRP based on valuation of natural resources

1. Collating Mineral Output Data for nations
2. Finding the Common Price Index of each commodity
3. Extracting other economic data like Agriculture revenue and population
4. Final derivation of GNRP based on Land revenue and population factor

GNRP as an indicator of economic growth potential is defined principally to include the valuation of natural resources, mainly agriculture and mineral revenue.

4.3.2 Part B: derivation of UGNRP and UGDP

Nation is denoted by N, Land Revenue by L, agriculture revenue by A, mineral revenue by M.

Land revenue is the sum of Agriculture revenue and Mineral revenue.

Mineral Revenue (M1) for nation N1 is the sum of revenues derived from all minerals extracted.

For mineral ma, potential revenue derived is the product of quantity q of mineral ma and (common) price c of mineral ma. The total Mineral Revenue M1 of nation N1 is the sum of potential revenue of all its minerals m to mz.

Now:

The economic wealth potential of nation N_1 is the sum of A_1 and M_1 (Equation 3).

$$W_{N_1} = A_1 + M_1 \tag{3}$$

M_1 is the summation of revenues from minerals m_1 to m_m (Equation 4).

$$M_1 = \sum_{a=1}^{m} R_{m_a} \tag{4}$$

The revenue derived from mineral m_a is the product of q_a and c_a (Equation 5).

$$R_{m_a} = q_a \times c_a \tag{5}$$

Mineral revenue M_1 is therefore the sum of mineral revenue from m_1 to m_m (Equation 6).

$$M_1 = \sum_{a=1}^{m} q_a c_a \tag{6}$$

Total agriculture and mineral revenue is calculated as shown in Equation (7):

$$A_{\text{total}} = \sum_{i=1}^{n} A_i,\ M_{\text{total}} = \sum_{i=1}^{n} \sum_{j=1}^{m} m_{ij} \tag{7}$$

where *i* denotes nations and *j* minerals.

Total revenue potential (TRP) is the sum of A_{total} and M_{total} (Equation 8).

$$TRP = A_{\text{total}} + M_{\text{total}} \tag{8}$$

This is the underlying statistical derivation of UGNRP

Similarly, the concept of cumulative economic wealth created is calculated as the sum of the GDP of all nations. i.e. UGDP (Equation 9).

$$UGDP_{\text{total}} = \sum_{i=1}^{n} GDP_i \tag{9}$$

4.3.3 Part C: comparing achieved wealth with potential wealth

Let the GNRP of each nation be x1, x2, x3…. xn, respectively.

At the end of the business cycle, the value of the economic wealth achieved by each nation as a result of individual economic activity is the GDP of that nation.

Let the GDP of each nation be y1, y2, y3…. yn, respectively.

Mean UGDP is given by the division of UGDP by the number of participating nations.

Let this mean UGDP value be denoted by X.

On comparing the GDP value (yn) of each nation with the mean UGDP (X) we find three likely situations for that nation (y1):

1. y_1 is more than X ($y_1 > X$: surplus growth)
2. y_1 is less than X ($y_1 < X$: deficit growth)
3. y_1 is equal to X ($y_1 = X$: constant growth)

4.3.4 *Part D: actualising the economic-environmental equilibrium point*

Phase 1: Injection of Excess Growth into successive year's GNRP

If a nation achieves surplus growth, the excess amount of achieved wealth (y n - X) is ploughed back (injected) into the wealth potential (GNRP) of the nation in the next business cycle. If there is growth deficit, no action is taken.

Phase 2: Economic Excess Dis- incentivization

All the nations who have surplus growth (overachievers) will contribute more to the cumulative wealth potential UGNRP of next business cycle.

Phase 3: Break-even point of Economic-Environmental Equilibrium

Nations who achieve a higher economic wealth will ensure that fewer natural resources are used to reach level of equilibrium with their individual growth potential, thus ensuring sustainable growth through optimal resource utilization.

Underachieving nations (GDP less than mean UGDP) will by default ensure distribution of excess wealth created, creating an environment for sufficing growth instead of maximizing growth.

When there is constant growth for maximum nations for a consistent time period, it can be concluded that the Economic-Environmental Equilibrium point has been achieved.

4.4 Summary of the research methodology

This section has introduced the research strategy and the design of the research methodology.

The conceptual and strategic framework of the study is outlined for better understanding of the detailed working to follow.

5 Economic growth and environmental degradation

This section, presents a statistical analysis of the factors responsible for economic growth and environmental degradation and attempts to discover the most relevant economic and environmental factors for the purpose of the study.

The study sets to prove that environmental degradation is caused by economic growth using correlational analysis. Factor analysis and Principal Component Analysis (PCA) determine the factors that influence both economic and environmental aspects of the study.

5.1 Hypothesis formation

Hypothesis: Economic Development is responsible for Environmental Degradation

5.2 Methodology followed for hypothesis testing

To test the hypothesis that economic growth is the cause of environmental degradation, we use socio-economic database pertaining to the emerging economies in South Asia (SAARC nations), namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

Data type: Secondary data of the type one-time longitudinal time-series.

Table 2 presents the socio-economic variables used for SAARC nations.

Table 2. Socio-economic variables used for SAARC nations.

Variables	Description
Variables measuring Environmental Impact	Variables measuring Environmental Impact
Forest Cover	Percentage of Forest in Total Geographic area
RSPM Level	Average annual Respirable Suspended Particulate Matter
SO2 Level	Average annual SO2 emission (gm/m3)
NO2 Level	Average annual NO2 emission (gm/m3)
Explanatory Variables	Explanatory Variables
Population Size	Total Projected Population (in thousands)
Urbanization	Percentage of Urban Population in the Total
Population in Working Age	Percentage of Population in age Group 15-59
Population Density	Number of Persons per Sq. Km.
State GDP	Gross State Domestic Product at Current Prices (Rs in Crores)
Urban MPCE	Average Monthly Consumption Expenditure (Rs) per person for Urban Areas
Electricity Consumption	Gross Annual per Capita Consumption of Electricity
Mobile cellular subscription	Percentage of Urban Population in the Total

The database is appended below:

Table 3 presents the database of the socio-economic variables: SAARC nations.

Table 3. Database of the socio-economic variables: SAARC nations.

Description/ Country	Unit	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri-Lanka
Population	('000)	25985.6	153600 (2013)	745 (2014)	1210569 (2011)	331 (2012)	26494.5 (2011)	184350 (2012-13)	20483 (2013)
Population growth rate	(%)	2.03	1.36 (2011)	1.8 (2005)	1.8 (2011)	1.69 (2006)	1.35 (2011)	2.0 (2012-13)	0.9 (2012)

Description/ Country	Unit	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri-Lanka
Population density		37.5	1021 (2011)	19.4 (2014)	382 (2011)	1053 (2010)	180 (2011)	231 (2012-13)	327 (2013)
Sex ratio		104.7	100.3 (2011)	108.4 (2014)	106.07 (2011)	103 (2006)	94.2 (2011)	106.99 (2012-13)	94.3 (2013)
Crude Birth Rate)	CBR	NA	19.2 (2011)	18.5 (2012)	21.6 (2012)	22 (2010)	24.3 (2011)	26.8 (2012-13)	17.5 (2012)
Crude Death Rate	CDR	NA	5.5 (2011)	8.5 (2012)	7.0 (2012)	3 (2010)	8.3 (2006)	7 (2012-13)	6.0 (2012)
Total Fertility Rate	TFR	NA	2.1 (2011)	2.1 (2012)	2.4 (2012)	2.1 (2006)	2.6 (2006)	3.3 (2012-13)	2.3 (2006/07)
Life expectancy	Males, (Years)	NA	67.9 (2011)	67.3 (2013)	64.6 (2006-10)	73 (2012)	63.6 (2006)	64.6 (2012-13)	68.8 (2001)
GDP	(mn USD)	9600	73780	1120	1147740	1400	9740	129380	31500
Private Cons Exp	(% of GDP)	98.2 (2009)	75.15 (2012)	45.8 (2012)	57.1 (2012-13)	NA	76.41 (2012)	81.05 (2012-13)	66.8 (2013)
Private Cons Exp	(% of GDP)	98.2	75.15	45.8	57.1	NA	76.41	81.05	66.8
Private Cons Exp	(mn USD)	9427.2	55445.67	512.96	655359.54	#VALUE!	7442.334	104862.49	21042
		Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri-Lanka
GHG AND OTHER GASES	('000 tons CO2 equi)	20221.4	144666.95	989.25	1197470.175	0.8	38183.15	252057.7	11279.025
Ozone-depleting subs cons	gm/ 1000 GDP (2005 PPP $)	2.26	0.96	0.1	0.92	2.12	#DIV/0!	1	0.62

5.3 Statistical tools used to prove the hypothesis

Factor analysis and Principal Component Analysis (PCA) are used to arrive at key factors responsible for Environmental degradation in SAARC nations.

Table 4 presents the components of regression analysis.

Table 4. Components of regression analysis.

Component	Regressed with	Variables
Environmental Impact	Forest Cover	RSPM, SO2, NO2
Population	GDP	Size, Density, Working % age
Affluence	Population Size	GDP, Cons Exp., Electricity cons
Technology	GDP	Urbanization, Mobile subscription

5.4 SPSS output for FA and PCA: SAARC nations

SPSS output for the different variables, dependent as well as explanatory, gave an output which is tabulated below in the correlation matrix. Result of Factor Analysis, Regression, Correlation and Co-variance, along with Principal Component Analysis is presented.

5.4.1 Correlation matrix

Table 5 presents the correlation matrix of dependent vs explanatory variables.

Table 5. Correlation matrix of dependent vs explanatory variables.

Independent Variables	Pop Size	Pop Density	Wkng Popn	GDP	Cons Exp	Elect Cons	Urbansn	Mobile subs
Population Size	1							
Population Density	-0.008	1						
Working Population	-0.195	0.062	1					
GDP	0.997	-0.032	-0.190	1				
Consumption Expenditure	0.999	-0.031	-0.210	0.999	1			
Electricity Consumption	0.991	-0.062	-0.265	0.989	0.994	1		
Urbanization	0.142	0.363	-0.288	0.132	0.143	0.204	1	
Mobile subscription	-0.164	0.605	-0.169	-0.136	-0.146	-0.148	0.515	1
Dependent Variables	Dependent Variables	Dependent Variables						
Forest Cover	-0.066	-0.442	0.515	-0.035	-0.056	-0.075	-0.061	-0.222
RSPM Level	0.074	-0.326	-0.344	0.034	0.062	0.104	-0.267	-0.621
SO2 Level	-0.302	0.173	-0.443	-0.282	-0.297	-0.303	0.177	0.484
NO2 Level	1.000	-0.013	-0.188	0.999	0.999	0.990	0.144	-0.157

Note: Correlation is significant at the 0.01 level (2-tailed)

5.4.2 Result of principal component analysis

Extraction Method used is Principal Component Analysis. Rotation Method used is Varimax with Kaiser Normalization. Rotation is converged in 4 iterations.

Table 6 presents the SPSS output of principal component analysis.

Table 6. SPSS output of principal component analysis.

Component	Component	Percentage Variation
X11	Population Size	0.998
X22	Private Consumption Expenditure	0.996
X21	GDP	0.995
X23	Electricity Consumption	0.986

5.4.3 Result of regression model fit

- There is no model fit for Y1, Y2, Y3
- Only Y4 shows Model fit.

5.5 Inference

From principal component analysis

The First Component explains 51.26 % of the total variation in the data. Since the Eigen-Value of the first three components (4.10, 2.02, 1.01) is greater than 1, the first three components are used to calculate component score for each nation to determine its ranking in environmental degradation.

From correlation analysis

Population size has a strong impact on Environmental degradation.

There is strong correlation between GDP (economic growth indicator), and each of the factors: Consumer Expenditure (satisfaction), Electricity Consumed (urbanization) and NO2 levels (environmental degradation)

5.6 Conclusion of the hypothesis test

The factors to be considered for the research study based on the above results are: GDP and Population size.

5.7 Stage a: data collection

Source of data: Secondary data is used for statistical analysis of macroeconomic components of the various factors of economics from various sources. These are mentioned against each database.

Data Characteristics: The periodicity of data collection is annual. The unit of analysis (level of aggregation) is nation of the world. A one-shot longitudinal time series data is maintained for a time period from 2009 to 2013. The database related to GDP of the nations is utilized at a later stage to derive the Econometric Model and the Equilibrium Point of Economic growth and Environmental decline.

The characteristics of the data are presented below in tabular form

Table 7 presents the characteristics of data used for research study.

Table 7. Characteristics of data used for research study.

Type of data	Pooled cross-sectional and Time series data (Panel data)
Periodicity	Annual
Unit of Analysis	Nations (the level of aggregation of data)
Time Horizon	One shot/longitudinal time series
Variables (Objects)	Economic Growth potential of Nations of the World
Attributes/Characteristics	Land area, Population, Agriculture Revenue, Mineral Revenue (derived), GDP

5.7.1 Aggregation of data

Data is aggregated as a time-series data over different time periods ranging from 2009 to 2013. For any given year, the data for a group of nation (64 nations in aggregate) is used as cross-section data, while data for the same group for 64 nations over the time period of 5 years (in average) is used as panel data type.

Nations are included from different geographic areas: the five major continents of the world. The database of nations includes nations from all the various economic strata: Developed, developing as well as transient economies. These are indicated by the GDP factor over differing time periods. Thus, the data type used is multi-variate data varying over different geographic areas and different time periods.

A summary table of the data is presented below.

Table 8 presents the summary of data aggregation.

Table 8. Summary of data aggregation.

Over different Time periods	Time Series data
Group of Nations in one year	Cross –section data
Group of Nations over many years	Panel data
Multivariate data over several geographic areas	aggregate cross section data
developed, developing, transient economies	strata of nations
Multivariate data over time for all Universe	aggregate time series data

5.8 Stage b: sampling method

- The sampling method used is non-probability sampling.
- The samples used are convenience sample based on data availability.
- Judgment sampling is used for selecting nations having significant economic growth in relation to world GDP.

5.9 Stage c: database of economic parameters

The nation-wise database of different economic parameters used in the research study is collected and tabulated for ease of reference. These databases are used in further in the statistical derivation of the new economic parameters and models proposed in the research.

The databases collated relevant to this section of the study are as follows:

- i) Database of all the nations used as sample size for the study
- ii) Database of Minerals: nation-wise
- iii) Pricing of Minerals: commodity-wise
- iv) Production of Minerals: nation-wise

Table 9 presents the list of all nations of the world.

Table 9. List of all nations of the world.

Sr No	Country	Sr No	Country	Sr No	Country
1	Afghanistan	36	Canada	71	French Polynesia
2	Albania	37	Cayman Islands	72	Gabon
3	Algeria	38	Central African Rep	73	Gambia
4	Andorra	39	Chad	74	Georgia
5	Angola	40	Chile	75	Germany
6	Anguilla	41	China	76	Ghana
7	Antigua/	42	Hong Kong	77	Greece
8	Argentina	43	Colombia	78	Greenland
9	Armenia	44	Comoros	79	Grenada
10	Aruba	45	Congo	80	Guatemala
11	Australia	46	Cook Islands	81	Guinea
12	Austria	47	Costa Rica	82	Guinea-Bissau
13	Azerbaijan	48	Côte d'Ivoire	83	Guyana
14	Bahamas	49	Croatia	84	Haiti
15	Bahrain	50	Cuba	85	Honduras
16	Bangladesh	51	Curaçao	86	Hungary
17	Barbados	52	Cyprus	87	Iceland
18	Belarus	53	Czech Republic	88	India
19	Belgium	54	D.P.R. of Korea	89	Indonesia
20	Belize	55	D.R. of the Congo	90	Iran
21	Benin	56	Denmark	91	Iraq
22	Bermuda	57	Djibouti	92	Ireland
23	Bhutan	58	Dominica	93	Israel
24	Bolivia	59	Dominican Republic	94	Italy

Sr No	Country	Sr No	Country	Sr No	Country
25	Bosnia /Herzegovina	60	Ecuador	95	Jamaica
26	Botswana	61	Egypt	96	Japan
27	Brazil	62	El Salvador	97	Jordan
28	British Virgin Islands	63	Equatorial Guinea	98	Kazakhstan
29	Brunei Darussalam	64	Eritrea	99	Kenya
30	Bulgaria	65	Estonia	100	Kiribati
31	Burkina Faso	66	Ethiopia	101	Kosovo
32	Burundi	67	Fiji	102	Kuwait
33	Cabo Verde	68	Finland	103	Kyrgyzstan
34	Cambodia	69	Netherlands Antilles	104	Lao
35	Cameroon	70	France	105	Latvia
106	Lebanon	141	Oman	176	Sri Lanka
107	Lesotho	142	Pakistan	177	St. Vincent/Grenada
108	Liberia	143	Palau	178	State of Palestine
109	Libya	144	Panama	179	Sudan
110	Liechtenstein	145	Papua New Guinea	180	Suriname
111	Lithuania	146	Paraguay	181	Swaziland
112	Luxembourg	147	Peru	182	Sweden
113	Madagascar	148	Philippines	183	Switzerland
114	Malawi	149	Poland	184	Syria
115	Malaysia	150	Portugal	185	Tajikistan
116	Maldives	151	Puerto Rico	186	Macedonia
117	Mali	152	Qatar	187	Thailand
118	Malta	153	Republic of Korea	188	Timor-Leste
119	Marshall Isles	154	Republic of Moldova	189	Togo
120	Mauritania	155	Romania	190	Tonga
121	Mauritius	156	Russian Federation	191	Trinidad/Tobago
122	Mexico	157	Rwanda	192	Tunisia
123	Micronesia	158	Saint Kitts/Nevis	193	Turkey
124	Monaco	159	Saint Lucia	194	Turkmenistan
125	Mongolia	160	Samoa	195	Turks/Caicos Isles
126	Montenegro	161	San Marino	196	Tuvalu
127	Montserrat	162	Sao Tome/Principe	197	U.R. of Tanzania
128	Morocco	163	Saudi Arabia	198	Uganda
129	Mozambique	164	Senegal	199	Ukraine
130	Myanmar	165	Serbia	200	United Arab Emirates

Sr No	Country	Sr No	Country	Sr No	Country
131	Namibia	166	Seychelles	201	United Kingdom
132	Nauru	167	Sierra Leone	202	United States
133	Nepal	168	Singapore	203	Uruguay
134	Netherlands	169	Sint Maarten	204	Uzbekistan
135	New Caledonia	170	Slovakia	205	Vanuatu
136	New Zealand	171	Slovenia	206	Venezuela
137	Nicaragua	172	Solomon Islands	207	Viet Nam
138	Niger	173	Somalia	208	Yemen
139	Nigeria	174	South Africa	209	Zambia
140	Norway	175	Spain	210	Zanzibar
				211	Zimbabwe

Table 10 presents the list of 191 nations used in the research study.

Table 10. List of 191 nations used in the research study.

Rank	Economy	GDP	Rank	Economy	GDP	Rank	Economy	GDP
1	United States	19,417.14	33	Hong Kong	332.266	65	Ukraine	95.934
2	China	11,795.30	34	Philippines	329.716	66	Slovak Rep	89.134
3	Japan	4,841.22	35	South Africa	317.568	67	Sri Lanka	84.023
4	Germany	3,423.29	36	Malaysia	309.86	68	Ethiopia	78.384
5	United Kingdom	2,496.76	37	Colombia	306.439	69	Dominican Rep	76.85
6	India	2,454.46	38	Denmark	304.216	70	Kenya	75.099
7	France	2,420.44	39	Ireland	294.193	71	Myanmar	72.368
8	Brazil	2,140.94	40	Egypt	294.109	72	Oman	71.325
9	Italy	1,807.43	41	Singapore	291.86	73	Guatemala	70.943
10	Canada	1,600.27	42	Venezuela	251.589	74	Uzbekistan	68.324
11	Russia	1,560.71	43	Pakistan	251.487	75	Luxembourg	59.997
12	Korea	1,498.07	44	Chile	251.22	76	Costa Rica	59.796
13	Australia	1,359.72	45	Bangladesh	248.853	77	Panama	59.486
14	Spain	1,232.44	46	Finland	234.524	78	Uruguay	58.123
15	Indonesia	1,020.52	47	Vietnam	215.829	79	Belarus	54.689
16	Mexico	987.303	48	Peru	207.072	80	Libya	54.411
17	Turkey	793.698	49	Portugal	202.77	81	Lebanon	53.915
18	Netherlands	762.694	50	New Zealand	198.043	82	Bulgaria	52.291
19	Saudi Arabia	707.379	51	Czech Rep	196.068	83	Tanzania	51.194
20	Switzerland	659.368	52	Greece	193.1	84	Croatia	50.084

Rank	Economy	GDP	Rank	Economy	GDP	Rank	Economy	GDP
21	Argentina	628.935	53	Romania	189.79	85	Macao SAR	45.728
22	Taiwan	566.757	54	Iraq	189.432	86	Slovenia	43.503
23	Sweden	507.046	55	Algeria	173.947	87	Lithuania	42.826
24	Poland	482.92	56	Qatar	173.649	88	Ghana	42.753
25	Belgium	462.715	57	Kazakhstan	157.878	89	Turkmenistan	42.355
26	Thailand	432.898	58	Kuwait	126.971	90	Congo	41.098
27	UAE	407.21	59	Hungary	125.297	91	Jordan	40.506
28	Nigeria	400.621	60	Angola	122.365	92	Tunisia	40.289
29	Norway	391.959	61	Sudan	115.874	93	Bolivia	39.267
30	Austria	383.509	62	Morocco	105.623	94	Azerbaijan	38.583
31	Iran	368.488	63	Puerto Rico	99.727	95	Serbia	37.739
32	Israel	339.99	64	Ecuador	97.362	96	Côte d'Ivoire	36.873
97	Bahrain	34.31	129	Eq. Guinea	11.686	161	Burundi	3.384
98	Cameroon	29.547	130	Mozambique	11.17	162	Timor-Leste	2.727
99	Paraguay	28.743	131	Malta	11.164	163	Lesotho	2.439
100	Latvia	27.795	132	Macedonia	10.951	164	Bhutan	2.308
101	El Salvador	27.548	133	Armenia	10.741	165	Liberia	2.215
102	Yemen	27.189	134	Madagascar	10.372	166	Djibouti	2.088
103	Uganda	27.174	135	Mongolia	10.271	167	C. African Rep.	1.992
104	Estonia	23.422	136	Chad	9.636	168	Belize	1.829
105	Nepal	23.316	137	Bahamas	9.172	169	Cabo Verde	1.637
106	Zambia	23.137	138	Rwanda	8.918	170	San Marino	1.551
107	Iceland	22.97	139	Benin	8.792	171	Seychelles	1.475
108	Honduras	21.79	140	Rep. of Congo	8.341	172	Antigua/Barbuda	1.454
109	Trinidad/Tobago	21.748	141	Haiti	7.897	173	St. Lucia	1.428
110	Papua Guinea	21.189	142	Niger	7.674	174	Solomon Islands	1.245
111	Cambodia	20.953	143	Moldova	7.409	175	Guinea-Bissau	1.166
112	Afghanistan	20.57	144	Tajikistan	7.242	176	Grenada	1.089
113	Cyprus	19.648	145	Guinea	6.936	177	The Gambia	1.041
114	Bosnia	16.78	146	Kyrgyz Rep.	6.854	178	St. Kitts/Nevis	0.951
115	Botswana	15.564	147	Kosovo	6.809	179	Samoa	0.843
116	Senegal	15.431	148	Malawi	6.182	180	Vanuatu	0.829
117	Zimbabwe	15.285	149	Eritrea	6.051	181	St. Vincent	0.809
118	Lao P.D.R.	14.971	150	Mauritania	5.063	182	Comoros	0.654
119	Mali	14.344	151	Fiji	4.869	183	Dominica	0.539
120	Jamaica	14.272	152	South Sudan	4.812	184	Tonga	0.422

Rank	Economy	GDP	Rank	Economy	GDP	Rank	Economy	GDP
121	Gabon	14.208	153	Barbados	4.759	185	São Tomé	0.355
122	Nicaragua	13.748	154	Togo	4.554	186	Micronesia	0.334
123	Georgia	13.723	155	Montenegro	4.185	187	Palau	0.315
124	Brunei Darussalam	12.326	156	Sierra Leone	4.088	188	Marshall Isles	0.188
125	Albania	12.294	157	Swaziland	3.938	189	Kiribati	0.173
126	Burkina Faso	12.258	158	Suriname	3.641	190	Nauru	0.114
127	Mauritius	12.245	159	Guyana	3.591	191	Tuvalu	0.036
128	Namibia	11.765	160	Maldives	3.578	192	Syria	-

Note: GDP is the Nominal GDP projected for 2017 (USD billion). Source: - StatisticsTimes.com

Sample Size of Nations used for the Research Study: The sample size of nations selected for the research study is based on the contribution of that nation to a projected value world GDP.

The top five economies account for 53.82 %, the top ten accounts for approx. 67.19 %, and the top 20 economies add up to over 80% of World GDP.

Out of the universal sample size of 191 nations (economies), the first 64 nations account for 95.63 % of the World GDP (US$77.99 trillion in 2017).

Table 11 presents the world GDP and share of top 64 nations (year 2017).

Table 11. World GDP and share of top 64 nations (year 2017).

Aggregate Economy Unit	Cumulative GDP (USD bn)	Percentage of World GDP
TOP 64 nations	74,577	95.63 %
World GDP	77,988	

Source: IMF Statistics.com

Database of Sample size of nations: 64 nations sample size are tabulated below:

Table 12 presents the research sample size of 64 nations.

Table 12. Research sample size of 64 nations.

SN	Country/Economy	SN	Country/Economy	SN	Country/Economy
1	United States	23	Sweden	45	Finland
2	China	24	Poland	46	Vietnam
3	Japan	25	Belgium	47	Peru
4	Germany	26	Thailand	48	Portugal
5	United Kingdom	27	United Arab Emirates	49	New Zealand
6	India	28	Nigeria	50	Czech Republic
7	France	29	Norway	51	Greece
8	Brazil	30	Austria	52	Romania

SN	Country/Economy	SN	Country/Economy	SN	Country/Economy
9	Italy	31	Iran	53	Iraq
10	Canada	32	Israel	54	Algeria
11	Russia	33	Philippines	55	Qatar
12	Korea	34	South Africa	56	Kazakhstan
13	Australia	35	Malaysia	57	Kuwait
14	Spain	36	Colombia	58	Hungary
15	Indonesia	37	Denmark	59	Kenya
16	Mexico	38	Ireland	60	Luxembourg
17	Turkey	39	Egypt	61	Tanzania
18	Netherlands	40	Venezuela	62	Bahrain
19	Saudi Arabia	41	Pakistan	63	Zimbabwe
20	Switzerland	42	Chile	64	Central African Republic
21	Argentina	43	Bangladesh		
22	Taiwan Province of China	44	Central America		

Important point to note

It is highly interesting to note that the IMF, an internationally recognized institute, utilizes the term Gross World Product, which is quite similar to the new concept of Universal Gross Domestic Product (UGDP) proposed in this research.

Table 13 presents the database of the minerals used in the research study.

Table 13. Database of the minerals used in the research study.

S. No.	Commodity	S. No.	Commodity	S. No.	Commodity
1	Abrasives	41	Calcareous	81	Ferronickel magnesium
2	Acid Clay	42	Calcite	82	Ferroniobium
3	Agate	43	Calcium carbonate	83	Ferrophosphorus
4	Aggregates	44	Carbon	84	Ferrosilicon
5	Alabaster	45	Caustic Soda	85	Ferrovanadium
6	Alexandrite	46	Cement	86	Fire Clay
7	Alginate (sodium)	47	Chalk	87	Flagstone
8	Alumina	48	Chromite	88	Fluorspar
9	Aluminum	49	Clay	89	Fuel oil
10	Amethyst	50	Clinker	90	Fuller's Earth
11	Ammonia	51	Coal	91	Gabbro (Dim. stone)
12	Amphibolite (feldspar)	52	Cobalt	92	Gallium
13	Andalusite	53	Coke, metallurgical	93	Garnet

S. No.	Commodity	S. No.	Commodity	S. No.	Commodity
14	Anthracite Coal	54	Construction sand	94	Gas Oil
15	Antimony	55	Copper	95	Gasoline
16	Apatite (Phosphate rock)	56	Copper sulfate	96	Gemstones
17	Aquamarine	57	Coquina	97	Gemstones Crude
18	Aromatic Tar	58	Cordierite, Iolite	98	Geniss (feldspar)
19	Arsenic	59	Crude Oil	99	Germanium
20	Asbestos	60	Crushed/broken Stone	100	Glauberite
21	Asphalt	61	Cyclohexane	101	Gold
22	Attapulgite clay	62	Diamond	102	Granite
23	Avigas	63	Diaspore	103	Graphite
24	Ball (Clay)	64	Diatomite	104	Gravel
25	Barite	65	Diesel	105	Greywacke (sandstone)
26	Basalt	66	Dimension stone	106	Guano
27	Bauxite	67	Distillate fuel oil	107	Gypsum
28	Bentonite	68	Dolomite	108	Helium
29	Beryllium	69	Dunite	109	Igneous rock
30	Biotite	70	Electrolytic, cathode4	110	Ilmenite
31	Bismuth	71	Emerald	111	Indium
32	Bitumen fuel	72	Ethane	112	Iodine
33	Bituminous Coal	73	Fe content	113	Iolite
34	Blister Copper	74	Feldspar	114	Iridium
35	Boron	75	Felsite	115	Iron
36	Brine, salt	76	Ferro Titanium	116	Iron Oxide pigments
37	Briquets (Peat)	77	Ferrochromium	117	Jadeite
38	Bromine	78	Ferrochromium silicon	118	Jasper
39	Butane	79	Ferromanganese	119	Kaolin
40	Cadmium	80	Ferromolybdenum	120	Kerosene and jet fuel
121	Kyanite	161	Phosphate rock	201	Silica
122	Lead	162	Phosphatic Fertilizer	202	Siliceous earth
123	Leonardite	163	Phosphoric acid	203	Silicomanganese
124	Leucoxene	164	Phosphorite	204	Silicon
125	Lignite	165	Pig iron	205	Sillimanite
126	Lime	166	Pigments, Iron oxide	206	Silver
127	Limestone	167	Platinum	207	Slate
128	Liquefied petroleum gas	168	Porphyry	208	Soda ash
129	Lithium	169	Potash	209	Sodium Sulfate (mirabilite)

S. No.	Commodity	S. No.	Commodity	S. No.	Commodity
130	Lubricants	170	Potassium Nitrate	210	Solvent (Toluene)
131	Magnesite	171	Pottery Clay	211	Sponge iron
132	Magnesium	172	Pozzolan	212	Steatite
133	Manganese	173	Propane	213	Steel, crude
134	Marble	174	Pumice, pumicite	214	Stone
135	Marl (lime)	175	Pyrite	215	Strontium
136	Mercury	176	Pyrochlore (niobium)	216	Sulfur
137	Methanol	177	Pyrope	217	Sulfuric acid
138	Mica	178	Pyrophyllite (Talc)	218	Talc
139	Moldavite	179	Pyroxenite	219	Tantalum
140	Moler (Diatomite)	180	Quartz and quartzite	220	Tanzanite
141	Molybdenum	181	Rare-earths	221	Tellurium
142	Monazite	182	Refinery gas	222	Tin
143	Naphtha	183	Residual fuel oil	223	Titanium, slag
144	Natural Gas	184	Rhenium	224	Topaz
145	Natural gas liquid	185	Rhodium	225	Tourmaline
146	Nepheline syenite (feldspar)	186	Rhodochrosite	226	Travertine (limestone)
147	Nickel	187	Rock salt	227	Tuff
148	Niobium	188	Ruby	228	Tungsten
149	Nitrogen	189	Ruthenium	229	Ulexite
150	Obsidian	190	Rutile	230	Uranium
151	Olivine	191	Salable crude	231	Vanadium
152	Onyx	192	Salt	232	Vermiculite
153	Palladium	193	Sandstone	233	Volcanic sand
154	Paludal mud (clay)	194	Sapphire	234	White clay (kaolin)
155	Paraffin wax	195	Schist	235	Wollastonite
156	Peat	196	Selenite	236	Zeolite
157	Pentane	197	Selenium	237	Zinc
158	Perlite	198	Sepiolite clay	238	Zirconium
159	Petroleum Crude	199	Serpentine		
160	Petroleum Refinery	200	Shale		

Table 14 presents the classification of the minerals and metals.

Table 14. Classification of the minerals and metals.

Iron and Ferro-Alloy Metals	Non-Ferrous Metals	Precious Metals	Industrial Minerals	Mineral Fuels
Iron	Aluminum	Gold	Asbestos	Anthracite
Chromium	Antimony	Palladium	Baryte	Bituminous coal
Cobalt	Arsenic	Platinum	Bentonite	Coking coal
Manganese	Bauxite	Rhodium	Boron	Lignite
Molybdenum	Bismuth	Silver	Diamond	Natural Gas
Nickel	Cadmium		Diatomite	Crude Petroleum
Niobium	Copper		Feldspar	Oil Sands
Tantalum	Gallium		Fluorspar	Oil Shales
Titanium	Germanium		Graphite	Uranium
Tungsten	Lead		Gypsum	
Vanadium	Lithium		Anhydrite	
	Mercury		Kaolin	
	Rare Earth Minerals		Magnesite	
	Rhenium		Perlite	
	Selenium		Phosphates	
	Tellurium		Potash	
	Tin		Salt	
	Zinc		Sulfur	
			Talc	
			Vermiculite	
			Zircon	

5.10 Database of mineral prices based on the common price mechanism

The database of mineral prices based on a "Common Price mechanism" can be achieved in two different ways as described below:

5.10.1 Method 1: average annual price of commodity

In this method, the average of prices from annual price database for a pre-determined time horizon is considered. The basis for establishing the common price of most of the minerals used in the research is the pricing structure sourced from USGS: Mineral Commodity Summaries, Jan 2017 database.

The price per unit by weight of the commodity for the time horizon 2012 to 2016 is considered. The average price for this 5-year time period is considered as base price for establishing the "Common Price" of each mineral.

The database of prices for the minerals as per Method 1: Average annual price of commodity is given below.

Table 15 presents the average common price of minerals (2012–2016).

Table 15. Average common price of minerals (2012–2016).

Commodity	Annual Price of Commod-ity	Annual Price of Commod-ity	Annual Price of Commod-ity	Annual Price of Commod-ity	Annual Price of Commod-ity	Avg Price	per Unit
Commodity	2012	2013	2014	2015	2016	Avg Price	per Unit
Abrasives	988	1030	1020	584	468	818	USD/T
Aluminum	101	94.2	104.5	88.2	80	93.58	USD/T
Antimony	565	463	425	327	300	416	USD/T
Arsenic	75	72	75	84	88	78.8	USD/T
Asbestos	931	1570	1510	1830	1610	1630	USD/T
Ball (Clay)	46	43	44	46	45	44.8	USD/T
Barite	187	180	191	197	198	190.6	USD/T
Bauxite	28	27	27	28	29	27.8	USD/T
Bentonite	62	65	69	74	74	68.8	USD/T
Bismuth	10.1	8.71	11.14	6.43	4.5	8.176	USD/lbs.
Boron	510	433	372	400	550	453	USD/T
Bromine				3650	4400	4025	USD/T
Cadmium	2030	1920	1940	1050		1735	USD/T
Calcareous	9.73	9.89	10.15	10.57	10.98	10.264	USD/mT
Chalk	115.4	117.8	119.1	120	120	118.46	USD/T
Chromite	381	309	243	217	200	270	USD/T
Clay	12	12	11	13	13	12.2	USD/T
Construction sand	7.65	7.89	8.09	8.58	8.8	8.202	USD/mT
Crushed & broken Stone	9.73	9.89	10.15	10.57	10.98	10.264	USD/mT

Commodity	Annual Price of Commod-ity	Annual Price of Commod-ity	Annual Price of Commod-ity	Annual Price of Commod-ity	Annual Price of Commod-ity	Avg Price	per Unit
Diaspore	563	663	659	579	445	581.8	USD/T
Diatomite	286	293	298	291	294	292.4	USD/T
Dimension stone	154309	171371	169557	124786	87931	141591	USD/mT
Fe content	116.48	87.42	84.43	81.19	82.41	90.386	USD/mT
Feldspar	66	73	66	73	73	70.2	USD/T
Ferromolyb-denum		11.955	12.83			12.3925	USD/kg
Fire Clay	27	18	17	14	11	17.4	USD/T
Fluorspar	425	350	310	270	270	325	USD/T
Fuller's Earth	92	88	86	106	99	94.2	USD/T
Gallium	529	502	363	317	400	422.2	USD/Kg
Germanium	1640	1900	1900	1250	950	1528	USD/Kg
Graphite	339	375	360	394	364	366.4	USD/T
Gypsum	8.16	7.6	8.9	8.9	9	8.512	USD/mT
Ilmenite	300	265	155	110	105	187	USD/mT
Indium	540	570	705	520	340	535	USD/kg
Iodine	42.28	42.77	37.04	27.74	23	34.566	USD/kg
Iridium	1066.23	826.45	556.19	544.19	575	713.612	USD/kg
Kaolin	149	146	144	130	132	140.2	USD/T
Kyanite	340	300	260	270	300	294	USD/mT

Table 16 presents the average common price of minerals (2012–2016) (continued).

Table 16. Average common price of minerals (2012–2016) (continued).

Commodity	Annual Price of Commodity	Annual Price of Commodity	Annual Price of Commodity	Annual Price of Commodity	Annual Price of Commodity	Annual Price of Commodity	Avg Price	per Unit
Commodity	2012	2013	2014	2015	2016			per Unit
Lime	115.4	818	119.1	120	120	118.46	118.46	USD/T
Lithium	6060	6800	6690	6500	7400	6690	6690	USD/mT
Magnesium	3170	2615	2325	1825	2400	2467	2467	USD/mT
Mercury	2578	3412	3037	1954	1400	2476.2	2476.2	USD/flask
Mica	281	279	285	290	290	285	285	USD/mT
Molybdenum	28.09	22.85	25.84	15.01	14.5	21.258	21.258	USD/Kg
Natural gas liquid	10.98	9.93	9.65	4.99	5.03	8.114	8.114	USD/MMBtu
Nickel	17533	15018	16865	11831	9298	14109	14109	USD/mT
Niobium	27	27	25	24	20	24.6	24.6	USD/Kg
Nitrogen	579	541	531	481	270	480.4	480.4	USD/T
Palladium	649.27	729.58	809.89	694.99	615	699.746	699.746	USD/kg
Peat	52	55	55	60	61	56.6	56.6	USD/T
Perlite	24.44	25.37	24.97	28.37	27	26.03	26.03	USD/T
Petroleum Crude	103.41	105.43	96.2	50.8	42.8	79.728	79.728	USD/bbl
Phosphate rock	102.54	91.11	78.59	72.41	77	84.33	84.33	USD/T
Pigments, Iron oxide	1.61	1.6	1.58	1.46	1.46	1.542	1.542	USD/kg
Platinum	1555.39	1489.57	1387.89	1056.09	1000	1297.788	1297.788	USD/kg
Potash	650	590	560	570	360	546	546	USD/T
Pumice, pumicite	31.85	34.65	38.52	32.68	33	34.14	34.14	USD/T
Pyrophyllite (Talc)	152	163	171	169	180	167	167	USD/mT
Rhenium	4040	3160	3000	2700	2000	2980	2980	USD/Kg
Rhodium	1274.98	1069.1	1174.23	954.9	670	1028.642	1028.642	USD/kg

Commodity	Annual Price of Commodity	Annual Price of Commodity	Annual Price of Commodity	Annual Price of Commodity	Annual Price of Commodity	Annual Price of Commodity	Avg Price	per Unit
Rock salt			110.2	117.5	112.2	113.3	113.3	USD/mT
Ruthenium	112.26	75.63	65.13	47.63	42	68.53	68.53	USD/kg
Salt	169.93	172.09	180.61	185	190	179.526	179.526	USD/T
Selenium	54.47	36.17	26.78	22.09	26	33.102	33.102	USD/T
Silicon	1.27	1.22	1.4	1.27	0.91	1.214	1.214	USD/Kg
Soda ash	141.9	131.71	134.87	140.88	141	138.072	138.072	USD/T
Sodium Sulfate	134	134	134	134	140	135.2	135.2	USD/T
Steatite	152	163	171	169	180	167	167	USD/mT
Stone	9.73	9.89	10.15	10.57	10.98	10.264	10.264	USD/mT
Strontium	50	50	50	51	70	54.2	54.2	USD/T
Sulfur	123.54	68.71	80.07	87.62	78	87.588	87.588	USD/T
Tantalum	239	260	221	193	193	221.2	221.2	USD/Kg
Tellurium	150	112	119	77	34	98.4	98.4	USD/Kg
Titanium, slag	766.5	657.5	741	740	679	716.8	716.8	USD/T
Tungsten	358	358	348	302	142	301.6	301.6	USD/mT
Vanadium	6.49	6.04	5.61	4.16	3.1	5.08	5.08	USD/lbs.
Vermiculite	287.5	335	355	357.5	357.5	338.5	338.5	USD/T
Zeolite	425	425	275	530	530	437	437	USD/mT
Zirconium	64000	91000	75000	59000	86000	75000	75000	USD/T

Method 2: For the remaining minerals, Common Pricing Structure is determined by the price of the mineral as given by the source associated with the pricing of the mineral.

Table 17 presents the other source of common price of minerals.

Table 17. Other source of common price of minerals.

Commodity	Avg	Unit	Source
Acid Clay	250.00	USD/mT	https://www.alibaba.com › Minerals & Metallurgy › bleaching earth

Commodity	Avg	Unit	Source
Agate	0.50	USD/ carat	
Aggregates	8.71	USD/T	USGS: Mineral Commodity Summaries, 2010-2014 summaries
Alabaster	3.50	USD/lbs.	https://www.sculpturehouse.com/s-267-alabaster.aspx
Alexandrite	15000.00	USD/ carat	
Alginate (sodium)	3750.00	USD/mT	https://www.alibaba.com › Chemicals › alginate › sodium alginate
Alumina	283.10	USD/T	
Amethyst	25.50	USD/ carat	https://www.pricescope.com/community/threads/value-of-amethyst.
Ammonia	425.00	USD/T	farmdocdaily.illinois.edu
Andalusite	40.00	USD/ carat	www.ebay.com/gds/Andalusite-Gemstone-Value-Price-and-Jewelry/g.html
Anthracite Coal	42.58	USD/T	https://www.eia.gov/energyexplained/index.cfm?page=coal_prices
Aquamarine	175.00	USD/ carat	https://www.ajsgem.com/articles/aquamarine-prices.html
Aromatic Tar	425.00	USD/mT	https://www.alibaba.com › Energy › oil
Asphalt	117.50	USD/T	https://sciencing.com/how-6558396-calculate-asphalt-prices.html
Attapulgite clay	250.00	USD/mT	https://www.alibaba.com/showroom/attapulgite-clay-price.html
Avigas	305.62	USD/bbl	aviationweek.com/bca/jet-and-avgas-fuel-prices-august-2015 (USD 7.3/gn)
Basalt	92.50	USD/mT	https://www.alibaba.com › Construction & Real Estate › basalt
Beryllium	230.00	USD/lbs.	www.beresources.ca/AboutBeryllium/BerylliumPrices.htm
Biotite	450.00	USD/mT	https://www.alibaba.com › Minerals & Metallurgy › biotite
Bitumen fuel	404.56	USD/mT	https://www.iocl.com/Product_PreviousPrice/BitumenPreviousPrice.aspx
Bituminous	46.70	USD/T	https://www.eia.gov/coal/
Blister Copper	4756.00	USD/T	https://www.zauba.com/import-blister-copper-hs-code.html (Rs 311/Kg)
Brine, salt	140.00	USD/T	www.caryinstitute.org/newsroom/road-salt-winters-23-billion-game-changer
Calcite	165.00	USD/T	https://www.alibaba.com/showroom/calcite-prices.html
Calcium carbonate	118.46	USD/T	USGS: Mineral Commodity Summaries, Jan 2017
Carbon	26.00	USD/T	www.synapse-energy.com/sites/.../2015CarbonDioxidePriceReport.pdf
Caustic Soda	425.00	USD/mT	https://www.alibaba.com › Chemicals › soda › caustic soda
Cement	48.75	USD/T	Alibaba.com
Clinker	30.80	USD/T	www.cwgrp.com/.../434681-fob-prices-for-cement-increase-clinker-prices

Commodity	Avg	Unit	Source
Coal	71.39	USD/T	
Cobalt	14.21	USD/T	
Coke,	200.00	USD/T	https://www.alibaba.com/showroom/metallurgical-coke-price.html
Copper	5593.67	USD/T	
Copper sulfate	2000.00	USD/mT	https://www.alibaba.com › Chemicals › sulphate › copper sulphate
Coquina	45.85	USD/T	www.energyprofessional.in/14_8854/crushed-coquina-cost/

(Note: A blank cell in the Source column indicates global internet price)

5.11 Final consolidated database of mineral prices

The final consolidated pricing structure for all the 238 minerals is as given below.

Table 18 presents the consolidated database of common price of all minerals.

Table 18. Consolidated database of common price of all minerals.

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Abrasives	818.0	USD/T	Cadmium	1735.0	USD/T	Ferroman-ganese	2281.8	USD/T
Acid Clay	250.0	USD/mT	Calcareous	10.3	USD/mT	Ferromolyb-denum	5.6	USD/kg
Agate	0.5	USD/Ct	Calcite	165.0	USD/T	Ferronickel magnesium	8551.4	USD/T
Aggregates	8.7	USD/T	Calcium carbonate (lime)	118.5	USD/T	Ferroniobium	33.5	USD/Kg
Alabaster	3.5	USD/lb.	Carbon	26.0	USD/T	Ferro Phos-phorous	612.0	USD/T
Alexandrite	15000.0	USD/carat	Caustic Soda	425.0	USD/mT	Ferrosilicon	1380.0	USD/T
Alginate (so-dium)	3750.0	USD/mT	Cement	48.8	USD/T	Ferrovanadium	22.6	USD/Kg
Alumina	283.1	USD/T	Chalk	118.5	USD/T	Fire Clay	17.4	USD/T
Aluminum	424.5	USD/T	Chromite	270.0	USD/T	Flagstone	400.0	USD/T
Amethyst	25.5	USD/carat	Clay	12.2	USD/T	Fluorspar	325.0	USD/T
Ammonia	425.0	USD/T	Clinker	30.8	USD/T	Fuel oil	2.7	USD/gn
Amphibolite (feldspar)	70.2	USD/T	Coal	71.4	USD/T	Fuller's Earth	94.2	USD/T
Andalusite	40.0	USD/carat	Cobalt	14.2	USD/T	Gabbro (Di-mension stone)	10.3	USD/mT
Anthracite Coal	42.6	USD/T	Coke, metal-lurgical	200.0	USD/T	Gallium	422.2	USD/Kg

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Antimony	1886.9	USD/T	Construction sand	8.2	USD/ mT	Garnet	365.0	USD/T
Apatite (Phosphate rock)	84.3	USD/T	Copper	5593.7	USD/T	Gas Oil	56.0	USD/ bbl
Aquamarine	175.0	USD/ carat	Copper sulfate	2000.0	USD/ mT	Gasoline	170.1	USD/ bbl
Aromatic Tar	425.0	USD/mT	Coquina	45.9	USD/T	Gemstones	2005.0	USD/ carat
Arsenic	1737.2	USD/T	Cordierite, Iolite	450.0	USD/ Mt	Gemstones Crude	500.0	USD/ carat
Asbestos	1630.0	USD/T	Crude Oil	54.4	USD/ bbl	Geniss (feld-spar)	70.2	USD/T
Asphalt	117.5	USD/T	Crushed & broken Stone	10.3	USD/ mT	Germanium	1528.0	USD/ Kg
Attapulgite clay	250.0	USD/mT	Cyclohexane	1065.0	USD/ mT	Glauberite	90.0	USD/T
Avigas	305.6	USD/bbl	Diamond	1400.0	USD/ carat	Gold	1223.7	USD/ oz
Ball (Clay)	44.8	USD/T	Diaspore	581.8	USD/T	Granite	242.0	USD/T
Barite	190.6	USD/T	Diatomite	292.4	USD/T	Graphite	366.4	USD/T
Basalt	92.5	USD/mT	Diesel	121.8	USD/ bbl	Gravel	8.7	USD/ mT
Bauxite	27.8	USD/T	Dimension stone	10.3	USD/ mT	Greywacke (sandstone)	130.0	USD/T
Bentonite	68.8	USD/T	Distillate fuel oil	151.7	USD/ bbl	Guano	242.5	USD/ mT
Beryllium	230.0	USD/lb.	Dolomite	115.0	USD/ mT	Gypsum	8.5	USD/ mT
Biotite	450.0	USD/mT	Dunite	46.5	USD/T	Helium	3.4	USD/ cu m
Bismuth	8.2	USD/lb.	Electrolytic, cathode4	220.0	USD/T	Igneous rock	6.0	USD/ lb.
Bitumen fuel	404.6	USD/mT	Emerald	800.0	USD/ carat	Ilmenite	187.0	USD/ mT
Bituminous Coal	46.7	USD/T	Ethane	11.8	USD/ bbl	Indium	535.0	USD/ kg
Blister Cop-per	4756.0	USD/T	Fe content	90.4	USD/ mT	Iodine	34.6	USD/ kg
Boron	453.0	USD/T	Feldspar	70.2	USD/T	Iolite	97.5	USD/ carat
Brine, salt	140.0	USD/T	Felsite	69.7	USD/ mT	Iridium	22943.1	USD/ kg

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Briquets (Peat)	56.6	USD/T	Ferro Titanium	3770.0	USD/T	Iron	61.9	USD/T
Bromine	4025.0	USD/T	Ferrochromium	2480.0	USD/T	Iron Oxide pigments	950.0	USD/T
Butane	51.2	USD/bbl	Ferrochromium silicon	31325.0	USD/T	Jadeite	5000.0	USD/carat
Jasper	33069.4	USD/T	Perlite	26.0	USD/T	Sepiolite clay	1835.0	USD/T
Kaolin	140.2	USD/T	Petroleum Crude	79.7	USD/bbl	Serpentine	1250.0	USD/mT
Kerosene and jet fuel	84.3	USD/bbl	Petroleum Refinery	47.6	USD/bbl	Shale	50.0	USD/bbl
Kyanite	294.0	USD/mT	Phosphate rock	84.3	USD/T	Silica	107.0	USD/mT
Lead	2169.3	USD/T	Phosphatic Fertilizer	425.0	USD/T	Siliceous earth	9.3	USD/T
Leonardite	200.0	USD/mT	Phosphoric acid	600.0	USD/T	Silicomanganese	948.4	USD/T
Leucoxene	778.0	USD/T	Phosphorite	125.0	USD/T	Silicon	267.6	USD/Kg
Lignite	45.0	USD/mT	Pig iron	344.0	USD/T	Sillimanite	475.0	USD/T
Lime	118.5	USD/T	Pigments, Iron oxide	1.5	USD/kg	Silver	17.5	USD/oz.
Limestone	198.0	USD/T	Platinum	41724.8	USD/kg	Slate	605.0	USD/T
Liquefied petroleum gas	100.2	USD/bbl	Porphyry	40.0	USD/kg	Soda ash	138.1	USD/T
Lithium	6690.0	USD/mT	Potash	546.0	USD/T	Sodium Sulfate	135.2	USD/T
Lubricants	545.0	USD/bbl	Potassium Nitrate	675.0	USD/mT	Solvent (Toluene)	157.5	USD/bbl
Magnesite	130.0	USD/mT	Pottery Clay	25.5	USD/T	Sponge iron	311.1	USD/T
Magnesium	2467.0	USD/mT	Pozzolan	60.0	USD/mT	Steatite	167.0	USD/mT
Manganese	187.1	USD/T	Propane	68.9	USD/bbl	Steel, crude	300.0	USD/mT
Marble	304.0	USD/T	Pumice, pumicite	34.1	USD/T	Stone	10.3	USD/mT
Marl (lime)	118.5	USD/T	Pyrite	475.0	USD/mT	Strontium	54.2	USD/T
Mercury	2476.2	USD/flask	Pyrochlore (niobium)	24.6	USD/Kg	Sulfur	87.6	USD/T
Methanol	549.0	USD/T	Pyrope	5000.0	USD/T	Sulfuric acid	280.0	USD/mT

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Mica	285.0	USD/mT	Pyrophyllite (Talc)	167.0	USD/ mT	Talc	167.0	USD/ mT
Moldavite	20000.0	USD/Kg	Pyroxenite	54.0	USD/T	Tantalum	221.2	USD/ Kg
Moler (Diat-omite)	292.4	USD/T	Quartz and quartzite	220000.0	USD/T	Tanzanite	675.0	USD/ carat
Molybdenum	21.3	USD/Kg	Rare-earths	102712.1	US$/T	Tellurium	98.4	USD/ Kg
Monazite	9.1	USD/T	Refinery gas	84.0	USD/ bbl	Tin	20638.7	USD/T
Naphtha	549.5	USD/T	Residual fuel oil	43.1	USD/ bbl	Titanium, slag	716.8	USD/T
Natural Gas	3.2	USD/ MMBtu	Rhenium	2980.0	USD/ Kg	Topaz	20.0	USD/ carat
Natural gas liquid	8.1	USD/ MMBtu	Rhodium	33071.6	USD/ kg	Tourmaline	400.0	USD/ carat
Nepheline sy-enite	70.2	USD/T	Rhodochros-ite	30000.0	USD/ Kg	Travertine (limestone)	198.0	USD/T
Nickel	14109.0	USD/mT	Rock salt	113.3	USD/ mT	Tuff	923.5	USD/T
Niobium	24.6	USD/Kg	Ruby	1650.0	USD/ carat	Tungsten	301.6	USD/ mT
Nitrogen	480.4	USD/T	Ruthenium	2203.3	USD/ kg	Ulexite	754.1	USD/ mT
Obsidian	4409.2	USD/T	Rutile	822.6	USD/T	Uranium	25.7	USD/ lb..
Olivine	145.0	USD/T	Salable crude	61.5	USD/ bbl	Vanadium	5.1	USD/ lb..
Onyx	599.0	USD/T	Salt	179.5	USD/T	Vermiculite	338.5	USD/T
Palladium	22497.3	USD/kg	Sandstone	130.0	USD/T	Volcanic sand	190.0	USD/ mT
Paludal mud (clay)	12.2	USD/T	Sapphire	4000.0	USD/ carat	White clay (ka-olin)	140.2	USD/T
Paraffin wax	1085.0	USD/mT	Schist	75.0	USD/T	Wollastonite	360.0	USD/T
Peat	56.6	USD/T	Selenite	55000.0	USD/T	Zeolite	437.0	USD/ mT
Pentane	95.8	USD/bbl	Selenium	72977.5	USD/T	Zinc	2739.7	USD/T
						Zirconium	75000.0	USD/T

Table 19 presents the mineral production (2009–2013) India/cluster Asia.

Table 19. Mineral production (2009–2013) India/cluster Asia.

Commodity	Units	2009	2010	2011	2012	2013
Agate	metric tons	20	20	400	500	200
Alumina Metal, primary	thousand metric tons	1,598	1,607	1,667	1,700	1,606
Asbestos	metric tons	261	262	274	359	267
Ball Clay	thousand metric tons	949	1,000	1,500	1,800	1,900
Barite	thousand metric tons	2,000	2,300	1,900	1,700	1,200
Bauxite, gross weight	thousand metric tons	15,460	14,124	12,723	13,600	15,360
Bentonite	metric tons	671,000	561,000	739,000	996,000	1,100,000
Bituminous Coal	thousand metric tons	450,000	480,000	500,000	550,000	563,000
Bromine, elemental	metric tons	1,500	1,600	1,600	1,700	1,700
Cadmium metal	metric tons	550	550	450	450	450
Calcareous (Sand)	thousand metric tons	280	285	290	295	290
Calcite	metric tons	54,000	41,000	50,000	68,000	87,000
Cement, hydraulic	thousand metric tons	205,000	220,000	240,000	270,000	280,000
Chalk	metric tons	189,000	179,000	178,000	170,000	136,000
Chromium, chromite	thousand metric tons	2,588	4,101	3,274	2,943	2,950
Cobalt metal	metric tons	1,001	1,187	1,299	800	295
Copper Mine output	metric tons	29,500	35,500	37,700	34,000	36,100
Diamond Gem	thousand carats	13	13	16	28	36
Diaspore	metric tons	25,000	26,000	24,000	18,000	15,000
Distillate fuel oil	thousand 42-gallon barrels	480,000	490,000	500,000	520,000	511,200
Dolomite	thousand metric tons	5,800	5,900	5,900	6,600	7,000
Dunite	metric tons	66,500	35,700	35,000	75,000	70,000
Electrolytic, cathode Copper	metric tons	705,100	654,900	671,100	670,000	680,000
Feldspar	metric tons	523,000	503,000	763,000	1,200,000	1,200,000
Felsite	metric tons	3,000	2,000	1,300	1,200	700
Ferrochromium,	metric tons	873,385	850,000	891,000	1,001,582	903,000
Ferrochromium silicon	metric tons	10,000	10,000	11,000	11,000	11,000
Ferromanganese	metric tons	399,100	440,000	440,000	402,000	447,000
Ferronickel magnesium	metric tons	88	96	107	110	200
Ferrosilicon	metric tons	101,337	115,000	127,000	130,000	132,000
Fire clay	thousand metric tons	540	780	950	900	740
Fluorspar	metric tons	8,786	8,400	8,500	8,600	8,800
Fuller's earth	metric tons	29,000	5,600	5,600	5,600	5,600

Commodity	Units	2009	2010	2011	2012	2013
Garnet	thousand metric tons	1,500	2,000	1,800	1,400	700
Gas, Natural Gross	million cubic meters	35,000	37,000	38,000	40,000	39,600
Gasoline	thousand 42-gallon barrels	125,000	130,000	135,000	137,000	135,000
Gold metal	kilograms	2,173	2,320	2,245	1,740	1,570
Graphite	metric tons	123,000	118,000	144,000	140,000	143,000
Gypsum	thousand metric tons	3,500	4,500	5,200	3,600	3,000
Ilmenite	metric tons	675,000	729,000	550,000	340,000	340,000
Iron ore	thousand metric tons	217,155	210,006	178,226	144,160	117,000
Jasper	metric tons	8,700	8,800	8,900	8,800	8,800
Kaolin	thousand metric tons	2,500	2,700	2,900	3,400	4,400
Kerosene and jet fuel	thousand 42-gallon barrels	120,000	125,000	130,000	133,000	131,000
Kyanite	metric tons	5,300	5,900	4,500	1,800	1,700
Lead Mine output	metric tons	62,000	70,000	84,000	100,000	105,000
Lignite Coal	thousand metric tons	25,000	27,000	28,000	30,000	27,000
Lime (shell)	metric tons	71,000	38,000	33,000	26,000	19,900
Limestone	thousand metric tons	230,000	243,000	259,000	275,000	279,000
Liquefied petroleum gas	thousand 42-gallon barrels	55,000	58,000	60,000	62,000	61,000
Magnesite	metric tons	253,000	301,000	236,000	224,000	213,000
Manganese Ore	thousand metric tons	2,374	2,858	2,542	2,225	2,264
Nitrogen,	thousand metric tons	10,100	10,600	10,500	10,700	10,800
Petroleum, crude	thousand 42-gallon barrels	255,000	260,000	265,000	270,000	265,000
Phosphate rock,	thousand metric tons	7,800	6,400	5,500	3,400	2,200
Pig iron	thousand metric tons	34,000	38,685	43,600	48,000	51,359
Pyrite, gross weight	metric tons	115,000	115,000	110,000	110,000	110,000
Pyrophyllite	metric tons	244,000	240,000	252,000	248,000	218,000
Pyroxenite	metric tons	280,000	260,000	128,000	62,000	16,000
Rare-earths	metric tons	5,000	5,200	5,200	5,400	2,900
Residual fuel oil	thousand 42-gallon barrels	140,000	145,000	150,000	152,000	149,000
Rock (Salt)	thousand metric tons	2	1	2	2	2
Rutile	metric tons	25,000	19,000	19,000	24,000	26,000
Selenite	metric tons	14,800	8,700	11,500	8,900	2,300
Selenium	kilograms	15,000	15,000	16,000	16,000	16,000
Silica	thousand metric tons	2,600	3,200	4,500	4,000	3,400

Commodity	Units	2009	2010	2011	2012	2013
Silicomanganese	metric tons	875,500	1,000,000	1,433,600	1,522,600	1,418,844
Sillimanite	metric tons	33,700	45,000	56,600	47,600	57,100
Silver, smelter output	kilograms	130,406	145,922	192,434	332,321	355,842
Slate	metric tons	14,000	14,500	15,000	15,500	17,000
Soda ash	thousand metric tons	1,400	1,500	1,400	1,500	1,500
Steatite, soapstone	metric tons	880,000	897,000	974,000	954,000	940,000
Steel Crude	thousand metric tons	63,500	69,000	73,500	77,300	81,300
Tin	kilograms	59,206	60,236	51,735	48,023	38,082
Uranium	metric tons	290	400	400	385	400
Vermiculite	metric tons	12,000	17,000	12,000	8,000	10,000
Wollastonite	metric tons	127,000	171,000	184,000	152,000	18,000
Zinc ore	metric tons	1,260,000	1,400,000	1,350,000	1,400,000	1,493,000
Zirconium concentrate	metric tons	32,000	27,800	39,000	40,000	40,000

6 Mineral value of a nation

6.1 Purpose of this section

In order to postulate a new economic growth indicator, the mineral value is the most critical consideration for this research. This section describes the processes for quantifying this value in terms of economic worth.

The economic worth of a nation is its potential for economic activity. Mineral resources being the DNA of economic activity, its economic worth is the potential based on its mineral content. In this stage, it is proposed to reinforce the “Common Pricing mechanism”, in order to eliminate the economic distortions (inequality) caused by differential pricing.

The stages involved are:

1. To establish the Conversion factor
2. To calculate mineral value for the particular commodity
3. To arrive at the aggregate value of all minerals for a particular nation

6.2 Stage 1: conversion factor

Important note: It is observed that the measuring unit for quantity and price for most minerals differ i.e. the unit of measurement of physical quantity differs from the physical unit used for per unit price of minerals.

See table below displaying different units for physical quantity and price.

Table 20 presents the difference in measuring units for quantity and price of minerals.

Table 20. Difference in measuring units for quantity and price of minerals.

Mineral	Unit of Physical Quantity	Price	Unit of Pricing
Alumina	thousand metric tons	283.1	USD/T
Diamond	thousand carats.	1400.0	USD/carat
Anthracite Coal	thousand metric tons	42.6	USD/T
Zirconium	metric tons	75000.0	USD/T
Talc (Pyrophyllite)	thousand metric tons	167.0	USD/mT
Natural gasoline (butane)	million 42-gallon barrels	8.1	USD/MMBtu
Gold	metric tons	1223.7	USD/oz
Steel, crude	thousand metric tons	300.0	USD/mT
Liquefied petroleum gas	thousand 42-gallon barrels	100.2	USD/bbl
Ferrochromium	metric tons	2480.0	USD/T
Uranium	metric tons	25.7	USD/lbs.

Due to this differentiation, it is necessary to arrive at a common rate of measurement between quantitative and pricing units. This is achieved mathematically through a conversion factor using simple logic and the mensuration tables used in physics.

This “Conversion factor” is presented in a database which is tabulated below.

Table 21 presents the conversion factor table.

Table 21. Conversion factor table.

Measurement Unit	Pricing Unit	Conversion factor	Measurement Unit	Pricing Unit	Conversion factor
cubic meters	T	0.35	flask	lbs.	76.00
cubic meters	mT	0.39	Ton	flask	26.32
kilograms	flask	0.02632	Ton	carat	5000000
kilograms	T	0.00100	Ton	bbl	7.35
kilograms	ounce	35.27	42-gallon barrels	mT	0.14
kilograms	bbl	0.007	42-gallon barrels	T	0.12
kilograms	carat	5000.00	Metric tons	mT	1.00
Metric tons	carat	5511550	Metric tons	Oz.	35274.00
Metric tons	flask	29.01	Metric tons	bbl	8.10
Metric tons	T	1.10	thousand carats	Kg	0.20
Metric tons	Kg	1102.31	thousand carats	T	0.0002205
Metric tons	Lbs.	2204.62	thousand carats	mT	0.0002
thousand cubic meters	MMBtu	42.38	thousand 42-gallon barrels	mT	136.00
thousand cubic meters	T	353.14	thousand 42-gallon barrels	T	123.38

Measurement Unit	Pricing Unit	Conversion factor	Measurement Unit	Pricing Unit	Conversion factor
thousand cubic meters	mT	388.45	thousand 42-gallon barrels	MMBtu	5551.37
million cubic meters	MMBtu	42380.00	thousand metric tons	barrels	8101.98
million cubic meters	bbl	7634.16	thousand metric tons	MMBtu	133.47
million cubic meters	T	350000.00	thousand metric tons	T	1102.31
million cubic meters	mT	317515.04			

Note: The table may be read as: "Conversion from Unit of Measurement to Unit". For e.g.,

- i) 1 cubic meters is 0.35 Tons or 0.39 metric Tons
- ii) 1 Ton is 26.32 flask or 5000000 carats or 7.35 bn barrels
- iii) 1 Flask is 76 lbs. and 1 thousand carats equal 0.20 Kgs
- iv) 1 million cubic meters is 7634.16 barrels or 350000 Tons or 42380 million British Thermal Units (MMBtu)

The Database of "Common Price of all minerals" used in the research is The same is also tabulated below.

Table 22 presents the common price table: All minerals.

Table 22. Common price table: All minerals.

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Acid Clay	250.0	USD/mT	Calcite	165.0	USD/T	Ferroniobium	33.5	USD/Kg
Agate	0.5	USD/Ct	Calcium carbonate	118.5	USD/T	FerroPhosphorous	612.0	USD/T
Aggregates	8.7	USD/T	Carbon	26.0	USD/T	Ferrosilicon	1380.0	USD/T
Alabaster	3.5	USD/lbs.	Caustic Soda	425.0	USD/mT	Ferrovanadium	22.6	USD/Kg
Alexandrite	15000.0	USD/carat	Cement	48.8	USD/T	Fire Clay	17.4	USD/T
Alginate	3750.0	USD/mT	Chalk	118.5	USD/T	Flagstone	400.0	USD/T
Alumina	283.1	USD/T	Chromite	270.0	USD/T	Fluorspar	325.0	USD/T
Aluminum	424.5	USD/T	Clay	12.2	USD/T	Fuel oil	2.7	USD/gn
Amethyst	25.5	USD/carat	Clinker	30.8	USD/T	Fuller's Earth	94.2	USD/T
Ammonia	425.0	USD/T	Coal	71.4	USD/T	Gabbro	10.3	USD/mT

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Amphibolite	70.2	USD/T	Cobalt	14.2	USD/T	Gallium	422.2	USD/ Kg
Andalusite	40.0	USD/car-at	Coke, met.	200.0	USD/T	Garnet	365.0	USD/T
Anthracite Coal	42.6	USD/T	Construc-tion sand	8.2	USD/ mT	Gas Oil	56.0	USD/ bbl
Antimony	1886.9	USD/T	Copper	5593.7	USD/T	Gasoline	170.1	USD/ bbl
Apatite	84.3	USD/T	Copper sulfate	2000.0	USD/ mT	Gemstones	2005.0	USD/ carat
Aquamarine	175.0	USD/car-at	Coquina	45.9	USD/T	Crude Gem-stones	500.0	USD/ carat
Aromatic Tar	425.0	USD/mT	Cordierite, Iolite	450.0	USD/ Mt	Geniss	70.2	USD/T
Arsenic	1737.2	USD/T	Crude Oil	54.4	USD/ bbl	Germanium	1528.0	USD/ Kg
Asbestos	1630.0	USD/T	Crushed Stone	10.3	USD/ mT	Glauberite	90.0	USD/T
Asphalt	117.5	USD/T	Cyclohexane	1065.0	USD/ mT	Gold	1223.7	USD/ oz
Attapulgite clay	250.0	USD/mT	Diamond	1400.0	USD/ carat	Granite	242.0	USD/T
Avigas	305.6	USD/bbl	Diaspore	581.8	USD/T	Graphite	366.4	USD/T
Ball (Clay)	44.8	USD/T	Diatomite	292.4	USD/T	Gravel	8.7	USD/ mT
Barite	190.6	USD/T	Diesel	121.8	USD/ bbl	Greywacke	130.0	USD/T
Basalt	92.5	USD/mT	Dimension stone	10.3	USD/ mT	Guano	242.5	USD/ mT
Bauxite	27.8	USD/T	Distillate fuel oil	151.7	USD/ bbl	Gypsum	8.5	USD/ mT
Bentonite	68.8	USD/T	Dolomite	115.0	USD/ mT	Helium	3.4	USD/ cu m
Beryllium	230.0	USD/lbs.	Dunite	46.5	USD/T	Igneous rock	6.0	USD/ lbs.
Biotite	450.0	USD/mT	Electrolytic	220.0	USD/T	Ilmenite	187.0	USD/ mT
Bismuth	8.2	USD/lbs.	Emerald	800.0	USD/ carat	Indium	535.0	USD/ kg
Bitumen fuel	404.6	USD/mT	Ethane	11.8	USD/ bbl	Iodine	34.6	USD/ kg
Bituminous Coal	46.7	USD/T	Fe content	90.4	USD/ mT	Iolite	97.5	USD/ carat

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Blister Copper	4756.0	USD/T	Feldspar	70.2	USD/T	Iridium	22943.1	USD/kg
Boron	453.0	USD/T	Felsite	69.7	USD/mT	Iron	61.9	USD/T
Brine, salt	140.0	USD/T	Ferro Titanium	3770.0	USD/T	Iron Oxide pig.	950.0	USD/T
Briquets (Peat)	56.6	USD/T	Ferrochromium	2480.0	USD/T	Jadeite	5000.0	USD/carat
Bromine	4025.0	USD/T	Ferro Ch. silicon	31325.0	USD/T	Jasper	33069.4	USD/T
Butane	51.2	USD/bbl	Ferromanganese	2281.8	USD/T	Kaolin	140.2	USD/T
Cadmium	1735.0	USD/T	Ferromolybdenum	5.6	USD/kg	Kerosene/jet fuel	84.3	USD/bbl
Lead	2169.3	USD/T	Phosphate rock	84.3	USD/T	Shale	50.0	USD/bbl
Leonardite	200.0	USD/mT	Phosphatic Fert	425.0	USD/T	Silica	107.0	USD/mT
Leucoxene	778.0	USD/T	Phosphoric acid	600.0	USD/T	Siliceous earth	9.3	USD/T
Lignite	45.0	USD/mT	Phosphorite	125.0	USD/T	Silicomanganese	948.4	USD/T
Lime	118.5	USD/T	Pig iron	344.0	USD/T	Silicon	267.6	USD/Kg
Limestone	198.0	USD/T	Pigments, FeO	1.5	USD/kg	Sillimanite	475.0	USD/T
Liq. Petroleum gas	100.2	USD/bbl	Platinum	41724.8	USD/kg	Silver	17.5	USD/oz
Lithium	6690.0	USD/mT	Porphyry	40.0	USD/kg	Slate	605.0	USD/T
Lubricants	545.0	USD/bbl	Potash	546.0	USD/T	Soda ash	138.1	USD/T
Magnesite	130.0	USD/mT	Potassium Nitro	675.0	USD/mT	Sodium Sulfate	135.2	USD/T
Magnesium	2467.0	USD/mT	Pottery Clay	25.5	USD/T	Toluene	157.5	USD/bbl
Manganese	187.1	USD/T	Pozzolan	60.0	USD/mT	Sponge iron	311.1	USD/T
Marble	304.0	USD/T	Propane	68.9	USD/bbl	Steatite	167.0	USD/mT
Marl (lime)	118.5	USD/T	Pumice,	34.1	USD/T	Steel, crude	300.0	USD/mT
Mercury	2476.2	USD/flask	Pyrite	475.0	USD/mT	Stone	10.3	USD/mT

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Methanol	549.0	USD/T	Pyrochlore	24.6	USD/ Kg	Strontium	54.2	USD/T
Mica	285.0	USD/mT	Pyrope	5000.0	USD/T	Sulfur	87.6	USD/T
Moldavite	20000.0	USD/Kg	Pyrophyllite	167.0	USD/ mT	Sulfuric acid	280.0	USD/ mT
Moler	292.4	USD/T	Pyroxenite	54.0	USD/T	Talc	167.0	USD/ mT
Molybdenum	21.3	USD/Kg	Quartz	220000.0	USD/T	Tantalum	221.2	USD/ Kg
Monazite	9.1	USD/T	Rare-earths	102712.1	US$/T	Tanzanite	675.0	USD/ carat
Naphtha	549.5	USD/T	Refinery gas	84.0	USD/ bbl	Tellurium	98.4	USD/ Kg
Natural Gas	3.2	USD/ MMBtu	Res. fuel oil	43.1	USD/ bbl	Tin	20638.7	USD/T
Natural gas liquid	8.1	USD/ MMBtu	Rhenium	2980.0	USD/ Kg	Titanium, slag	716.8	USD/T
Nepheline syenite	70.2	USD/T	Rhodium	33071.6	USD/ kg	Topaz	20.0	USD/ carat
Nickel	14109.0	USD/mT	Rhodochros-ite	30000.0	USD/ Kg	Tourmaline	400.0	USD/ carat
Niobium	24.6	USD/Kg	Rock salt	113.3	USD/ mT	Travertine	198.0	USD/T
Nitrogen	480.4	USD/T	Ruby	1650.0	USD/ carat	Tuff	923.5	USD/T
Obsidian	4409.2	USD/T	Ruthenium	2203.3	USD/ kg	Tungsten	301.6	USD/ mT
Olivine	145.0	USD/T	Rutile	822.6	USD/T	Ulexite	754.1	USD/ mT
Onyx	599.0	USD/T	Salable crude	61.5	USD/ bbl	Uranium	25.7	USD/ lbs.
Palladium	22497.3	USD/kg	Salt	179.5	USD/T	Vanadium	5.1	USD/ lbs.
Paludal mud	12.2	USD/T	Sandstone	130.0	USD/T	Vermiculite	338.5	USD/T
Paraffin wax	1085.0	USD/mT	Sapphire	4000.0	USD/ carat	Volcanic sand	190.0	USD/ mT
Peat	56.6	USD/T	Schist	75.0	USD/T	White clay	140.2	USD/T
Pentane	95.8	USD/bbl	Selenite	55000.0	USD/T	Wollastonite	360.0	USD/T
Perlite	26.0	USD/T	Selenium	72977.5	USD/T	Zeolite	437.0	USD/ mT
Petroleum Crude	79.7	USD/bbl	Sepiolite clay	1835.0	USD/T	Zinc	2739.7	USD/T

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Petroleum Ref.	47.6	USD/bbl	Serpentine	1250.0	USD/ mT	Zirconium	75000.0	USD/T

6.3 Stage 2: economic value of mineral commodities

The economic value for a particular commodity (mineral) is calculated as a simple arithmetic product of quantity produced and its average price, with the conversion factor factored in in order to neutralize the difference in units of measurement.

The product of (i) the quantity of commodity produced, (ii) the average price, and (iii) the Conversion factor, gives the economic value of that commodity.

Consider the example of the mineral (commodity): Aluminum

Table 23 presents the economic value: Mineral aluminum.

Table 23. Economic value: Mineral aluminum.

Commodity	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Year	Economy	Production Unit	Avg price	Conversion Factor	Mineral Value
Year	Economy	thousand mT	USD/lbs.	Conversion Factor	(US$ mn)
2012	USA	2070	0.94	2204620.00	4270.58
2013	USA	1946	0.94	2204620.00	4014.76
2014	USA	1710	0.94	2204620.00	3527.87
2015	USA	1587	0.94	2204620.00	3274.11
2016	USA	840	0.94	2204620.00	1732.99
Year	Economy	mT	USD/Ton	CF	(US$ mn)
2012	UK	208,800	283.10	1.10231	65.16
2013	UK	192,800	283.10	1.10231	60.17
2014	UK	191,000	283.10	1.10231	59.60
Year	Economy	thousand mT	USD/Ton	CF	(US$ mn)
2012	China	47,000	27.80	1102.31	1440.28
2013	China	50,400	27.80	1102.31	1544.47
2014	China	65,000	27.80	1102.31	1991.87
Year	Economy	thousand mT	USD/Ton	CF	(US$ mn)
2012	Saudi Arabia	426	283.10	1102.31	132.94
2013	Saudi Arabia	187	283.10	1102.31	58.36
2014	Saudi Arabia	665	283.10	1102.31	207.52
Year	Economy	mT	USD/Ton	CF	(US$ mn)
2012	Argentina	413,395	424.47	1.10	193.43
2013	Argentina	440,176	424.47	1.10	205.96
2014	Argentina	442,900	424.47	1.10	207.23

Note

1. The production unit of UK and Argentina (mT) is different from that of other nations (thousand mT).
2. The pricing unit of USA is USD/lbs., whereas for other nations it is USD/T.
3. Consequently, the conversion factor differs for different nations.
4. Hence the need for Common Pricing is justified.

6.4 Stage 3: aggregate economic value of all minerals for a particular nation

In this part, the economic value of all minerals for a given nation is calculated.

- **Step 1:** The Quantity of Production (extraction) of All minerals
- **Step 2:** Average Common Price and Conversion factor
- **Step 3:** Economic value = Quantity x Average Price x Conversion Factor

Step 1: Database of all minerals for USA (2012-2016) is tabulated below:

Table 24 presents the mineral production – USA (2012–2016).

Table 24. Mineral production – USA (2012–2016).

Commodity	Unit	2012	2013	2014	2015	2016
Magnesium	thousand mT	341	324	342	380	390
Steel	million mT	88.7	86.9	88.2	78.8	80
Tripoli	thousand mT	120000	110000	93100	70500	93857
Calcium carbonate	million mT	1180	1180	1250	1330	1480
Crushed stone	million mT	1180	1180	1250	1330	1480
Granite	million mT	1180	1180	1250	1330	1480
Sandstone	million mT	1180	1180	1250	1330	1480
Traprock	million mT	1180	1180	1250	1330	1480
Crushed stone	million mT	1180	1180	1180	1180	1180
Gold	mT	235	230	210	214	209
Copper	thousand mT	1170	1250	1360	1380	1410
Salt	thousand mT	37200	39900	45300	45000	42000
Cement	thousand mT	67173	69420	74372	76000	77000
Sand, Gravel	million mT	812	847	897	937	1010
Sand and Gravel	million mT	812	847	897	937	1010
Tin	mT	13640	12750	12000	12500	12100
Nitrogen	thousand mT	8730	9170	9330	9590	9800
Aluminum	thousand mT	2070	1946	1710	1587	840
Phosphate rock	thousand mT	30100	31200	25300	27400	27800
Lime	thousand mT	18800	19200	19500	18300	17000

Commodity	Unit	2012	2013	2014	2015	2016
Zinc	thousand mT	999	1017	1012	997	920
Iron and Steel	million mT	30.1	30.3	29.4	25.4	23
Soda ash	thousand mT	11100	11500	11700	11600	11700
Alumina	thousand mT	4370	4320	4460	4540	2500
Titanium dioxide	mT	1140000	1280000	1260000	1220000	1200000
Diamond industrial	million carats	80.5	84.1	96.7	103.5	108.3
Molybdenum	mT	60400	61000	68200	47400	31600
Silicon	thousand mT	390	392	401	411	396
Sulfur	thousand mT	9000	9210	9630	9540	9780
Silver	mT	1060	1040	1180	1090	1100

Note: Cells in yellow highlights are average values based on previous data.

Step 2: The database of average price (of 2012-2016 prices) of all minerals for USA and the conversion factor (in italics) to neutralize differentiation in measuring and pricing units is given below:

Table 25 presents the average price of minerals/conversion factor – USA (2012–2016).

Table 25. Average price of minerals/conversion factor – USA (2012–2016).

USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	Conversion Factor
Commodity	2012	2013	2014	2015	2016	Avg price	Unit	Conversion Factor
Magnesium						199.50	USD/Kg	1102310
Steel						545.00	USD/mT	1000000
Tripoli						280.00	USD/Kg	1000
Calcium carbonate	9.73	9.9	10.15	10.57	10.98	10.26	USD/mT	1000000
Crushed stone	9.73	9.9	10.15	10.57	10.98	10.26	USD/mT	1000000
Granite	9.73	9.9	10.15	10.57	10.98	10.26	USD/mT	1000000
Sandstone						10.26	USD/mT	1000000
Traprock						10.26	USD/mT	1000000
Crushed stone	9.73	9.9	10.15	10.57	10.98	10.26	USD/mT	1000000
Gold	1673	1415.0	1269	1163	1270	1358.00	USD/tr oz	35274
Copper	3.673	3.4	3.181	2.562	2.2	3.00	USD/lbs.	2204620

USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	USA: PRICE OF MINERALS	Conversion Factor
Salt	169.93	172.09	180.61	185	190	179.53	USD/T	1102.31
Cement	89.5	95.0	100.5	105.5	111	100.30	USD/T	1102.31
Sand, Gravel	7.65	7.9	8.09	8.58	8.8	8.20	USD/mT	1000000
Sand and Gravel	7.65	7.89	8.09	8.58	8.8	8.20	USD/mT	1000000
Tin	973.5	10.265	10.085	7.425	7.575	201.77	USD/lbs.	2204.62
Nitrogen	579	541	531	481	270	480.40	USD/T	1102.31
Aluminum	1.01	0.9	1.045	0.882	0.8	0.94	USD/lbs.	2204620
Phosphate rock	102.54	91.11	78.59	72.41	77	84.33	USD/T	1102.31
Lime	115.4	117.8	119.1	120	120	118.46	USD/T	1102.31
Zinc	0.9205	0.911	1.026	0.9155	0.955	0.95	USD/lbs.	2204620
Iron and Steel						71.53	USD/mT	1000000
Soda ash	141.9	131.71	134.87	140.88	141	138.07	USD/T	1102.31
Alumina	374	368.0	394	400	360	379.20	USD/T	1102.31
Titanium dioxide						1250.00	USD/mT	1
Diamond industrial	15.3	15.5	14.4	17.5	16.8	15.90	USD/ct.	1000000
Molybdenum	28.09	22.85	25.84	15.01	14.5	21.26	USD/Kg	1102.31
Silicon	1.27	1.22	1.4	1.27	0.91	1.21	USD/lbs.	2204620
Sulfur	123.54	68.71	80.07	87.62	78	87.59	USD/T	1102.31
Silver	31.22	23.87	19.37	15.72	19.62	21.96	USD/troz	35274

Step 3: The database of the economic value all minerals for the time period 2012 to 2016 for USA is calculated as a product of

(i) quantity extracted, (ii) Average price, and (iii) Conversion factor

The same is tabulated below:

Table 26 presents the economic value of all minerals – USA (2012–2016).

Table 26. Economic value of all minerals – USA (2012–2016).

Commodity	2012	2013	2014	2015	2016
Magnesium	74989.60	71251.11	75209.51	83566.12	85765.23

Commodity	2012	2013	2014	2015	2016
Steel	48341.50	47360.50	48069.00	42946.00	43600.00
Tripoli	33600.00	30800.00	26068.00	19740.00	26280.00
Calcium carbonate	12111.52	12111.52	12830.00	13651.12	15190.72
Crushed stone	12111.52	12111.52	12830.00	13651.12	15190.72
Granite	12111.52	12111.52	12830.00	13651.12	15190.72
Sandstone	12111.52	12111.52	12830.00	13651.12	15190.72
Traprock	12111.52	12111.52	12830.00	13651.12	15190.72
Crushed stone	12111.52	12111.52	12111.52	12111.52	12111.52
Gold	11256.99	11017.48	10059.44	10251.05	10011.54
Copper	7745.95	8275.59	9003.84	9136.25	9334.87
Salt	7361.63	7895.94	8964.57	8905.20	8311.52
Cement	7426.76	7675.19	8222.69	8402.69	8513.25
Sand, Gravel	6660.02	6947.09	7357.19	7685.27	8284.02
Sand and Gravel	6660.02	6947.09	7357.19	7685.27	8284.02
Tin	6067.43	5671.53	5337.91	5560.33	5382.40
Nitrogen	4622.97	4855.97	4940.70	5078.38	5189.59
Aluminum	4270.58	4014.76	3527.87	3274.11	1732.99
Phosphate rock	2798.03	2900.28	2351.83	2547.04	2584.23
Lime	2454.90	2507.13	2546.30	2389.61	2219.85
Zinc	2082.60	2120.13	2109.70	2078.43	1917.91
Iron and Steel	2153.05	2167.36	2102.98	1816.86	1645.19
Soda ash	1689.40	1750.28	1780.72	1765.50	1780.72
Alumina	1826.64	1805.74	1864.26	1897.70	1044.99
Titanium dioxide	1425.00	1600.00	1575.00	1525.00	1500.00
Diamond industrial	1279.95	1337.19	1537.53	1645.65	1721.97
Molybdenum	1415.35	1429.41	1598.12	1110.72	740.48
Silicon	1043.80	1049.15	1073.24	1100.00	1059.86
Sulfur	868.94	889.22	929.77	921.08	944.25
Silver	821.09	805.60	914.05	844.33	852.08

6.5 Stage 4: total mineral value of nations

USA: Mineral Value of USA (2012-2016, in USD mn) is appended below:

Table 27 presents the mineral value of USA (2012–2016).

Table 27. Mineral value of USA (2012–2016).

USA	2012	2013	2014	2015	2016
Total Mineral Value (USD mn)	396391	391276	392487	388740	402423

6.5.1 Algeria

Algeria: A few select minerals and their "Economic Value" (in USD mn) for the years 2010, 2012, and 2014 is given below:

Table 28 presents the mineral database for Algeria (2010, 2012, 2014).

Table 28. Mineral database for Algeria (2010, 2012, 2014).

Commodity	Units	Qty 2010	Qty 2012	Qty 2014	Avg price	Unit of price	Conv. factor	Value 2010 (USD mn)	Value 2012 (USD mn)	Value 2014 (USD mn)
Aggregates	000 cubic meters	25,381	72,040	80,905	8.7	USD/T	353.14	78.07	221.58	248.85
Barite, crude	metric tons	42,254	36,211	56,829	190.6	USD/T	1.10	8.88	7.61	11.94
Bentonite	metric tons	34,126	26,278	31,510	68.8	USD/T	1.10	2.59	1.99	2.39
Bitumen	000 42-gn barrels	1,279	1,060	1,000	404.6	USD/mT	136.00	70.37	58.32	55.02
Calcite	000 metric tons	339	232	335	165.0	USD/T	1102.31	61.58	42.16	60.85
Cement, hydraulic	000 metric tons	19,100	19,000	21,000	48.8	USD/T	1102.31	1026.39	1021.01	1128.49
Common Clay	metric tons	10,973	10,167	12,467	12.2	USD/T	1.10	0.15	0.14	0.17
Construction sand	000 cubic meters	3,164	2,898	2,998	8.2	USD/mT	388.45	10.08	9.23	9.55
Crushed stone	000 cubic meters	114	287	203	10.3	USD/mT	388.45	0.45	1.15	0.81
Diatomite	metric tons	2,104	2,398	2,426	292.4	USD/T	1.10	0.68	0.77	0.78
Distillate fuel oil	000 42-gn barrels	55,618	51,474	69,496	151.7	USD/bbl	1000.00	8436.69	7808.09	10541.8

Commodity	Units	Qty 2010	Qty 2012	Qty 2014	Avg price	Unit of price	Conv. factor	Value 2010 (USD mn)	Value 2012 (USD mn)	Value 2014 (USD mn)
Dolomite	metric tons	2,260	743	60	115.0	USD/mT	1.00	0.26	0.09	0.01
Feldspar	000 metric tons	164	163	230	70.2	USD/T	1102.31	12.69	12.59	17.83
Gas, natural	mn cubic meters	275,579	267,794	214,200	3.2	USD/MMBtu	42380.00	36968.05	35923.72	28734.25
Gasoline, normal	000 42-gn barrels	17,436	18,944	23,105	170.1	USD/bbl	1000.00	2966.15	3222.69	3930.5
Gold, mine output	kilograms	723	264	85	1223.7	USD/oz.	35.27	31.21	11.40	3.67
Gypsum	000 metric tons	1,610	1,958	2,130	8.5	USD/mT	1000.00	13.70	16.67	18.13
Helium, liquid	million cubic meters	17	17	25	3.4	USD/cu m	1000000	57.72	57.72	84.88
Iron	000 metric tons	2,240	2,730	1,394	61.9	USD/T	1102.31	152.74	186.14	95.06
Kaolin	metric tons	71,065	100,97	181,06	140.2	USD/T	1.10	10.98	15.60	27.98
Kerosene/jet fuel	000 42-gn barrels	11,050	9,600	15,403	84.3	USD/bbl	1000.00	930.96	808.80	1297.70
Lime, hydraulic	000 metric tons	63	66	49	118.5	USD/T	1102.31	8.23	8.62	6.46
Limestone	000 metric tons	20,000	20,000	24,880	198.0	USD/T	1102.31	4365.15	4365.15	5430.20
Liquefied petroleum gas	000 42-gn barrels	90,874	76,572	95,120	100.2	USD/bbl	1000.00	9102.12	7669.61	9527.41

Note: Due to constraints of displayable space, the database is presented for given three years.

Explanation

1. The quantity extracted in 2010 of Liquefied Petroleum Gas is 90,874,000 42-gallon barrels.

2. The Average (Common) Price of Liquefied Petroleum Gas is 100.2 USD per 42-gallon barrel.
3. The conversion factor is 1000.
4. Economic value of LPG in 2010 is 9102.12 USD mn (90,874 * 100.2 * 1000 = 9102.12).
5. For 2012 & 2014 it is 7669.61 USD mn and 9527.41 USD mn respectively

Economic value for all minerals for Algeria is tabulated below:

Table 29 presents the economic value of minerals – Algeria (2010–2014).

Table 29. Economic value of minerals – Algeria (2010–2014).

Commodity	2010	2011	2012	2013	2014
Aggregates, crushed stone, gravel	78.07	169.17	221.58	224.22	248.85
Barite, crude	8.88	8.40	7.61	6.35	11.94
Bentonite	2.59	2.20	1.99	2.10	2.39
Bitumen	70.37	58.21	58.32	55.02	55.02
Calcite	61.58	61.58	42.16	48.57	60.85
Cement, hydraulic	1026.39	1021.01	1021.01	994.15	1128.49
Common Clay	0.15	0.15	0.14	0.16	0.17
Construction sand	10.08	13.06	9.23	8.39	9.55
Crushed stone	0.45	0.47	1.15	0.95	0.81
Diatomite	0.68	0.69	0.77	0.72	0.78
Distillate fuel oil	8436.69	8442.16	7808.09	7968.73	10541.85
Dolomite	0.26	0.26	0.09	0.01	0.01
Feldspar	12.69	11.45	12.59	20.02	17.83
Gas, natural	36968.05	36513.02	35923.72	35016.61	28734.25
Gasoline, normal	2966.15	3375.28	3222.69	3099.18	3930.54
Gold, mine output	31.21	19.38	11.40	6.04	3.67
Gypsum	13.70	13.70	16.67	17.69	18.13
Helium, liquid	57.72	57.72	57.72	84.88	84.88
Iron	152.74	137.26	186.14	111.26	95.06
Kaolin	10.98	10.98	15.60	6.57	27.98
Kerosene and jet fuel	930.96	749.24	808.80	1144.45	1297.70
Lime, hydraulic	8.23	8.23	8.62	6.27	6.46
Limestone	4365.15	4365.15	4365.15	4786.82	5430.20
Liquefied petroleum gas	9102.12	8349.31	7669.61	7682.33	9527.41
Lubricants	576.61	447.45	1144.50	1144.50	1362.50
Methanol	56.28	71.17	67.78	47.43	54.47
Naphtha	4134.70	3865.48	3532.20	3644.33	3667.72
Natural gas plant liquids	2616.00	2289.48	2033.00	2081.02	2079.28

Commodity	2010	2011	2012	2013	2014
Nitrogen	317.73	314.02	377.57	328.32	820.80
Petroleum, Crude	49151.12	47783.38	44727.81	45833.63	44378.60
Phosphate rock	184.36	155.50	151.08	139.06	171.32
Pig iron	263.92	136.51	132.72	113.76	113.76
Pozzolan	14.22	8.46	19.50	23.29	18.88
Residual fuel oil	2106.51	2145.03	1363.69	1537.69	2192.56
Salt, brine and sea salt	21.21	47.10	35.32	34.22	38.19
Silica sand	0.97	1.02	1.28	1.54	1.74
Silver	0.09	0.06	0.03	0.02	0.01
Steel	395.70	328.80	332.10	261.60	247.50
Stone	0.04	0.04	0.06	0.07	0.13
Sulfur	8.30	8.30	8.30	8.30	8.30
Tuff	593.31	554.43	554.43	554.43	554.43
Zinc	64.98	49.22	50.43	62.51	68.55

Total Economic Value (2010-2014) for all minerals for Algeria, i.e. the total Mineral value of Algeria is given below:

Table 30 presents the mineral value of Algeria (2010–2014).

Table 30. Mineral value of Algeria (2010–2014).

ALGERIA: Statistics	2010	2011	2012	2013	2014
Total Mineral Value (USD mn)	124822	121594	116003	117107	117014

6.6 Summary of the database of mineral value of 64 nations

Summary of the Economic Worth (Mineral Value) for all the 64 nations used in the research for the time period 2010 to 2013 is appended below for ready reference.

Table 31 presents the mineral value of all nations (2010–2013).

Table 31. Mineral value of all nations (2010–2013).

Sr. No	Mineral Value (USD mn)	2010	2011	2012	2013
1	United States	340271	358312	397016	359668
2	China	34787250	41075086	34635730	39740951
3	Japan	447848	462763	430174	345223
4	Germany	869243	882329	883093	865908
5	United Kingdom	655951	649894	588006	588958
6	India	260797	270026	279877	277234
7	France	109985	107583	96147	97871

Sr. No	Mineral Value (USD mn)	2010	2011	2012	2013
8	Brazil	1773281	1890668	1925578	1939853
9	Italy	254909	252443	252441	216594
10	Canada	1101688	1153411	1247554	1416651
11	Russia	9760917	10103695	10863288	11643462
12	Korea	989786	1002065	1145949	1146753
13	Australia	221395	245874	234806	226740
14	Spain	1165297	1127343	881483	839692
15	Indonesia	1089	1049	1123	801
16	Mexico	3764874	4381572	4511042	4377408
17	Turkey	1303608	1090486	1223343	1099964
18	Netherlands	76003	74062	72652	72692
19	Saudi Arabia	457802	491439	451689	484879
20	Switzerland	101975	116628	98800	134277
21	Argentina	847272	877807	560316	553222
22	Taiwan	21094	22954	21334	22201
23	Sweden	1278103	1181653	1320945	1333508
24	Poland	3209459	3213026	3216311	3233018
25	Belgium	37138	35598	34987	35384
26	Thailand	147295	179833	248342	274156
27	United Arab Emirates	108744	126193	128449	136213
28	Nigeria	101455	99351	100897	97817
29	Norway	413596	437272	407472	376504
30	Austria	98985	98184	105063	104512
31	Islamic Republic of Iran	657286	721138	728533	715929
32	Israel	19672	19531	19534	19530
33	Philippines	14902	16864	20855	27646
34	South Africa	8431704	8289183	7296733	8195571
35	Malaysia	70935	71931	71466	68997
36	Colombia	47841	52375	54939	54706
37	Denmark	16022	14808	15028	14126
38	Ireland	1040709	1044782	1025009	993042
39	Egypt	86656	88746	81918	79369
40	Venezuela	940330	942309	940150	873185
41	Pakistan	48344	31609	34130	34242
42	Chile	278025	268427	253069	248712
43	Bangladesh	5413	5629	5319	5275

Sr. No	Mineral Value (USD mn)	2010	2011	2012	2013
44	Central America	4912	5167	4711	5543
45	Finland	76329	87862	75344	76927
46	Vietnam	31600	32450	33006	32139
47	Peru	73011	74797	66389	68625
48	Portugal	41035	41299	39383	38450
49	New Zealand	7575	6866	7011	7149
50	Czech Republic	74208	84949	58516	56866
51	Greece	25032	20683	20497	18812
52	Romania	60351	47716	50589	50917
53	Iraq	92313	105654	114915	117046
54	Algeria	124822	121594	116003	117107
55	Qatar	105640	121128	128637	134091
56	Kazakhstan	80119	83849	87805	89185
57	Kuwait	107397	118067	121992	126111
58	Hungary	14270	14185	14468	13498
59	Kenya	124587	143251	152042	180204
60	Luxembourg	1409	1493	1335	1324
61	Tanzania	6607536	3103774	3078647	3257143
62	Bahrain	17684	17295	17523	16889
63	Zimbabwe	14089	14525	19582	17455
64	Central African Republic	7	7	8	5

This mineral value is the Most critical element in calculating the proposed Gross National Resource Product (GNRP)

7 Critical economic data of all nations

7.1 Purpose of the section

In order to calculate the proposed new Economic Growth Indicator, the required economic data critical to economic growth of a nation is:

- GDP
- Land Revenue, made up of
- Agriculture Revenue
- Mineral Revenue
- Population

Note: While the GDP is a measure of economic wealth of a nation acquired as a result of economic activity for a given time period, and population is considered as a multiplicative factor for boosting

economic growth, land revenue is considered to be the basis for economic activity i.e. the "economic potential" of the nation.

The concept of GDP is used in this research is to compare this existing measure of economic growth with the new proposed economic growth indictor which measures economic potential of nation. This comparison is necessary to achieve two purposes:

1. To curb excess economic growth through common distribution mechanism (equalize GDP with GNRP);
2. To regulate utilization of natural resources (optimize economic potential).

For this research study, land revenue is sub-divided into sub-soil (Mineral) and supra-soil (Agriculture) Revenue.

In earlier section we have already arrived at the database of mineral value of all 64 nations used in the research. In this section, the database of the other critical economic elements (GDP, Agriculture Revenue, and Population) are collated for the 64 nations. The time period is the same as for mineral value of nations. i.e. 2010 to 2013.

7.2 Gross domestic product (GDP)

GDP is a national accounting measure for economic growth. GDP is a measure of overall economic activity, co-existing and co-varying with many other economic variables. The GDP database for the 64 nations for the time period 2010-2013 is given below:

Table 32 presents the database of GDP values of 64 nations (2010–2013).

Table 32. Database of GDP values of 64 nations (2010–2013).

Sr No	Country	GDP 2010 (USD mn)	GDP 2011 (USD mn)	GDP 2012 (USD mn)	GDP 2013 (USD mn)
1	USA	14964372	15517926	16155255	16691517
2	China	6100620	7572554	8560547	9607224
3	Japan	5700098	6157460	6203213	5155717
4	Germany	3417095	3757698	3543984	3752514
5	UK	2429680	2608825	2646003	2719509
6	India	1656617	1823050	1827638	1856722
7	France	2646837	2862680	2681416	2808511
8	Brazil	2208872	2616202	2465189	2472807
9	Italy	2125058	2276292	2072823	2130491
10	Canada	1613464	1788648	1824289	1842628
11	Russia	1524916	2031769	2170144	2230625
12	Korea	1094499	1202464	1222807	1305605
13	Australia	1142877	1390557	1538194	1567179
14	Spain	1431588	1488017	1335946	1361776
15	Indonesia	755094	892969	917870	912524
16	Mexico	1051129	1171188	1186598	1261982

Sr No	Country	GDP 2010 (USD mn)	GDP 2011 (USD mn)	GDP 2012 (USD mn)	GDP 2013 (USD mn)
17	Turkey	771877	832546	873982	950596
18	Netherlands	836390	893757	828947	866680
19	Saudi Arabia	528207	671239	735975	746647
20	Switzerland	581209	696279	665054	684835
21	Argentina	423627	530163	545982	552025
22	Taiwan	377529	428186	465187	475257
23	Sweden	488378	563110	543881	578742
24	Poland	479321	528820	500344	524215
25	Belgium	483549	527008	497884	520117
26	Thailand	341105	370819	397560	420529
27	UAE	289880	350908	374818	390427
28	Nigeria	369062	411744	460954	514966
29	Norway	428527	498157	509705	522746
30	Austria	390212	429037	407452	428248
31	Iran	467790	592038	587209	511621
32	Israel	233755	261375	257642	293315
33	Philippines	199591	224143	250092	271836
34	South Africa	375349	416419	396328	366624
35	Malaysia	255017	297952	314443	323277
36	Colombia	287018	335415	369660	380192
37	Denmark	321995	344003	327149	343584
38	Ireland	221343	240591	225819	239271
39	Egypt	218888	236002	279373	288586
40	Venezuela	393191	316482	381286	371006
41	Pakistan	177407	213587	224384	231219
42	Chile	218538	252252	267122	278384
43	Bangladesh	115279	128638	133356	149990
44	Central America	153541	174915	189691	202286
45	Finland	247800	273674	256706	269980
46	Vietnam	115932	135539	155820	171222
47	Peru	147529	171762	192649	201218
48	Portugal	238303	244895	216368	226073
49	New Zealand	146581	168462	176193	190521
50	Czech Republic	207016	227948	207376	209402
51	Greece	299362	287798	245671	239862
52	Romania	167998	185363	171665	191549

Sr No	Country	GDP 2010 (USD mn)	GDP 2011 (USD mn)	GDP 2012 (USD mn)	GDP 2013 (USD mn)
53	Iraq	138517	185750	218001	234648
54	Algeria	161207	200013	209047	209784
55	Qatar	125122	167775	186834	198728
56	Kazakhstan	148047	192627	207999	236635
57	Kuwait	115419	154028	174070	174161
58	Hungary	130256	140092	127321	134680
59	Kenya	40000	41953	50413	55097
60	Luxembourg	53212	60005	56678	61808
61	Tanzania	31408	33879	39088	44333
62	Bahrain	25713	29157	30749	32899
63	Zimbabwe	10052	12072	14058	15224
64	Central Africa	1986	2213	2184	1519

Source of data: The World Bank

8 Relationship between ecology and economy

The relationship between ecology and economy is best summed by Mike Nickerson in his book "Planning for Seven Generations" (1993) xxvii wherein he states:

8.1 Economy is three-fifths of ecology

The progress of mankind can be charted on three axes- Social, Economic and Environmental. Economy is a subset of human society, and society in turn is wholly contained within the biophysical environment of the planet (see figure 1.A)

Figure 2 shows the embedded structure of ecology.

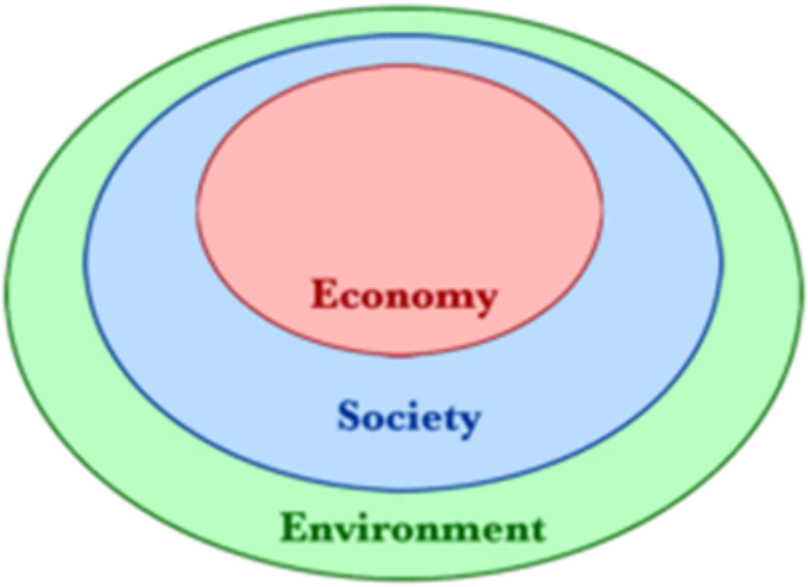


Figure 2. Embedded structure of ecology.

Table 33 presents the comparison of environmental vs ecological economics.

Table 33. Comparison of environmental vs ecological economics.

Environmental Economics	Ecological Economics
applies tools of economics to address environmental problems	focuses on long-term environmental sustainability, issues of scale, nature, justice, and time (Malte Faber xxv)
mainstream economic analysis of the environment	addresses interdependence and coevolution of human economies and natural ecosystems over time and space
Emphasizes cost-benefit analysis	Emphasizes upon preserving natural capital, non-substitutable by human capital
Stresses separability of economic values from scientific research	Stresses on strong sustainability and positional analysis
technological optimists	technological sceptics
welfare economics	well-being economics

8.2 Nature and ecology

Ecological economics consists of a complex circular flow of inputs in the form of natural resources and environmental services used as units of production. Once consumed, natural inputs pass out of the economy as pollution and waste. This concept is useful in understanding the planet as a closed economic system with natural resources as the input into the business cycle, and GDP as indicator of economic wealth produced as output.

Figure 3 shows the planet Earth: closed economic system.

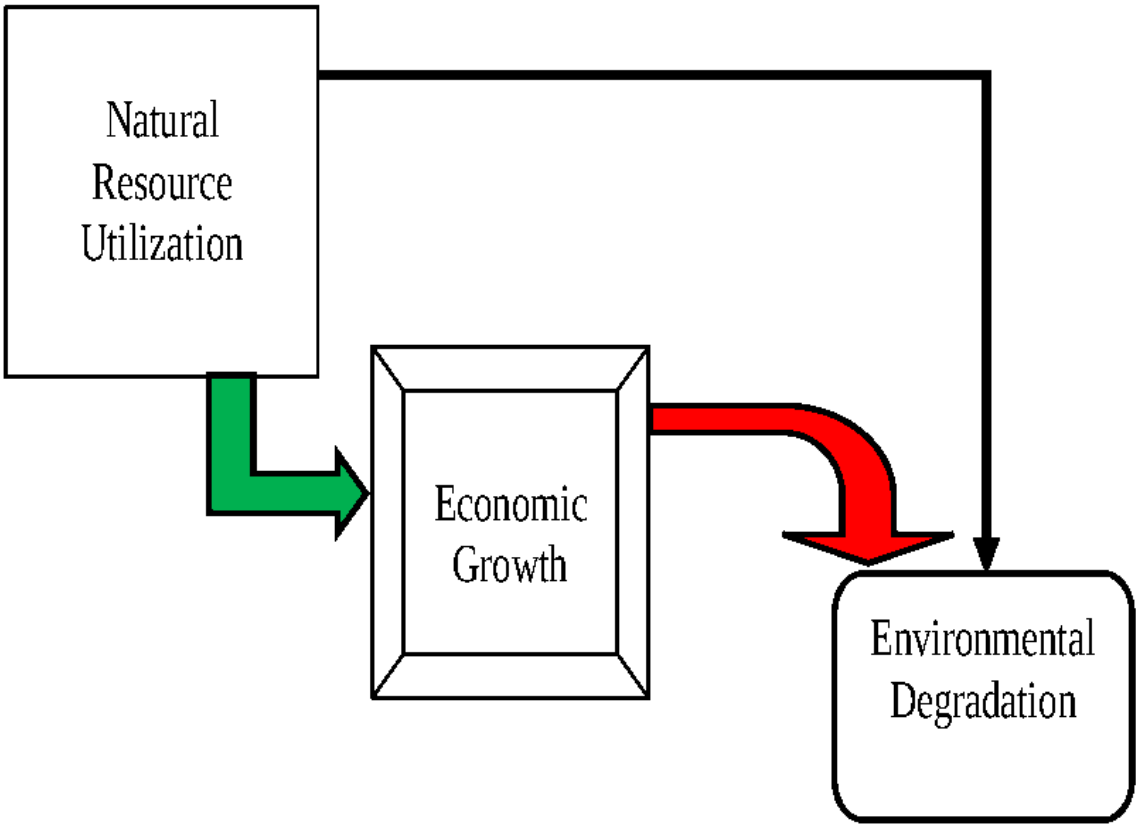


Figure 3. Planet Earth: closed economic system.

8.3 Economic valuation of the global ecosystem

This research attempts to evaluate world economy in order to arrive at a universal solution for global economic problems. The economic value of natural capital and ecosystem services is accepted by both environmental and ecological economics. The prerequisite condition is to maintain a stable environment before assessing the cost in dollar terms. This idea is central to the research undertaken, wherein a steady economic-environmental equilibrium state is proposed after valuation of the natural resources.

In 1997, Robert Costanza attempted valuation of the global ecosystem at $33 trillion with a range from $16 trillion to $54 trillion. In 1997, total global GDP was $27 trillion. The work was criticized by articles in Ecological Economics, Volume 25, Issue 1, but the critics acknowledged the positive potential for economic valuation of the global ecosystem.

The research evaluates management concepts of utility, efficiency, and cost-benefits such as positional analysis or multi-criteria analysis for sustainable development. It singularly addresses the underlying problems associated with mainstream economics such as growth, market capitalism and monetary valuation of the environment. A more meaningful relationship with nature and the non-human world is established, overriding shallow ecology (defn 40) and commodification of everything external to the market system.

Conclusion: This section addresses the topic of Environmental Economics as a broad area covering the symbiotic relationship between ecology and economy. The concept of the planet as a closed economic system is presented in this section.

9 Basic critical economic concepts discussed in the research

A brief review of the socio-economic concepts and issues dealt with during this research process is presented in this section, offering a holistic view of the research problem. This section covers the role of economics as a science, and economic activity as an anthropogenic function. An insight is offered into basic economic concepts like indicators of economic growth and their inadequacy, economic growth models, role of aggregation in economics, and the role of national accounting systems (SNA). The relation between economics and environment is explained in this section. Finally, the concept of sustainable growth is introduced.

9.1 Role of economic activity in human development

The anthropocentric aim of economic activity is maximizing profit. Adam Smith (1776) expounds the profit-only theory, while John Maynard Keynes (1936) propagates a more socioeconomic viewpoint. Economic activity enhances wealth and consumerism and increases well-being and prosperity.

Environmentalists consider 'human well-being in the present and future' as the final goal of economic systems.

Synergetic economic effects of cities extend to nation-state, successively forming medieval city economies, then national economies, and finally the phenomenon of "globalization" (Polanyi, 1957).

9.2 Economic growth and development

The scale of world economy in 1900 was USD 600 bn/year. At present, it is USD 16 trillion/year, expected to be 5 times by the next generation (source: WCED 1987, Brundtland commission).

The evolutionary anthropocentric growth engine considers environment as an infinite resource-provider for growth, and a perennial sink for waste and pollutants.

Hsieh and Hsing determine that economic growth brings mixed outcomes and is prerequisite to achieving the utopian state of economic equality. William Lyakurwa stresses the need to integrate development, climate change and environmental sustainability. Emil Urhammer states that economic growth is a powerful agent that determines policies regarding issues such as climate change, loss of biodiversity and pollution.

9.3 Defining economic growth

In the course of the history of anthropogenic development, mankind has reached a stage where economic growth is good for "economic" development, but unhealthy for "human" development. This economic growth is merely a market-friendly development which favors the rich and remains perennially unfair to the marginalized poor.

Economics is the art of managing resources.

Resources are necessary for growth. Managing resources is necessary because they are finite and scarce. Growth must therefore be limited.

Management of people, of businesses, of economy, is an outward, unattached, dis-involved process of man's outlook towards human growth and happiness. Managing of resources, on the other hand, is an inward, attached, involved process that creates harmony between man and nature, the primary stake-holders.

The ultimate purpose of growth is happiness of mankind. An integrated approach is necessary to achieve this goal.

Ecological Economics defines growth as a quantitative increase in economic output, and development as a qualitative improvement of the quality of life. But beyond modest levels, increased per-capita consumption does not lead to improvement in human well-being; rather it has harmful effects on the environment and social well-being on a larger scale. Economic and environmental objectives are often considered as contradictory, but this thesis attempts to prove that they can be achieved concurrently; i.e. economy and environment can go together.

In the context of this study, a business cycle is no more a cycle, but a race. It is an unending competition, wherein the nations with the highest GDP is the winner, and the ones with lower GDP remain marginalized, unless and until they obtain hefty loans from the IMF and the WB, just to remain significant in the (human) race. Thus, they are perennially entrapped in the vicious circle of poverty.

9.4 Real purpose of economic growth

Economic system enhances wealth and consumerism. Satisfaction of wants must lead to happiness. Instead, it is observed globally that there is misery due to skewed patterns of consumption and distribution of wealth.

Table 34 presents the desirable and undesirable effects of modern economic systems.

Table 34. Desirable and undesirable effects of modern economic systems.

Undesirable Effects	Desirable Effects
Greater inequality	Well-being of those deprived
Environmentally harmful	Resource conservation
Socially undesirable	Produce happiness

Environmentalists consider 'human well-being in the present and future' as the final goal of economic systems. Increased production and consumption are mere intermediaries.

Happiness is only marginally related to wealth; what matters are personality traits, security, relativity and temporal adjustments to changes in circumstances, and fairness in resource distribution. Human well-being is characterized by security, happiness, fairness, freedom, and participation. Sustainable development means undertaking economic activities that maintain or increase essential capital stock necessary for production.

The three Growth Goals are:

- Social justice
- Individual well-being
- Environmental sustainability.

9.5 Real growth

Globally, the ever-changing flux of macro dynamics, and the sterile inertness of macro statics cause economic disturbances, giving rise to cyclic business disruptions. These cause recessions and

depressions, booms and busts, economic disruptions which play havoc with micro level economies of nations, while destroying families and individuals.

The need of the hour is a middle path of macro constancy based on equilibrium economics. This study proposes a "Wealth Redistribution Model" for equitable growth at equilibrium point: the E3 concept.

Equilibrium Growth is the proposed Real Growth.

9.6 Drawbacks of economic growth

It makes sense to work with nature rather than mastering it (Ehrenfeld, 1978; Maffe, 1992)

The most sensitive aspect of economic growth concerns the distribution of wealth and the role of economic power in society. The biggest threat evolving out of economic growth is the human transformation of the natural environment. The biggest failure of economic progress is the "Ecological Footprint" that man leaves behind on the planet.

Friedman's 'Free Market theory' is misinterpreted by people who consider that increasing wealth is the "only legitimate purpose" of business; and that continuously rising GDP maintains a strong and vital economy.

Calista Rajasingham writes about the causes leading to exploitation of the third world, while Jalali-Naini attributes causal factors for stagnant economies. Differentiation and disparity cause socioeconomic inequality. Li Yining states that social conflicts offset the economic progress made to improve living conditions.

The Alesina and Rodrik model demonstrates that greater inequality leads to lower equilibrium growth rate, while Banerjee and Duflo state that change in income distribution in any direction would reduce economic growth. Easterly and Levine both believe that the cause of declining economic growth is ethnic or cultural fractionalization.

In defining economic growth, value is reduced to economic value, development to economic development, success to economic success, utility to economic utility. Neglect of ecologically important distinctions such as location and regional differences create an "under-socialized" (Biesecker, 1994) and under-ecologized individual. No individual is expected to accept responsibility for social or environmental spillovers or externality.

9.7 GDP: accepted indicator of economic growth

While the GDP and the rest of the national income accounts may seem to be arcane concepts, they are truly among the great inventions of the twentieth century.

……Paul A. Samuelson and William D. Nordhaus

9.8 Correlation between economic growth and happiness

A growing economy increases human well-being. GDP is a measure of economic growth, not well-being. Well-being is measured by other alternative indicators of growth like Happiness Index (HI), Human Development Index (HDI), and Environmental Protection Index (EPI). Purchasing Power (PP) is another measure of economic activity which accounts for consumerism.

In order to understand the relation between GDP as an indicator of economic growth and other indicators of real growth (HDI and HI), consider the following data table for of the growth indicators for various nations for year 2014.

Table 35 presents the GDP, HDI & HI.

Table 35. GDP, HDI & HI.

Rank	GDP 2014	HDI 2014	HI 2014
1	United States	Norway	Switzerland
2	China	Australia	Iceland
3	Japan	Switzerland	Denmark
4	Germany	Netherlands	Norway
5	United Kingdom	United States	Brazil
6	France	Germany	Finland
7	Brazil	New Zealand	Netherlands
8	Italy	Canada	Sweden
9	India	Singapore	New Zealand
10	Russia	Denmark	Australia

Different nations are highest ranked for GDP, HDI, and HI in the same year 2014.

Inference: High GDP does not mean more well-being.

Table 36 presents the statistical data: GDP, HDI & HI.

Table 36. Statistical data: GDP, HDI & HI.

GDP v/s	Happiness Index	HDI	EPI
Correlation	0.21	0.322	-0.06
Co-variance	30640243381	30640243381	-2.97395E+11
R Square	0.04	0.103880239	0.0036

The statistical relationship for correlation and co-variance between GDP and indicators of well-being (HI, HDI, and EPI) show weak correlation for HI and HDI, and negative for EPI.

Inference: Higher Economic Growth results in more Environmental degradation.

Table 37 presents the statistical data: PPP, HDI & EPI.

Table 37. Statistical data: PPP, HDI & EPI.

PPP v/s	Happiness Index	HDI	EPI
Correlation	0.44	0.07	0.47
Co-variance	448.89	11.79	14023.20

The statistical relationship between PPP and well-being also show weak correlation for HI, HDI, and EPI.

Inference: More Consumerism does not mean more well-being. It also means more Environmental degradation.

9.9 National accounting systems (SNA)

National income is calculated to assess the value and amount of commodity production in an economy. It is the total income of production of commodities in a given time period. Robert Repetto states that current System of National Accounting undermines the idea of sustainable development promoted by the WECD (World Commission on Environment and Development).

9.10 Deficiency: growth indicators and SNAs

GDP, a measure of economic growth, is misinterpreted as a measure of human well-being. Ricardo Aguado and Jabier Martinez highlight the inconvenience and unsuitability of using GDP as a proper indicator for economic sustainability, while Simon Kuznets criticized the use of GDP as an indicator of wellbeing, since it measures only level of production. Fleurbaey points out that GDP ignores wealth distribution and variation, environmental damage, the quality of social relationships, health and economic and personal security.

Certain GDP-based reports chart India in Lower Middle-Income economies although World Bank's Report (2012) ranks India at No 4 with PPP at 4.06 Trillion. The same report charts Britain as the fifth largest economy although it includes Prostitution and Narcotics Industry income in measuring GDP.

9.11 Concept of sustainability

Economic growth and social sustainability must be combined with environmental sustainability in order to guarantee a better future for future generations

UN World Summit 2005 defines the three pillars of growth as economic, social and environmental. Sustainability enforces equality between the present and the future, and creates a balance between ecological, social and economic needs. As per Brundtland Report (1987), sustainable development is the development that meets the needs of the present without jeopardizing the needs of the future generations.

UN World Summit 2005 defines the three pillars of growth as economic, social and environmental. Sustainability enforces equality between the present and the future, and creates a balance between ecological, social and economic needs. As per Brundtland Report (1987), sustainable development is the development that meets the needs of the present without jeopardizing the needs of the future generations.

Hazel Henderson examines the conventional economic models, policy models, assumptions, institutional inertia and cultural values that are driving the world toward increasing unsustainability.

Li Yining proposes that sustainable development demands both natural and social harmony, while Ancy Treesa and Jincy Joseph recommend using resources judiciously. Stern explores limits to substitution between inputs in production, and their implications for sustainability.

9.12 Resource depletion and optimal management

The global ecosystem and the economic subsystem are finite due to physical limitations of resources. Mankind lives on a planet with finite resources, where consumption pattern of each inhabitant varies. Developing nations do not consume at the same rate as the industrialized nations.

The current rate of resource consumption and waste production is unsustainable. Sustainable growth requires setting limits on consumption, but the prerequisite condition is setting limits on utilization of natural resources. Our society must transform into one that utilizes a fraction of current energy and resources.

9.13 Misconceptions about natural resources

- Natural resources are so abundant that they have no marginal value.
- Natural resources are free gifts of nature.
- There are no investment costs to be written off.

9.14 Resource scarcity

Hervé Boulhol et al finds that natural resources endowment is responsible for the variation in economic performance of nations. Surowiecki has proved that the “curse of natural resources” is real, while Sachs and Warner have empirically demonstrated its existence despite commodity price controls.

9.15 Resource endowment

Factors of non-renewable resource supply have reduced the scarcity effect of depleting existing deposits. Hotelling’s assumption of a known, fixed resource stock has been falsified by new discoveries and technological advances in the search, extraction and utilization of minerals.

9.16 Valuation of natural resources

Mankind depends heavily on natural resources in world trade and hence is vulnerable to the biodiversity loss that could result from climate change (IPCC, 2001). Assigning monetary value to natural resources is a key process in influencing economic practices, policy, and decision-making. The economic value of natural capital accepted by mainstream environmental economics is of special significance in ecological economics. Natural Capitalism describes the global economy as being dependent on natural resources and ecosystem services that nature provides. Traditional industrial capitalism fails to assign any value to the natural resources. Ecological economic analysis and valuation continue to be guided by issues of intergenerational equity, irreversibility of environmental change, uncertainty of long-term outcomes, and sustainable development. This research study aims to overcome this deficiency by laying emphasize on assessing the economic value of the environment. Generally, the values related to direct and indirect use are estimated based on observed prices. Non-use values are estimated using a variant of “Choice modelling” method. The econometric model in this research attempts to model the decision process via "utility" preference made in the context of utility maximization and resource optimization.

9.17 Resource conservation

Natural resource economics deals with the optimal commercial exploitation of natural resource stocks. Both environmental and natural resource economics are associated with sustainability. The

theory of natural capitalism (Hawken, Lovins, Lovins) is concerned with resource conservation in production and considers natural services on par with physical capital.

9.18 Common ownership of natural resources and wealth

The planet provides natural resources freely and abundantly to mankind for basic consumption needs and for economic activity for satisfying desires, wants and comforts. Nations bound by geo-political boundaries are merely custodians and guardians of the resources. All wealth derived from utilization of resources is common property of mankind and must be distributed equally among all nation for the common good.

9.19 Wealth distribution

Amid rising concerns about globalization benefitting the world's richest more, India's wealthiest man Mukesh Ambani favors the free market economic model. He advocates that wealth creation should not be constrained as it is a precursor to the distribution of wealth.

Unscrupulous exploitation of natural resources and the environment degrades the quality of life; it destroys cultures and sinks the poor in misery. From social point of view, it is suggested that the profits of economic growth must be distributed among all the population.

Neoclassical theory relates distribution to production. Adam Smith explains how the "invisible hand" favors income distribution but not factor-price equalization, by arguing that the rich have a limited consuming capacity and hence are forced to share wealth with the poor. Gillian B. White discovers that wealth redistribution policies find little support from those very economically vulnerable groups who need income equality the most. Vivekinan Ashok observes the failure of redistribution methods to resolve increasing inequality.

9.20 Common wealth pool

Common ownership of resources and wealth mandates sharing the onus of the responsibility for managing the resources and creation of wealth through economic activity. A fair and equal wealth distribution mechanism is required to establish economic justice and parity.

In order to achieve this, this research study proposes two concepts:

- a "cumulative wealth pool" of all nations as a mathematical aggregate of the economic potential of individual nations at the beginning of a business cycle
- a "common pool of wealth" created out of the economic activity of all nations at the end of a business cycle

9.21 Dynamism and flux in economic behaviour

A dynamic economy is characterized by incessant and unpredictable changes of technology, consumers' preferences and the availability of natural resources, and endogenizes innovation, uncertainty and adaptation, part of the evolutionary process of the economy and society.

Economic systems are subject to dynamic behavior characterized by time lags and adjustments. Ragnar Frisch's theory of constant flux propounds a state of "dynamic macroeconomics" in which rates of adjustment are fast enough to create constant equilibrium.

Nobel laureates Finn E. Kydland and Edward C. Prescott researched on the time consistency of economic policy and the driving forces behind business cycles in dynamic and static macroeconom-

ics. Carmen M. Reinhart et al state that capital flow and commodity cycles have a causal relationship with economic crises. Classical economists attribute economic stability to the invisible hand of market forces, while Keynes attributes economic fluctuations to instability in monetary and credit system. Schumpeterian economics consider innovations as originating cause of cyclic fluctuations. J.M. Clark (Multiplier-Accelerator Interaction Theory) emphasizes the role of accelerators and multipliers in business fluctuation. This concept is manifested in the research wherein population of a nation is considered as a multiplier factor in deriving the economic wealth potential of a nation.

Conclusion: This section gave a brief review of the socio-economic concepts and the role of economics as a science. The relation between economics and environment and the concept of sustainable growth is introduced.

9.22 Pillars of sustainability

World Summit (UN, 2005) stated three mutually and interdependent reinforcing pillars of sustainable development: economic development, social development and environmental protection. Following figure describes these three main pillars of sustainability.

Figure 4 shows the the three pillars of sustainability.

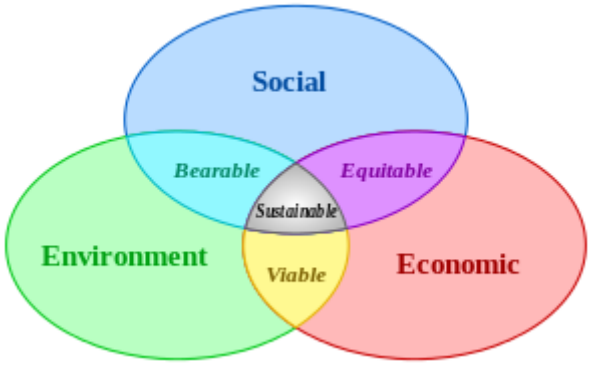


Figure 4. The three pillars of sustainability.

Figure 5 shows the the nested system of sustainability.



Figure 5. The nested system of sustainability.

9.23 Ideal economic equilibrium state

The most robust, self-sustaining, self-sufficient, and efficient form of economy in an ideal economic equilibrium state is when output is equivalent to the GDP.

9.24 Dynamism and flux in economic behaviour (time lags and adjustments)

Economic systems are subject to dynamic behavior characterized by time lags and adjustments. Ragnar Frisch's theory of constant flux propounds a state of "dynamic macroeconomics" in which rates of adjustment are fast enough to create constant equilibrium. Nobel laureates Finn E. Kydland and Edward C. Prescott researched on the time consistency of economic policy and the driving forces behind business cycles in dynamic and static macroeconomics. Carmen M. Reinhart et al state that capital flow and commodity cycles have a causal relationship with economic crises. Classical economists attribute economic stability to the invisible hand of market forces, while Keynes attributes economic fluctuations to instability in monetary and credit system. Schumpeterian economics consider innovations as originating cause of cyclic fluctuations. Clark emphasizes the role of accelerators and multipliers in business fluctuation.

9.25 Equilibrium/steady economic state

The most robust, self-sustaining, self-sufficient, and efficient form of economy in an ideal economic equilibrium state is when output is equivalent to the GDP.

The "Balance of Nature" theory proposes that ecological systems are usually in a stable equilibrium, governing the management of natural resources. Keynes emphasizes the need for stability and an equilibrium state of economy. Boedo and Hernan considers macroeconomic equilibrium too statistical for a larger scope of demography or ethnicity. Debreu & Scarf explained the relationship between core and competitive equilibrium in determining prices. The neoclassic general economic equilibrium model suggests that the solution for economic equilibrium is the fixed-point theorem Note 7. Kakutam's "Fixed Point theorem" determines equilibrium prices along with production and distribution plans in an equilibrium model. Charles Perrings discusses analysis of change in economy-environment systems and linkages between resilience and stability of dynamical systems.

9.26 Common pricing

Consider the basic formula for GNP, given in Equation (10):

$$GNP = \text{Price} \times \text{Quantity} \tag{10}$$

Real GNP is an index of change in quantity. Regulation of the "Quantity" factor will ensure a static physical static state for economic equilibrium. For achieving the economic state of constancy, it is proposed to remove the dynamic influence of the "Price" factor (change in price), by introducing the concept of "Constant Pricing" or "Common Pricing".

The Theory of Utility supports common pricing. At constant prices, most of these fluctuations would cease, gradually leading to a state of economic equilibrium. In General Equilibrium model, approximation of fixed points of continuous mapping determines equilibrium prices and activity levels. The use of price-adjustment technique based on supply-demand function sets the final condition for algorithm to calculate equilibrium prices and production plans. This concept is applied in the research by proposing a constant price scalar in order to achieve the proposed equilibrium state.

10 Central research problem and research questions

The central research problem concerns economic disequilibrium, unsustainable growth, and resource depletion. The basic questions that the research proposes to seek answers to are:

- Is it possible to achieve a state of perfect equilibrium between economic growth and environmental decline?
- Can natural resources of the world be utilized optimally for achieving sustainable growth?
- If the resources are made freely available to mankind by earth, can the proceeds of the wealth be distributed equally among the nations and people?

10.1 Purpose of research

The subject of the research is a lively and vibrant topic of international academic interest, adding socio-economic value in intellectual circuits globally. The driving force is the pursuit of knowledge about a subject that deeply affects humanity and the planet, and the possibility of contributing an evolutionary dimension to the existing economic dynamics and adding to the existing knowledge base on the subject, at the same time, gaining meaningful insight about the multi-faceted aspect of the planet's economic environment.

The purpose of the research is a studious commitment to learn the inter-disciplinary approach, to explore new patterns of collective thinking, and to facilitate direction and implementation of new economic and environmental policies.

10.2 Research aims and objectives

The research aims to introduce new evolutionary concepts in economics by designing a system wherein economic growth and environmental decline will be balanced at equilibrium point, and to develop a model of distribution of wealth created out of economic activity, through the optimal utilization of natural resources, in order to achieve and maintain sustainability of ecosystem. The aim of this research is primarily to discover the equilibrium point at which planned resource utilization sustains world economic growth. The research tries to establish the linkage between world economic system and environmental ecosystem based on valuation of the natural resources of the world and assigning a constant Universal Economic Index. The study involves research about the world's economy and ecosystem for a dynamic world over a 10-year time horizon. The main objective of the research is to formulate an economic growth indicator accounting for utilization and valuation of natural resources; which, in turn, would form the foundation for an econometric decision model based on Law of Conservation of Energy to maintain constant equilibrium point between Economic Growth and Ecosystem sustainability, and to make it operational for predicting future economic growth.

10.2.1 Primary objectives

1. To formulate an econometric model for equilibrium between economic growth and environmental decline: Economic-Environmental Equilibrium (E3) model
2. To derive a distributive model of wealth created from economic activity as well as environmental resource evaluation: Wealth Distribution (WDM) Model
3. To propose an alternative indicator of economic growth potential based on valuation of environmental resources: Gross Natural Resource Product (GNRP)

10.2.2 Secondary objectives

- Common Pricing of minerals as DNA of economic growth (for macro-constancy)
- **Cumulative Wealth Pool of nations:** Universal Gross Domestic Product (UGDP)
- **Common Wealth Pool of natural resources:** Universal Gross Natural Resource Product (UGNRP)
- Database of production and pricing of all the natural resources of the world

Mathematically, the result expected from the study is: UGNRP equals UGDP.

10.3 Relationships between variables/constructs used in the model

Figure 6 shows the relationships between variables/constructs used in the model.

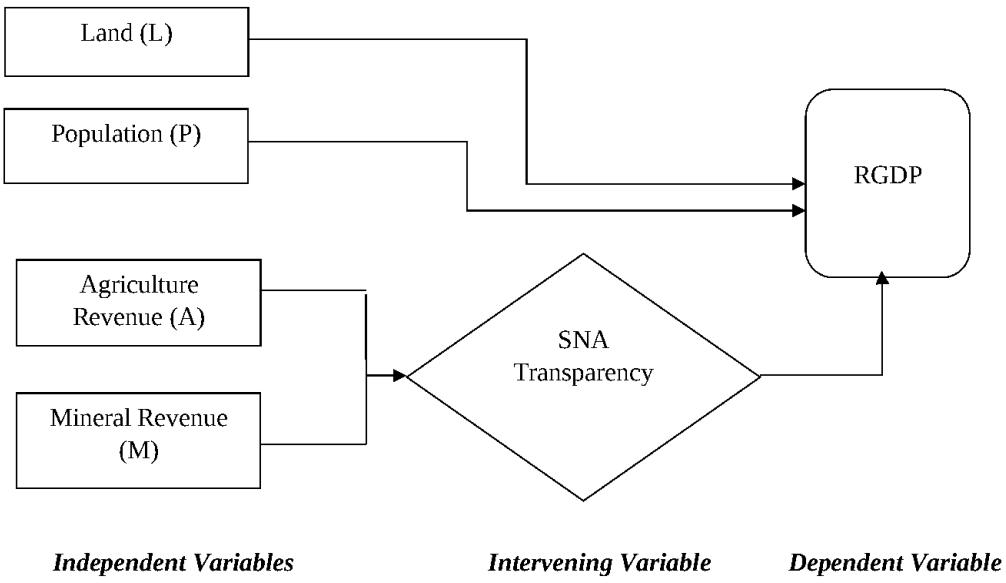


Figure 6. Relationships between variables/constructs used in the model.

11 Statistical framework and sample design

11.1 General framework

Type of Research: It is an exploratory type of research using secondary data from panel data framework which makes it possible to allow for differences in the form of unobservable individual country effects and ability to control for individual heterogeneity. Panel studies are able to control for state and time-invariant variables. Method of sampling used is non-probability, judgment, convenience sampling.

Statistical methods used: Regression analysis is the method adopted to reflect correlation between GDP growth and various factors of production. Correlation analysis is used for inferring correlation between GDP (dependent variable) and Land, Agriculture, Population, and Minerals (independent variables). The paper presented titled “Derivation of Constant UGDP using Econometric Models; Calculating Real GDP using Valuation of Key Natural Resources” presented at the 4th IRC at IIM-Ahmedabad- 'ICADABAI- 2015highlighted these methods.

Table 38 presents the factors of production for derivation of UGNRP and UGDP.

Table 38. Factors of production for derivation of UGNRP and UGDP.

1. GDP	4. Agriculture Revenue
2. Total population	5. Mineral Output
3. Surface area (Land)	6. Common Price Mechanism Note 8

Wealth Distribution Model (WDM) and Economic-Environmental Equilibrium Growth Model (E3 model) are proposed in the research, which also aims to establish the "Equilibrium Point for Sustainable Growth" (at which the E3 Growth model becomes functionally viable).

11.2 Sample design

11.2.1 Part I: data compilation

Data Collection Method: Secondary data is used for statistical analysis of macroeconomic components of the various factors of economics from various sources. The characteristics of the data for statistical purpose are presented in tabular form as follows:

Table 39 presents the characteristics of the data used in the research study.

Table 39. Characteristics of the data used in the research study.

Type of data	Pooled cross-sectional and Time series data (Panel data)
Periodicity	Annual
Unit of Analysis	Nations (the level of aggregation of data)
Study Setting	Contrived, Artificial, Stimulated
Time Horizon	One shot/cross-sectional
Variables (Objects)	Economic Growth potential of Nations of the World
Attributes/Characteristics	Land area, Population, Agriculture Revenue, Mineral Revenue (derived), GDP

Aggregation of Data: Data is aggregated for statistical analysis purpose as follows:

Table 40 presents the aggregation of data for statistical analysis.

Table 40. Aggregation of data for statistical analysis.

Over different Time periods	Time Series data
Group of Nations in one year	Cross –section data
Group of Nations over many years	Panel data
Multivariate data over several geographic areas	aggregate cross section data
developed, developing, transient economies	strata of nations
Multivariate data over time for all Universe	aggregate time series data

11.2.2 Sampling method

The type of sampling used is non-probability sampling. The samples used are convenience samples based on data availability. Judgment sampling is used for selecting nations having significant economic growth in relation to world GDP.

11.2.3 Sample size

i) Nations' database

The universal sample size is 191 is Countries/Economies. The database contains projected GDP's of the 191 Countries/ Economies in current prices (U.S. dollars) of year 2017 and 2022. Data is based on projection by IMF outlook April 2017. Gross World Product in 2017 is projected at $77.99 trillion, and its GDP (PPP) is forecasted at $126.69 trillion.

The list of nations is derived from the International Monetary Fund (IMF) which is an organization of 189 countries, working to foster global monetary cooperation, secure financial stability, facilitate international trade, promote high employment and sustainable economic growth, and reduce poverty around the world.

Following table lists the sample size for the research.

Table 41 presents the sample of 64 nations used in the research.

Table 41. Sample of 64 nations used in the research.

S. No.	Country/Economy	Sr. No	Country/Economy	Sr. No	Country/Economy
1	United States	23	Sweden	45	Finland
2	China	24	Poland	46	Vietnam
3	Japan	25	Belgium	47	Peru
4	Germany	26	Thailand	48	Portugal
5	United Kingdom	27	United Arab Emirates	49	New Zealand
6	India	28	Nigeria	50	Czech Republic
7	France	29	Norway	51	Greece
8	Brazil	30	Austria	52	Romania
9	Italy	31	Iran	53	Iraq
10	Canada	32	Israel	54	Algeria
11	Russia	33	Philippines	55	Qatar
12	Korea	34	South Africa	56	Kazakhstan
13	Australia	35	Malaysia	57	Kuwait
14	Spain	36	Colombia	58	Hungary
15	Indonesia	37	Denmark	59	Kenya
16	Mexico	38	Ireland	60	Luxembourg
17	Turkey	39	Egypt	61	Tanzania
18	Netherlands	40	Venezuela	62	Bahrain
19	Saudi Arabia	41	Pakistan	63	Zimbabwe
20	Switzerland	42	Chile	64	Central African Republic
21	Argentina	43	Bangladesh		
22	Taiwan Province of China	44	Central America		

The Region-wise breakup of the sample size of 64 economies is as follows:

Table 42 presents the region-wise breakup of the sample of 64 economies.

Table 42. Region-wise breakup of the sample of 64 economies.

Region/Area	Number of Economies
Europe	23
Africa	16
Asia	15
South Americas	6
North Americas	3
USA	1
Total	64

Top five economies account for 53.82 %, top ten accounts for approx. 67.19 %, top 20 economies add up to over 80% of World GDP. The sample size for the research is 64 Countries/Economies, as this sample size represents 95.63 % of the World GDP (in 2017).

Table 43 presents the share of the top economies in world GDP.

Table 43. Share of the top economies in world GDP.

Economy Unit	GDP (USD bn)	% of Ttl
Cumulative 64	74,577	95.63
World	77,988	

ii) Minerals database

The total number of commodities/minerals used in the research is 238.

Table 44 presents the commodities/minerals used in the research (238).

Table 44. Commodities/minerals used in the research (238).

No	Commodity	No	Commodity	No	Commodity
1	Abrasives	41	Calcareous	81	Ferronickel magnesium
2	Acid Clay	42	Calcite	82	Ferroniobium
3	Agate	43	Calcium carbonate (lime)	83	Ferrophosphorus
4	Aggregates	44	Carbon	84	Ferrosilicon
5	Alabaster	45	Caustic Soda	85	Ferrovanadium
6	Alexandrite	46	Cement	86	Fire Clay
7	Alginate	47	Chalk	87	Flagstone
8	Alumina	48	Chromite	88	Fluorspar
9	Aluminum	49	Clay	89	Fuel oil

No	Commodity	No	Commodity	No	Commodity
10	Amethyst	50	Clinker	90	Fuller's Earth
11	Ammonia	51	Coal	91	Gabbro
12	Amphibolite	52	Cobalt	92	Gallium
13	Andalusite	53	Coke, metallurgical	93	Garnet
14	Anthracite Coal	54	Construction sand	94	Gas Oil
15	Antimony	55	Copper	95	Gasoline
16	Apatite	56	Copper sulfate	96	Gemstones
17	Aquamarine	57	Coquina	97	Gemstones Crude
18	Aromatic Tar	58	Cordierite, Iolite	98	Geniss (feldspar)
19	Arsenic	59	Crude Oil	99	Germanium
20	Asbestos	60	Crushed & broken Stone	100	Glauberite
21	Asphalt	61	Cyclohexane	101	Gold
22	Attapulgite clay	62	Diamond	102	Granite
23	Avigas	63	Diaspore	103	Graphite
24	Ball (Clay)	64	Diatomite	104	Gravel
25	Barite	65	Diesel	105	Greywacke
26	Basalt	66	Dimension stone	106	Guano
27	Bauxite	67	Distillate fuel oil	107	Gypsum
28	Bentonite	68	Dolomite	108	Helium
29	Beryllium	69	Dunnite	109	Igneous rock
30	Biotite	70	Electrolytic, cathode4	110	Ilmenite
31	Bismuth	71	Emerald	111	Indium
32	Bitumen fuel	72	Ethane	112	Iodine
33	Bituminous Coal	73	Fe content	113	Iolite
34	Blister Copper	74	Feldspar	114	Iridium
35	Boron	75	Felsite	115	Iron
36	Brine, salt	76	Ferro Titanium	116	Iron Oxide pigments
37	Briquets (Peat)	77	Ferrochromium	117	Jadeite
38	Bromine	78	Ferrochromium silicon	118	Jasper
39	Butane	79	Ferromanganese	119	Kaolin
40	Cadmium	80	Ferromolybdenum	120	Kerosene and jet fuel
121	Kyanite	161	Phosphate rock	201	Silica
122	Lead	162	Phosphatic Fertilizer	202	Siliceous earth
123	Leonardite	163	Phosphoric acid	203	Silicomanganese
124	Leucoxene	164	Phosphorite	204	Silicon
125	Lignite	165	Pig iron	205	Sillimanite

No	Commodity	No	Commodity	No	Commodity
126	Lime	166	Pigments, Iron oxide	206	Silver
127	Limestone	167	Platinum	207	Slate
128	Liquefied petroleum gas	168	Porphyry	208	Soda ash
129	Lithium	169	Potash	209	Sodium Sulfate
130	Lubricants	170	Potassium Nitrate	210	Solvent (Toluene)
131	Magnesite	171	Pottery Clay	211	Sponge iron
132	Magnesium	172	Pozzolan	212	Steatite
133	Manganese	173	Propane	213	Steel, crude
134	Marble	174	Pumice, pumicite	214	Stone
135	Marl (lime)	175	Pyrite	215	Strontium
136	Mercury	176	Pyrochlore (niobium)	216	Sulfur
137	Methanol	177	Pyrope	217	Sulfuric acid
138	Mica	178	Pyrophyllite (Talc)	218	Talc
139	Moldavite	179	Pyroxenite	219	Tantalum
140	Moler (Diatomite)	180	Quartz and quartzite	220	Tanzanite
141	Molybdenum	181	Rare-earths	221	Tellurium
142	Monazite	182	Refinery gas	222	Tin
143	Naphtha	183	Residual fuel oil	223	Titanium, slag
144	Natural Gas	184	Rhenium	224	Topaz
145	Natural gas liquid	185	Rhodium	225	Tourmaline
146	Nepheline syenite	186	Rhodochrosite	226	Travertine
147	Nickel	187	Rock salt	227	Tuff
148	Niobium	188	Ruby	228	Tungsten
149	Nitrogen	189	Ruthenium	229	Ulexite
150	Obsidian	190	Rutile	230	Uranium
151	Olivine	191	Salable crude	231	Vanadium
152	Onyx	192	Salt	232	Vermiculite
153	Palladium	193	Sandstone	233	Volcanic sand
154	Paludal mud (clay)	194	Sapphire	234	White clay (kaolin)
155	Paraffin wax	195	Schist	235	Wollastonite
156	Peat	196	Selenite	236	Zeolite
157	Pentane	197	Selenium	237	Zinc
158	Perlite	198	Sepiolite clay	238	Zirconium
159	Petroleum Crude	199	Serpentine		
160	Petroleum Refinery	200	Shale		

Source of Mineral data: The research relies heavily on the mineral data from the secondary source of "USGS: Mineral Commodity Summaries", which is the National Minerals Information Centre website of United States Geological Survey of the U.S. Department of Interior (URL: minerals.usgs.gov/minerals). The website is: https://minerals.usgs.gov/minerals/ which gives information about the U.S. Geological Survey's National Minerals Information Center, including minerals information, commodity statistics and other information.

iii) Pricing of Minerals

Source: To ensure the tenets of Common Price mechanism, the Pricing structure for each mineral is given as follows for few sample nations.

Method 1: Price per unit for the period 2012 to 2016 is collated from USGS: Mineral Commodity Summaries, Jan 2017 database, and the average is calculated as base price.

Table 45 presents the average annual price of selected minerals (2012–2016).

Table 45. Average annual price of selected minerals (2012–2016).

Commodity	2012	2013	2014	2015	2016	Average	Unit
Abrasives	988	1030	1020	584	468	818.0	USD/T
Aluminum	101	94.2	104.5	88.2	80	424.5	USD/T
Antimony	565	463	425	327	300	1886.9	USD/T
Arsenic	75	72	75	84	88	1737.2	USD/T
Asbestos	931	1570	1510	1830	1610	1630.0	USD/T
Ball (Clay)	46	43	44	46	45	44.8	USD/T
Barite	187	180	191	197	198	190.6	USD/T
Bauxite	28	27	27	28	29	27.8	USD/T

Method 2: For other minerals, following source for Price per unit is adopted as per table given below (few sample nations from database):

Table 46 presents the other sources of price per unit of minerals.

Table 46. Other sources of price per unit of minerals.

Commodity	Avg	Unit	Source
Acid Clay	250.0	USD/mT	https://www.alibaba.com › Minerals & Metallurgy › bleaching earth
Alabaster	3.5	USD/lb.	https://www.sculpturehouse.com/s-267-alabaster.aspx
Alginate (sodium)	3750.0	USD/mT	https://www.alibaba.com › Chemicals › alginate › sodium alginate
Amethyst	25.5	USD/ carat	https://www.pricescope.com/community/threads/value-of-amethyst.117307/
Ammonia	425.0	USD/T	farmdocdaily.illinois.edu
Andalusite	40.0	USD/ carat	www.ebay.com/gds/Andalusite-Gemstone-Value-Price-and-Jewelry.../g.html
Anthracite Coal	42.6	USD/T	https://www.eia.gov/energyexplained/index.cfm?page=coal_prices
Aquamarine	175.0	USD/ carat	https://www.ajsgem.com/articles/aquamarine-prices.html

Commodity	Avg	Unit	Source
Aromatic Tar	425.0	USD/mT	https://www.alibaba.com › Energy › oil
Asphalt	117.5	USD/T	https://sciencing.com/how-6558396-calculate-asphalt-prices.html
Attapulgite clay	250.0	USD/mT	https://www.alibaba.com/showroom/attapulgite-clay-price.html
Avigas	305.6	USD/bbl	aviationweek.com/bca/jet-and-avgas-fuel-prices-august-2015

The final consolidated pricing structure for the 242 minerals is as given below:

Table 47 presents the consolidated pricing structure of all minerals.

Table 47. Consolidated pricing structure of all minerals.

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Abrasives	818.0	USD/T	Cadmium	1735.0	USD/T	Ferroman-ganese	2281.8	USD/T
Acid Clay	250.0	USD/mT	Calcareous	10.3	USD/mT	Ferromolyb-denum	5.6	USD/kg
Agate	0.5	USD/Ct	Calcite	165.0	USD/T	Ferronickel magnesium	8551.4	USD/T
Aggregates	8.7	USD/T	Calcium carbonate (lime)	118.5	USD/T	Ferroniobium	33.5	USD/Kg
Alabaster	3.5	USD/lb.	Carbon	26.0	USD/T	Ferro Phos-phorous	612.0	USD/T
Alexandrite	15000.0	USD/carat	Caustic Soda	425.0	USD/mT	Ferrosilicon	1380.0	USD/T
Alginate (so-dium)	3750.0	USD/mT	Cement	48.8	USD/T	Ferrovanadium	22.6	USD/Kg
Alumina	283.1	USD/T	Chalk	118.5	USD/T	Fire Clay	17.4	USD/T
Aluminum	424.5	USD/T	Chromite	270.0	USD/T	Flagstone	400.0	USD/T
Amethyst	25.5	USD/carat	Clay	12.2	USD/T	Fluorspar	325.0	USD/T
Ammonia	425.0	USD/T	Clinker	30.8	USD/T	Fuel oil	2.7	USD/gn
Amphibolite (feldspar)	70.2	USD/T	Coal	71.4	USD/T	Fuller's Earth	94.2	USD/T
Andalusite	40.0	USD/carat	Cobalt	14.2	USD/T	Gabbro (Di-mension stone)	10.3	USD/mT
Anthracite Coal	42.6	USD/T	Coke, metal-lurgical	200.0	USD/T	Gallium	422.2	USD/Kg
Antimony	1886.9	USD/T	Construction sand	8.2	USD/mT	Garnet	365.0	USD/T
Apatite (Phosphate rock)	84.3	USD/T	Copper	5593.7	USD/T	Gas Oil	56.0	USD/bbl

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Aquamarine	175.0	USD/ carat	Copper sulfate	2000.0	USD/ mT	Gasoline	170.1	USD/ bbl
Aromatic Tar	425.0	USD/mT	Coquina	45.9	USD/T	Gemstones	2005.0	USD/ carat
Arsenic	1737.2	USD/T	Cordierite, Iolite	450.0	USD/ Mt	Gemstones Crude	500.0	USD/ carat
Asbestos	1630.0	USD/T	Crude Oil	54.4	USD/ bbl	Geniss (feld-spar)	70.2	USD/T
Asphalt	117.5	USD/T	Crushed & broken Stone	10.3	USD/ mT	Germanium	1528.0	USD/ Kg
Attapulgite clay	250.0	USD/mT	Cyclohexane	1065.0	USD/ mT	Glauberite	90.0	USD/T
Avigas	305.6	USD/bbl	Diamond	1400.0	USD/ carat	Gold	1223.7	USD/ oz
Ball (Clay)	44.8	USD/T	Diaspore	581.8	USD/T	Granite	242.0	USD/T
Barite	190.6	USD/T	Diatomite	292.4	USD/T	Graphite	366.4	USD/T
Basalt	92.5	USD/mT	Diesel	121.8	USD/ bbl	Gravel	8.7	USD/ mT
Bauxite	27.8	USD/T	Dimension stone	10.3	USD/ mT	Greywacke (sandstone)	130.0	USD/T
Bentonite	68.8	USD/T	Distillate fuel oil	151.7	USD/ bbl	Guano	242.5	USD/ mT
Beryllium	230.0	USD/lb.	Dolomite	115.0	USD/ mT	Gypsum	8.5	USD/ mT
Biotite	450.0	USD/mT	Dunite	46.5	USD/T	Helium	3.4	USD/ cu m
Bismuth	8.2	USD/lb.	Electrolytic, cathode4	220.0	USD/T	Igneous rock	6.0	USD/ lb.
Bitumen fuel	404.6	USD/mT	Emerald	800.0	USD/ carat	Ilmenite	187.0	USD/ mT
Bituminous Coal	46.7	USD/T	Ethane	11.8	USD/ bbl	Indium	535.0	USD/ kg
Blister Cop-per	4756.0	USD/T	Fe content	90.4	USD/ mT	Iodine	34.6	USD/ kg
Boron	453.0	USD/T	Feldspar	70.2	USD/T	Iolite	97.5	USD/ carat
Brine, salt	140.0	USD/T	Felsite	69.7	USD/ mT	Iridium	22943.1	USD/ kg
Briquets (Peat)	56.6	USD/T	Ferro Titani-um	3770.0	USD/T	Iron	61.9	USD/T
Bromine	4025.0	USD/T	Ferrochromi-um	2480.0	USD/T	Iron Oxide pig-ments	950.0	USD/T
Butane	51.2	USD/bbl	Ferrochromi-um silicon	31325.0	USD/T	Jadeite	5000.0	USD/ carat

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Jasper	33069.4	USD/T	Perlite	26.0	USD/T	Sepiolite clay	1835.0	USD/T
Kaolin	140.2	USD/T	Petroleum Crude	79.7	USD/ bbl	Serpentine	1250.0	USD/ mT
Kerosene and jet fuel	84.3	USD/bbl	Petroleum Refinery	47.6	USD/ bbl	Shale	50.0	USD/ bbl
Kyanite	294.0	USD/mT	Phosphate rock	84.3	USD/T	Silica	107.0	USD/ mT
Lead	2169.3	USD/T	Phosphatic Fertilizer	425.0	USD/T	Siliceous earth	9.3	USD/T
Leonardite	200.0	USD/mT	Phosphoric acid	600.0	USD/T	Silicoman-ganese	948.4	USD/T
Leucoxene	778.0	USD/T	Phosphorite	125.0	USD/T	Silicon	267.6	USD/ Kg
Lignite	45.0	USD/mT	Pig iron	344.0	USD/T	Sillimanite	475.0	USD/T
Lime	118.5	USD/T	Pigments, Iron oxide	1.5	USD/ kg	Silver	17.5	USD/ oz.
Limestone	198.0	USD/T	Platinum	41724.8	USD/ kg	Slate	605.0	USD/T
Liquefied petroleum gas	100.2	USD/bbl	Porphyry	40.0	USD/ kg	Soda ash	138.1	USD/T
Lithium	6690.0	USD/mT	Potash	546.0	USD/T	Sodium Sulfate	135.2	USD/T
Lubricants	545.0	USD/bbl	Potassium Nitrate	675.0	USD/ mT	Solvent (Tolu-ene)	157.5	USD/ bbl
Magnesite	130.0	USD/mT	Pottery Clay	25.5	USD/T	Sponge iron	311.1	USD/T
Magnesium	2467.0	USD/mT	Pozzolan	60.0	USD/ mT	Steatite	167.0	USD/ mT
Manganese	187.1	USD/T	Propane	68.9	USD/ bbl	Steel, crude	300.0	USD/ mT
Marble	304.0	USD/T	Pumice, pumicite	34.1	USD/T	Stone	10.3	USD/ mT
Marl (lime)	118.5	USD/T	Pyrite	475.0	USD/ mT	Strontium	54.2	USD/T
Mercury	2476.2	USD/ flask	Pyrochlore (niobium)	24.6	USD/ Kg	Sulfur	87.6	USD/T
Methanol	549.0	USD/T	Pyrope	5000.0	USD/T	Sulfuric acid	280.0	USD/ mT
Mica	285.0	USD/mT	Pyrophyllite (Talc)	167.0	USD/ mT	Talc	167.0	USD/ mT
Moldavite	20000.0	USD/Kg	Pyroxenite	54.0	USD/T	Tantalum	221.2	USD/ Kg
Moler (Diat-omite)	292.4	USD/T	Quartz and quartzite	220000.0	USD/T	Tanzanite	675.0	USD/ carat

Commodity	Avg	Unit	Commodity	Avg	Unit	Commodity	Avg	Unit
Molybdenum	21.3	USD/Kg	Rare-earths	102712.1	US$/T	Tellurium	98.4	USD/ Kg
Monazite	9.1	USD/T	Refinery gas	84.0	USD/ bbl	Tin	20638.7	USD/T
Naphtha	549.5	USD/T	Residual fuel oil	43.1	USD/ bbl	Titanium, slag	716.8	USD/T
Natural Gas	3.2	USD/ MMBtu	Rhenium	2980.0	USD/ Kg	Topaz	20.0	USD/ carat
Natural gas liquid	8.1	USD/ MMBtu	Rhodium	33071.6	USD/ kg	Tourmaline	400.0	USD/ carat
Nepheline sy-enite	70.2	USD/T	Rhodochros-ite	30000.0	USD/ Kg	Travertine (limestone)	198.0	USD/T
Nickel	14109.0	USD/mT	Rock salt	113.3	USD/ mT	Tuff	923.5	USD/T
Niobium	24.6	USD/Kg	Ruby	1650.0	USD/ carat	Tungsten	301.6	USD/ mT
Nitrogen	480.4	USD/T	Ruthenium	2203.3	USD/ kg	Ulexite	754.1	USD/ mT
Obsidian	4409.2	USD/T	Rutile	822.6	USD/T	Uranium	25.7	USD/ lb..
Olivine	145.0	USD/T	Salable crude	61.5	USD/ bbl	Vanadium	5.1	USD/ lb..
Onyx	599.0	USD/T	Salt	179.5	USD/T	Vermiculite	338.5	USD/T
Palladium	22497.3	USD/kg	Sandstone	130.0	USD/T	Volcanic sand	190.0	USD/ mT
Paludal mud (clay)	12.2	USD/T	Sapphire	4000.0	USD/ carat	White clay (ka-olin)	140.2	USD/T
Paraffin wax	1085.0	USD/mT	Schist	75.0	USD/T	Wollastonite	360.0	USD/T
Peat	56.6	USD/T	Selenite	55000.0	USD/T	Zeolite	437.0	USD/ mT
Pentane	95.8	USD/bbl	Selenium	72977.5	USD/T	Zinc	2739.7	USD/T
						Zirconium	75000.0	USD/T

iv) Production of Minerals: Nation/Economy-wise

The aggregate production of minerals per nation/economy is considered for all 64 sample nations for the time period of 2010-2013 for analysis purpose. As example for Algeria is given below:

Table 48 presents the mineral production of Algeria.

Table 48. Mineral production of Algeria.

Commodity	Units	2010	2011	2012	2013	2014
Aggregates, crushed stone, gravel	thousand cubic meters	25,381	55,000	72,040	72,898	80,905

Commodity	Units	2010	2011	2012	2013	2014
Barite, crude	metric tons	42,254	40,000	36,211	30,245	56,829
Bentonite	metric tons	34,126	29,000	26,278	27,668	31,510
Bitumen	thousand 42-gallon barrels	1,279	1,058	1,060	1,000	1,000
Calcite	thousand metric tons	339	339	232	267	335
Cement, hydraulic	thousand metric tons	19,100	19,000	19,000	18,500	21,000
Common Clay	metric tons	10,973	11,000	10,167	11,829	12,467
Construction sand	thousand cubic meters	3,164	4,100	2,898	2,635	2,998
Crushed stone	thousand cubic meters	114	119	287	239	203
Diatomite	metric tons	2,104	2,132	2,398	2,224	2,426
Distillate fuel oil	thousand 42-gallon barrels	55,618	55,654	51,474	52,533	69,496
Dolomite	metric tons	2,260	2,260	743	60	60
Feldspar	thousand metric tons	164	148	163	259	230
Gas, natural	million cubic meters	275,579	272,187	267,794	261,032	214,200
Gasoline, normal	thousand 42-gallon barrels	17,436	19,841	18,944	18,218	23,105
Gold, mine output	kilograms	723	449	264	140	85
Gypsum	thousand metric tons	1,610	1,610	1,958	2,078	2,130
Helium, liquid	million cubic meters	17	17	17	25	25

12 Data analysis and interpretation

12.1 Economic worth of a nation: GNRP

Having tabulated the database about the nations, minerals, the production of minerals nation-wise, and the average price of minerals (for common pricing mechanism), the next step is to evaluate the economic worth of a nation based on its mineral composition and the common price. This will eliminate the cyclic economic fluctuations between nations caused by differential pricing.

Stage 1: For this purpose, the first step is to common-rate the differential units of measurement between quantitative and pricing units. This is achieved by conversion mechanism as tabulated below:

Table 49 presents the conversion factors between units of measurement and pricing units.

Table 49. Conversion factors between units of measurement and pricing units.

Unit of Measurement	Unit	Conversion factor	Unit of Measurement	Unit	Conversion factor
cubic meters	T	0.35	flask	lbs.	76
cubic meters	mT	0.39	million cubic meters	MMBtu	42380.00
kilograms	flask	0.02632	million cubic meters	bbl	7634.16

Unit of Measurement	Unit	Conversion factor	Unit of Measurement	Unit	Conversion factor
kilograms	T	0.00100	million cubic meters	T	350000.00
kilograms	mT	0.00091	million cubic meters	mT	317515.04
kilograms	ounce	35.27	42-gallon barrels	mT	0.14
kilograms	bbl	0.007	42-gallon barrels	T	0.12
kilograms	carat	5000.00	thousand 42-gallon barrels	mT	136.00
Metric tons	carat	5511550	thousand 42-gallon barrels	T	123.38
Metric tons	flask	29.01	thousand 42-gallon barrels	MMBtu	5551.37
Metric tons	T	1.10	thousand carats	Kg	0.20
Metric tons	Kg	1102.31	thousand carats	T	0.0002205
Metric tons	Lbs.	2204.62	thousand carats	mT	0.0002
Metric tons	mT	1.00	thousand cubic meters	MMBtu	42.38
Metric tons	Oz.	35274.00	thousand cubic meters	T	353.14
Metric tons	bbl	8.10	thousand cubic meters	mT	388.45
Ton	flask	26.32	thousand metric tons	barrels	8101.98
Ton	carat	5000000	thousand metric tons	MMBtu	133.47
Ton	bbl	7.35	thousand metric tons	T	1102.31

Stage 2: The next step is to obtain the year-wise economic value for the particular commodity/ mineral by multiplying the production quantity with the average price, using the conversion factor for neutralizing the difference in units of measurement.

An example of the nation Algeria is produced below. The product of (i) the quantity of commodity produced, (ii) the average price, and (iii) the Conversion factor, gives the economic value of that commodity for that year.

The Economic Value (in USD mn) for the years 2010, 2012, and 2014 are given below:

Table 50 presents the economic value of minerals for Algeria (2010, 2012 and 2014).

Table 50. Economic value of minerals for Algeria (2010, 2012 and 2014).

Com-modity	Units	Qty 2010	Qty 2012	Qty 2014	Avg price	Unit of price	Conv. factor	Value 2010 (USD mn)	Value 2012 (USD mn)	Value 2014 (USD mn)
Aggreg-ates,	000 cubic meters	25,381	72,040	80,905	8.7	USD/T	353.14	78.07	221.58	248.85
Barite, crude	metric tons	42,254	36,211	56,829	190.6	USD/T	1.10	8.88	7.61	11.94
Benton-ite	metric tons	34,126	26,278	31,510	68.8	USD/T	1.10	2.59	1.99	2.39

Commodity	Units	Qty 2010	Qty 2012	Qty 2014	Avg price	Unit of price	Conv. factor	Value 2010 (USD mn)	Value 2012 (USD mn)	Value 2014 (USD mn)
Bitumen	000 42-gn barrels	1,279	1,060	1,000	404.6	USD/mT	136.00	70.37	58.32	55.02
Calcite	000 metric tons	339	232	335	165.0	USD/T	1102.31	61.58	42.16	60.85
Cement, hydraulic	000 metric tons	19,100	19,000	21,000	48.8	USD/T	1102.31	1026.39	1021.01	1128.49
Common Clay	metric tons	10,973	10,167	12,467	12.2	USD/T	1.10	0.15	0.14	0.17
Construction sand	000 cubic meters	3,164	2,898	2,998	8.2	USD/mT	388.45	10.08	9.23	9.55
Crushed stone	000 cubic meters	114	287	203	10.3	USD/mT	388.45	0.45	1.15	0.81
Diatomite	metric tons	2,104	2,398	2,426	292.4	USD/T	1.10	0.68	0.77	0.78
Distillate fuel oil	000 42-gn barrels	55,618	51,474	69,496	151.7	USD/bbl	1000.00	8436.69	7808.09	10541.8
Dolomite	metric tons	2,260	743	60	115.0	USD/mT	1.00	0.26	0.09	0.01
Feldspar	000 metric tons	164	163	230	70.2	USD/T	1102.31	12.69	12.59	17.83
Gas, natural	mn cubic meters	275,579	267,794	214,200	3.2	USD/MMBtu	42380.00	36968.05	35923.72	28734.25
Gasoline, normal	000 42-gn barrels	17,436	18,944	23,105	170.1	USD/bbl	1000.00	2966.15	3222.69	3930.5
Gold, mine output	kilograms	723	264	85	1223.7	USD/oz.	35.27	31.21	11.40	3.67
Gypsum	000 metric tons	1,610	1,958	2,130	8.5	USD/mT	1000.00	13.70	16.67	18.13

Commodity	Units	Qty 2010	Qty 2012	Qty 2014	Avg price	Unit of price	Conv. factor	Value 2010 (USD mn)	Value 2012 (USD mn)	Value 2014 (USD mn)
Helium, liquid	million cubic meters	17	17	25	3.4	USD/ cu m	1000000	57.72	57.72	84.88
Iron	000 metric tons	2,240	2,730	1,394	61.9	USD/T	1102.31	152.74	186.14	95.06
Kaolin	metric tons	71,065	100,97	181,06	140.2	USD/T	1.10	10.98	15.60	27.98
Kerosene/ jet fuel	000 42-gn barrels	11,050	9,600	15,403	84.3	USD/ bbl	1000.00	930.96	808.80	1297.70
Lime, hydraulic	000 metric tons	63	66	49	118.5	USD/T	1102.31	8.23	8.62	6.46
Limestone	000 metric tons	20,000	20,000	24,880	198.0	USD/T	1102.31	4365.15	4365.15	5430.20
Liquefied petroleum gas	000 42-gn barrels	90,874	76,572	95,120	100.2	USD/ bbl	1000.00	9102.12	7669.61	9527.41

Stage 3: Carrying this further, the cumulative economic value for ALL minerals for the nation Algeria for the years 2010, 2012, and 2014 are calculated as tabulated below:

Table 51 presents the cumulative economic value of all minerals for Algeria.

Table 51. Cumulative economic value of all minerals for Algeria.

ALGERIA: MINERALS	Economic Value (USD mn)	Economic Value (USD mn)	Economic Value (USD mn)
Commodity	2010	2012	2014
Aggregates, crushed stone, gravel	78.07	221.58	248.85
Barite, crude	8.88	7.61	11.94
Bentonite	2.59	1.99	2.39
Bitumen	70.37	58.32	55.02
Calcite	61.58	42.16	60.85
Cement, hydraulic	1026.39	1021.01	1128.49
Common Clay	0.15	0.14	0.17
Construction sand	10.08	9.23	9.55

ALGERIA: MINERALS	Economic Value (USD mn)	Economic Value (USD mn)	Economic Value (USD mn)
Crushed stone	0.45	1.15	0.81
Diatomite	0.68	0.77	0.78
Distillate fuel oil	8436.69	7808.09	10541.85
Dolomite	0.26	0.09	0.01
Feldspar	12.69	12.59	17.83
Gas, natural	36968.05	35923.72	28734.25
Gasoline, normal	2966.15	3222.69	3930.54
Gold, mine output	31.21	11.40	3.67
Gypsum	13.70	16.67	18.13
Pig iron	263.92	132.72	113.76
Pozzolan	14.22	19.50	18.88
Residual fuel oil	2106.51	1363.69	2192.56
Salt, brine and sea salt	21.21	35.32	38.19
Silica sand	0.97	1.28	1.74
Silver	0.09	0.03	0.01
Steel	395.70	332.10	247.50
Stone	0.04	0.06	0.13
Sulfur	8.30	8.30	8.30
Tuff	593.31	554.43	554.43
Zinc	64.98	50.43	68.55
	124,822	116,003	117,014

Economic Value for 2010-2014 for minerals for the nation Algeria is calculated as below:

Table 52 presents the economic value of minerals for Algeria (2010–2014).

Table 52. Economic value of minerals for Algeria (2010–2014).

ALGERIA: Statistics	2010	2011	2012	2013	2014
Total Mineral Value (USD mn)	124822	121594	116003	117107	117014

Note: Some nations may have economic value data for the time period 2009-2013, and some for 2010-2014. This is due to data availability constraints, either for mineral production data or for mineral pricing data. But for the research purpose, only three-year common over-lapping time period of 2010 to 2013 is utilized. A special case for the USA is made where-in the Economic Value data for the time period 2009 to 2016 is presented.

Table 53 presents the economic value of minerals for the USA (2009–2016).

Table 53. Economic value of minerals for the USA (2009–2016).

USA: Statistics	2009	2010	2011	2012	2013	2014	2015	2016
Total Mineral Value (USD mn)	306590	340271	358312	397016	359668	362258	349802	357392

The cumulative database for the Economic Value (Mineral Value) for all the 64 sample nations is given below:

Table 54 presents the mineral value of the 64 sample nations (2010–2013).

Table 54. Mineral value of the 64 sample nations (2010–2013).

Sr. No	Mineral Value (USD mn)	2010	2011	2012	2013
1	United States	340271	358312	397016	359668
2	China	34787250	41075086	34635730	39740951
3	Japan	447848	462763	430174	345223
4	Germany	869243	882329	883093	865908
5	United Kingdom	655951	649894	588006	588958
6	India	260797	270026	279877	277234
7	France	109985	107583	96147	97871
8	Brazil	1773281	1890668	1925578	1939853
9	Italy	254909	252443	252441	216594
10	Canada	1101688	1153411	1247554	1416651
11	Russia	9760917	10103695	10863288	11643462
12	Korea	989786	1002065	1145949	1146753
13	Australia	221395	245874	234806	226740
14	Spain	1165297	1127343	881483	839692
15	Indonesia	1089	1049	1123	801
16	Mexico	3764874	4381572	4511042	4377408
17	Turkey	1303608	1090486	1223343	1099964
18	Netherlands	76003	74062	72652	72692
19	Saudi Arabia	457802	491439	451689	484879
20	Switzerland	101975	116628	98800	134277
21	Argentina	847272	877807	560316	553222
22	Taiwan	21094	22954	21334	22201
23	Sweden	1278103	1181653	1320945	1333508
24	Poland	3209459	3213026	3216311	3233018
25	Belgium	37138	35598	34987	35384
26	Thailand	147295	179833	248342	274156
27	United Arab Emirates	108744	126193	128449	136213

Sr. No	Mineral Value (USD mn)	2010	2011	2012	2013
28	Nigeria	101455	99351	100897	97817
29	Norway	413596	437272	407472	376504
30	Austria	98985	98184	105063	104512
31	Islamic Republic of Iran	657286	721138	728533	715929
32	Israel	19672	19531	19534	19530
33	Philippines	14902	16864	20855	27646
34	South Africa	8431704	8289183	7296733	8195571
35	Malaysia	70935	71931	71466	68997
36	Colombia	47841	52375	54939	54706
37	Denmark	16022	14808	15028	14126
38	Ireland	1040709	1044782	1025009	993042
39	Egypt	86656	88746	81918	79369
40	Venezuela	940330	942309	940150	873185
41	Pakistan	48344	31609	34130	34242
42	Chile	278025	268427	253069	248712
43	Bangladesh	5413	5629	5319	5275
44	Central America	4912	5167	4711	5543
45	Finland	76329	87862	75344	76927
46	Vietnam	31600	32450	33006	32139
47	Peru	73011	74797	66389	68625
48	Portugal	41035	41299	39383	38450
49	New Zealand	7575	6866	7011	7149
50	Czech Republic	74208	84949	58516	56866
51	Greece	25032	20683	20497	18812
52	Romania	60351	47716	50589	50917
53	Iraq	92313	105654	114915	117046
54	Algeria	124822	121594	116003	117107
55	Qatar	105640	121128	128637	134091
56	Kazakhstan	80119	83849	87805	89185
57	Kuwait	107397	118067	121992	126111
58	Hungary	14270	14185	14468	13498
59	Kenya	124587	143251	152042	180204
60	Luxembourg	1409	1493	1335	1324
61	Tanzania	6607536	3103774	3078647	3257143
62	Bahrain	17684	17295	17523	16889
63	Zimbabwe	14089	14525	19582	17455

Sr. No	Mineral Value (USD mn)	2010	2011	2012	2013
64	Central African Republic	7	7	8	5

This Mineral Value is the critical element in calculating the proposed Gross National Resource Product (GNRP).

Note: The production of mineral commodities is based on historical data. For forecasting purpose, the anticipated production is used as a control factor.

12.2 Comparison for derivation

4th Step: Having completed the evaluation of the mineral value for the nations, the next process involves the data collection of the other national level statistics data relevant to the research i.e. the Agriculture Revenue, the Population, the Land Area, and the Gross Domestic Product (GDP) for the same time period (2010-2013). Source: The World Bank.

The Gross Domestic Product (GDP) database for 2010-2013 is given below:

Table 55 presents the GDP of the nations (2010–2013).

Table 55. GDP of the nations (2010–2013).

Sr. No	GDP (Current USD mn)	2010	2011	2012	2013
1	United States	14964372	15517926	16155255	16691517
2	China	6100620	7572554	8560547	9607224
3	Japan	5700098	6157460	6203213	5155717
4	Germany	3417095	3757698	3543984	3752514
5	United Kingdom	2429680	2608825	2646003	2719509
6	India	1656617	1823050	1827638	1856722
7	France	2646837	2862680	2681416	2808511
8	Brazil	2208872	2616202	2465189	2472807
9	Italy	2125058	2276292	2072823	2130491
10	Canada	1613464	1788648	1824289	1842628
11	Russia	1524916	2031769	2170144	2230625
12	Korea	1094499	1202464	1222807	1305605
13	Australia	1142877	1390557	1538194	1567179
14	Spain	1431588	1488017	1335946	1361776

Agriculture Revenue as a percentage of the GDP for the nations is tabulated below:

Table 56 presents the agriculture revenue as a percentage of GDP (2010–2013).

Table 56. Agriculture revenue as a percentage of GDP (2010–2013).

Sr. No	Country/Economy	2010	2011	2012	2013
1	United States	175695	212096	200552	238079

Sr. No	Country/Economy	2010	2011	2012	2013
2	China	581401	714433	806399	893010
3	Japan	62983	66550	71201	57279
4	Germany	24579	30901	27722	35428
5	United Kingdom	17746	17711	17644	19443
6	India	312781	337750	332673	345140
7	France	47164	52694	48775	45699
8	Brazil	106960	133623	120840	130483
9	Italy	41841	47807	45375	49591
10	Canada	22964	30654	32108	33943
11	Russia	58975	80503	79628	85304
12	Korea	27046	30265	30071	30492
13	Australia	27148	34238	37560	38763
14	Spain	36520	36895	33634	37476
15	Indonesia	105179	120661	122756	121883

Land Area of the Nations (Sq. Km) is as given below for the nations:

Table 57 presents the land area of the nations (sq. km).

Table 57. Land area of the nations (sq. km).

Sr. No	Land Area (Sq. Km)	2010	2011	2012	2013
1	United States	9831510	9831510	9831510	9831510
2	China	9562911	9562911	9562911	9562911
3	Japan	377950	377955	377960	377962
4	Germany	357127	357140	357170	357340
5	United Kingdom	243610	243610	243610	243610
6	India	3287260	3287260	3287260	3287260
7	France	549087	549087	549087	549087
8	Brazil	8515770	8515770	8515770	8515770
9	Italy	301340	301340	301340	301340
10	Canada	9984670	9984670	9984670	9984670
11	Russia	17098250	17098250	17098250	17098250
12	Korea	100030	100030	100150	100266
13	Australia	7741220	7741220	7741220	7741220
14	Spain	505600	505600	505940	505940
15	Indonesia	1910930	1910930	1910930	1910930

Population (in millions) of the nations is tabulated below:

Table 58 presents the population of the nations (millions).

Table 58. Population of the nations (millions).

Sr. No	Population (million)	2010	2011	2012	2013
1	United States	309	312	314	316
2	China	1338	1344	1351	1357
3	Japan	128	128	128	127
4	Germany	82	80	80	81
5	United Kingdom	63	63	64	64
6	India	1231	1247	1263	1279
7	France	65	65	66	66
8	Brazil	197	199	201	202
9	Italy	59	59	60	60
10	Canada	34	34	35	35
11	Russia	143	143	143	144
12	Korea	50	50	50	50
13	Australia	22	22	23	23
14	Spain	47	47	47	47
15	Indonesia	243	246	249	252

The Total Land Revenue (sub-soil and supra-soil) is the sum of the Mineral Revenue and Agriculture Revenue. It is tabulated below:

Table 59 presents the total land revenue (sub-soil and supra-soil) of the nations.

Table 59. Total land revenue (sub-soil and supra-soil) of the nations.

Sr. No	Total Land Revenue (USD mn)	2010	2011	2012	2013
1	United States	515966	570408	597568	597747
2	China	35368652	41789519	35442129	40633961
3	Japan	510831	529313	501375	402502
4	Germany	893823	913230	910814	901336
5	United Kingdom	673696	667605	605650	608401
6	India	573578	607777	612550	622374
7	France	157149	160277	144922	143570
8	Brazil	1880241	2024291	2046418	2070336
9	Italy	296750	300250	297816	266185
10	Canada	1124652	1184065	1279663	1450594
11	Russia	9819892	10184198	10942916	11728765
12	Korea	1016832	1032330	1176019	1177246

Sr. No	Total Land Revenue (USD mn)	2010	2011	2012	2013
13	Australia	248543	280112	272366	265503
14	Spain	1201817	1164237	915117	877167
15	Indonesia	106267	121710	123878	122684

12.3 Stage 5: concept of gross natural resource product (GNRP)

The database for all nations (sample size 64) regarding GDP, Agriculture Revenue, Population, Land Area, and the Mineral Value of the nations is thus collated.

$$\text{Total land revenue} = \text{Mineral revenue} + \text{Agriculture revenue} \tag{11}$$

The Gross Natural Resource Product is the Total Land Revenue adjusted for the population considered as a multiplicative factor (pf: population factor).

$$GNRP = \text{Total land revenue} \times \text{Population} \tag{12}$$

For example, consider the economy of the USA.

Step 1: Land Revenue = Mineral Value + Agriculture Revenue

Table 60 presents the land revenue of the USA (step 1).

Table 60. Land revenue of the USA (step 1).

USA	2010	2011	2012	2013
(a) Total Mineral Value (USD mn)	340271	358312	397016	359668
(b) Agriculture Revenue (USD mn)	175695	212096	200552	238079
(x) Total Land Revenue (USD mn): {x= a + b}	515966	570408	597568	597747

Step 2: GNRP = Land Revenue * Population in bn

Table 61 presents the GNRP of the USA (step 2).

Table 61. GNRP of the USA (step 2).

USA	2010	2011	2012	2013
(c) Population (mn)	309.35	311.66	314.0	316.2
(d) Population (billion): (c) /1000	0.309	0.312	0.314	0.316
(x) Total Land Revenue (USD mn)	515966	570408	597568	597747
(z) GNRP (USD mn pf) [z = x * d]	159613	177775	187635	189010

The GNRP value for the sample size of 64 nations is provided below:

Table 62 presents the GNRP of the 64 sample nations (USD mn).

Table 62. GNRP of the 64 sample nations (USD mn).

Sr No	GNRP (USD mn pf)	2010	2011	2012	2013
1	United States	159613	177775	187635	189010
2	China	47312822	56170547	47871506	55155726
3	Japan	65422	67664	63990	51297
4	Germany	73094	73310	73253	72689
5	United Kingdom	42285	42232	38580	39016
6	India	706063	758041	773691	795743
7	France	10219	10473	9516	9475
8	Brazil	370024	402200	410432	419054
9	Italy	17591	17829	17732	16033
10	Canada	38244	40664	44469	50996
11	Russia	1402766	1455942	1567044	1683159
12	Korea	50388	51551	59036	59367
13	Australia	5476	6258	6190	6138
14	Spain	55977	54420	42803	40894
15	Indonesia	25772	29905	30831	30920
16	Mexico	445958	526477	550110	541838
17	Turkey	100017	85773	96949	88894
18	Netherlands	1528	1486	1461	1499
19	Saudi Arabia	12938	14289	13583	15002
20	Switzerland	831	963	827	1126
21	Argentina	36413	38406	25172	25227
22	Taiwan	636	690	690	723
23	Sweden	12061	11252	12652	12879
24	Poland	122629	122947	122996	123630
25	Belgium	450	435	438	441
26	Thailand	12312	15048	19952	21926
27	United Arab Emirates	899	1094	1143	1227
28	Nigeria	30072	31130	33887	35387
29	Norway	2059	2203	2077	1952
30	Austria	875	882	938	938
31	Islamic Republic of Iran	51404	57067	59235	59016
32	Israel	150	152	155	157
Sr. No	GNRP (USD mn pf)	2010	2011	2012	2013
33	Philippines	3700	4323	4887	5735
34	South Africa	430347	429340	383627	437378

Sr No	GNRP (USD mn pf)	2010	2011	2012	2013
35	Malaysia	2718	3037	2983	2925
36	Colombia	3132	3497	3672	3685
37	Denmark	114	112	119	108
38	Ireland	4756	4797	4713	4581
39	Egypt	9864	10566	9919	9970
40	Venezuela	27957	28270	28728	27077
41	Pakistan	14792	12742	15627	15892
42	Chile	4870	4777	4548	4523
43	Bangladesh	3948	4373	4378	4678
44	Central America	849	968	970	1021
45	Finland	446	514	446	462
46	Vietnam	4865	5483	5885	5956
47	Peru	2468	2620	2430	2548
48	Portugal	489	490	464	458
49	New Zealand	93	96	92	111
50	Czech Republic	814	949	672	657
51	Greece	387	337	326	301
52	Romania	1435	1235	1198	1252
53	Iraq	2840	3352	3767	3966
54	Algeria	5034	5111	5096	5346
55	Qatar	188	237	272	302
56	Kazakhstan	1423	1563	1637	1718
57	Kuwait	323	379	416	456
58	Hungary	189	206	202	195
59	Kenya	5612	6608	7277	8805
60	Luxembourg	1	1	1	1
61	Tanzania	305061	148154	151746	165678
62	Bahrain	22	22	23	22
63	Zimbabwe	217	229	311	286
64	Central African Republic	5	5	5	3

Stage 6: Having obtained the key statistical data for all nations, it is now time for the final results: To find the equilibrium point between economic growth and environmental disruption.

The database for GNRP (Resource value, economic potential of a nation at the beginning of economic cycle), and GDP (Created wealth, achieved economic performance at the end of the economic cycle) is tabulated for few sample nations as below:

Table 63 presents the GNRP and GDP of selected nations.

Table 63. GNRP and GDP of selected nations.

GNRP	USA	CHINA	JAPAN	GERMANY	UK	INDIA
2009	140775			68883		599635
2010	159613	47312822	65422	73094	42285	706063
2011	177775	56170547	67664	73310	42232	758041
2012	187635	47871506	63990	73253	38580	773691
2013	189010	55155726	51297	72689	39016	795743
2014	184761	51525965	47724		42337	
2015	173151					
2016	184482					
GDP(Current)	USA	CHINA	JAPAN	GERMANY	UK	INDIA
2009	14418739			3418005		1323940
2010	14964372	6100620	5700098	3417095	2429680	1656617
2011	15517926	7572554	6157460	3757698	2608825	1823050
2012	16155255	8560547	6203213	3543984	2646003	1827638
2013	16691517	9607224	5155717	3752514	2719509	1856722
2014	17393103	10482371	4848733		2998834	
2015	18036648					
2016	17069131					
GNRP	FRANCE	BRAZIL	ITALY	CANADA	RUSSIA	
2009	9396	326996	17320		1420388	
2010	10219	370024	17591	38244	1402766	
2011	10473	402200	17829	40664	1455942	
2012	9516	410432	17732	44469	1567044	
2013	9475	419054	16033	50996	1683159	
2014				63986		
2015						
2016						
GDP(Current)	FRANCE	BRAZIL	ITALY	CANADA	RUSSIA	
2009	2693827	1667020	2185160		1222644	
2010	2646837	2208872	2125058	1613464	1524916	
2011	2862680	2616202	2276292	1788648	2031769	
2012	2681416	2465189	2072823	1824289	2170144	
2013	2808511	2472807	2130491	1842628	2230625	
2014				1792883		

GNRP	USA	CHINA	JAPAN	GERMANY	UK	INDIA
2015						
2016						

The Cumulative and Mean values of UGNRP and UGDP are tabulated below:

Table 64 presents the cumulative and mean values of UGNRP and UGDP.

Table 64. Cumulative and mean values of UGNRP and UGDP.

YEAR	2010	2011	2012	2013	2014
CUMULATIVE GNRP (USD mn)	52005948	60953496	52785407	60267473	56432279
MEAN GNRP (USD mn)	812593	952398	824772	941679	881754
CUMULATIVE GDP (USD mn)	57213537	66370096	58199201	66007905	61914777
MEAN GDP (USD mn)	922799	1070485	938697	1064644	998625

The difference between GNRP and mean GNRP for few nations is tabulated below:

Table 65 presents the difference between GNRP and mean GNRP for selected nations.

Table 65. Difference between GNRP and mean GNRP for selected nations.

DIFFERENCE GNRP (USD mn)	2010	2011	2012	2013
USA	-640509	-760002	-624479	-738212
CHINA	46512700	55232770	47059392	54228503
JAPAN	-734700	-870113	-748124	-875926
GERMANY	-727028	-864468	-738861	-854534
UNITED KINGDOM	-757837	-895545	-773534	-888207

The difference between GDP and mean GDP for few nations is tabulated below:

Table 66 presents the difference between GDP and mean GDP for selected nations.

Table 66. Difference between GDP and mean GDP for selected nations.

DIFFERENCE GDP (USD mn)	2010	2011	2012	2013
USA	13999456	14446371	15061107	15568050
CHINA	5135705	6500999	7466398	8483757
JAPAN	4735183	5085905	5109065	4032250
GERMANY	2452179	2686143	2449836	2629046
UNITED KINGDOM	1464765	1537270	1551854	1596042
INDIA	691701	751495	733489	733255
FRANCE	1681922	1791125	1587268	1685044
BRAZIL	1243956	1544647	1371040	1349340

DIFFERENCE GDP (USD mn)	2010	2011	2012	2013
ITALY	1160143	1204738	978675	1007024
CANADA	648549	717093	730140	719161
RUSSIA	560001	960214	1075995	1107158

NOTE: It is necessary to understand the concept of the "Difference between UGNRP and UGDP", as this concept is the basic fulcrum on which rests the idea of equilibrium point between economic potential based on valuation of natural resources (UGNRP), and economic achievement (prevalent concept of UGDP as the value of all goods and services). This elusive point is the sought after Economic-Environmental-Equilibrium Point.

UGNRP is the value of all the natural resources (subsoil and supra-soil) which includes mineral revenue at common price and the agriculture revenue, adjusted for the population as multiplicative factor. It is an expected revenue potential calculated at the beginning of the economic cycle, and on which we have complete control.

In contrast to this, UGDP value is the value of economic performance at the end of the business cycle. It is a projected value, and as such, is subject to numerous variations during the course of the business cycles. The final UGDP value is often always in variation with the projected value, and this variation is the root cause of business cycles. The microeconomic fluctuations that give rise to cyclic variation are responsible for the economic disparity and discontent world over. Often, the victim of the uncontrolled economic growth engine is the environment.

This effect is manifested in the valuation of the UGNRP for the next year.

Only when the difference between the UGNRP and the UGDP is reduced to zero (nil), the Economic-Environmental-Equilibrium Point can be considered to have been achieved.

This stage implies that the cumulative value of the economic worth of the world at the beginning of the economic cycle is the same as (equal to) the economic worth at the end of the business cycle. There is no difference between expected and achieved economic worth. This is the state at which there is no profit-no loss for the world.

At this stage, all incentives for unplanned, uncontrollable, irregular, and false reporting of growth are neutralized.

The method to actualize this is:

1. Check the difference between the GDP and the mean UGDP for a nation for a particular year for the nation/economy (GDP – mean UGDP).
2. If the difference is a positive value, the difference (excess GDP) is to be added to the GNRP of that nation in the subsequent year (INJECT).
3. If the difference is a negative value, no action is to be taken for subsequent year.
4. The addition of excess GDP to the GNRP of that nation in the next year would ensure that the excess wealth created is ploughed back into the nation's economy for the next year. This will inflate the nation's wealth and subsequently get added onto the common wealth pool (UGNRP) of the next year.

This will ensure further dis-incentivization for unplanned and unwanted economic growth, and ensure re-distribution of created wealth.

For example, consider the table below for the year 2010 (base year)

Table 67 presents the excess growth and decision for the base year 2010.

Table 67. Excess growth and decision for the base year 2010.

DIFFERENCE (GDP-mean GDP) 2010	DIFFERENCE (GDP-mean GDP) 2010	DECISION	EXCESS GROWTH
DIFFERENCE (GDP-mean GDP) 2010	DIFFERENCE (GDP-mean GDP) 2010	DECISION	EXCESS GROWTH
USA	13984411	INJECT	13984411
CHINA	5120659	INJECT	5120659
JAPAN	4720137	INJECT	4720137
GERMANY	2437134	INJECT	2437134
UNITED KINGDOM	1449719	INJECT	1449719
INDIA	676656	INJECT	676656
FRANCE	1666876	INJECT	1666876
BRAZIL	1228911	INJECT	1228911
ITALY	1145097	INJECT	1145097
CANADA	633503	INJECT	633503
RUSSIA	544955	INJECT	544955
Rep of KOREA	114538	INJECT	114538
AUSTRALIA	162916	INJECT	162916
SPAIN	451627	INJECT	451627
INDONESIA	-224867	-	0
MEXICO	71168	INJECT	71168
TURKEY	-208084	-	0
NETHERLANDS	-143571	-	0
SAUDI ARABIA	-451754	-	0
SWITZERLAND	-398752	-	0

The decision for the next consecutive year (2011) for the nations is as tabulated below:

Table 68 presents the revised GNRP for 2011.

Table 68. Revised GNRP for 2011.

nation/economy 2011	GNRP (O)	DECISION	EXCESS GDP	REVISED GNRP
USA	177775	INJECT	13984411	14162186
CHINA	56170547	INJECT	5120659	61291206
JAPAN	67664	INJECT	4720137	4787801
GERMANY	73310	INJECT	2437134	2510443
UNITED KINGDOM	42232	INJECT	1449719	1491951
INDIA	758041	INJECT	676656	1434697
FRANCE	10473	INJECT	1666876	1677349

nation/economy 2011	GNRP (O)	DECISION	EXCESS GDP	REVISED GNRP
BRAZIL	402200	INJECT	1228911	1631110
ITALY	17829	INJECT	1145097	1162926
CANADA	40664	INJECT	633503	674168
RUSSIA	1455942	INJECT	544955	2000897
Rep of KOREA	51551	INJECT	114538	166089
AUSTRALIA	6258	INJECT	162916	169174
SPAIN	54420	INJECT	451627	506046
INDONESIA	29905	-	0	29905
MEXICO	526477	INJECT	71168	597645
TURKEY	85773	-	0	85773
NETHERLANDS	1486	-	0	1486
SAUDI ARABIA	14289	-	0	14289
SWITZERLAND	963	-	0	963

...where GNRP (O) is the original GNRP for the year 2011, and the Revised GNRP is the sum of GNRP (O) and the excess GDP is previous year (2010) for that nation.

Similarly, the data for the year 2011 for excess growth is tabulated below:

Table 69 presents the excess growth and decision for 2011.

Table 69. Excess growth and decision for 2011.

DIFFERENCE (GDP-mean GDP) 2011	DIFFERENCE (GDP-mean GDP) 2011	DECISION	EXCESS GROWTH
DIFFERENCE (GDP-mean GDP) 2011	DIFFERENCE (GDP-mean GDP) 2011	DECISION	EXCESS GROWTH
USA	14429659	INJECT	14429659
CHINA	6484288	INJECT	6484288
JAPAN	5069193	INJECT	5069193
GERMANY	2669432	INJECT	2669432
UNITED KINGDOM	1520558	INJECT	1520558
INDIA	734783	INJECT	734783
FRANCE	1774414	INJECT	1774414
BRAZIL	1527935	INJECT	1527935
ITALY	1188026	INJECT	1188026
CANADA	700381	INJECT	700381
RUSSIA	943502	INJECT	943502
Rep of KOREA	114197	INJECT	114197
AUSTRALIA	302291	INJECT	302291
SPAIN	399751	INJECT	399751

DIFFERENCE (GDP-mean GDP) 2011	DIFFERENCE (GDP-mean GDP) 2011	DECISION	EXCESS GROWTH
INDONESIA	-195297	-	0
MEXICO	82921	INJECT	82921
TURKEY	-255720	-	0

Derived data for revised GNRP for subsequent year (2013) is as tabulated below:

Table 70 presents the revised GNRP for 2013.

Table 70. Revised GNRP for 2013.

nation/economy 2013	GNRP (O)	DECISION	EXCESS GDP	REVISED GNRP	GDP
USA	189010	INJECT	15044042	15233052	16691517
CHINA	55155726	INJECT	7449334	62605060	9607224
JAPAN	51297	INJECT	5092000	5143297	5155717
GERMANY	72689	INJECT	2432771	2505460	3752514
UNITED KINGDOM	39016	INJECT	1534790	1573805	2719509
INDIA	795743	INJECT	716425	1512168	1856722
FRANCE	9475	INJECT	1570203	1579678	2808511
BRAZIL	419054	INJECT	1353976	1773029	2472807
ITALY	16033	INJECT	961610	977643	2130491
CANADA	50996	INJECT	713076	764072	1842628

The data for excess growth for the year 2013 is tabulated below:

Table 71 presents the excess growth and decision for 2013.

Table 71. Excess growth and decision for 2013.

DIFFERENCE (GDP-mean GDP) 2013	DIFFERENCE (GDP-mean GDP) 2013	DECISION	EXCESS GROWTH
DIFFERENCE (GDP-mean GDP) 2013	DIFFERENCE (GDP-mean GDP) 2013	DECISION	EXCESS GROWTH
USA	15550527	INJECT	15550527
CHINA	8466234	INJECT	8466234
JAPAN	4014727	INJECT	4014727
GERMANY	2611524	INJECT	2611524
UNITED KINGDOM	1578520	INJECT	1578520
INDIA	715732	INJECT	715732
FRANCE	1667521	INJECT	1667521
BRAZIL	1331817	INJECT	1331817
ITALY	989501	INJECT	989501
CANADA	701638	INJECT	701638

Corresponding data for revised GNRP for subsequent year (2014) is as tabulated below:

Table 72 presents the revised GNRP for 2014.

Table 72. Revised GNRP for 2014.

nation/economy 2014	GNRP (O)	DECISION	EXCESS GDP	REVISED GNRP
USA	184761	INJECT	15550527	15735288
CHINA	51525965	INJECT	8466234	59992199
JAPAN	47724	INJECT	4014727	4062451
GERMANY	73086	INJECT	2611524	2684610
UNITED KINGDOM	42337	INJECT	1578520	1620857
INDIA	758385	INJECT	715732	1474117
FRANCE	9921	INJECT	1667521	1677442
BRAZIL	400427	INJECT	1331817	1732244
ITALY	17296	INJECT	989501	1006797
CANADA	63986	INJECT	701638	765624

Note: The figures in yellow highlight are derived from historical data due to non-availability of actual data.

13 Forecasting the equilibrium point

The difference between UGNRP and UGDP (UGNRP – UGDP) is tabulated below:

Table 73 presents the difference between UGNRP and UGDP (USD mn).

Table 73. Difference between UGNRP and UGDP (USD mn).

YEAR	UGNRP	UGDP	Difference
2010	52005948	62717503	-10711555
2011	95361804	69649058	25712746
2012	90726738	71117633	19609105
2013	99033324	73023357	26009967
2014	96082237	73850628	22231609

(Note: all values in USD mn)

13.1 Stage a: trend analysis

The trend in difference between UGNRP and UGDP is presented graphically below:

Figure 7 shows the trend of variation in the difference between UGNRP and UGDP (2010–2014).

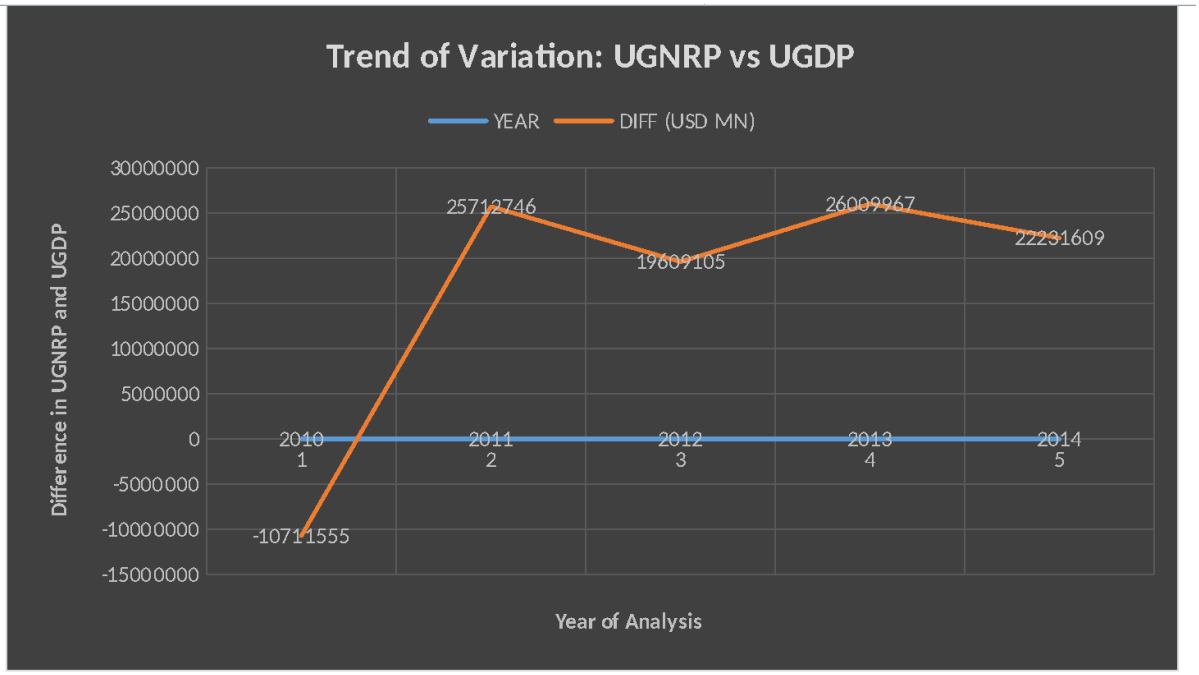


Figure 7. Trend of variation in the difference between UGNRP and UGDP (2010–2014).

Trend of variation in UGDP and UGNRP is tabulated below and also presented graphically:

Table 74 presents the trend of variation in UGDP and UGNRP (USD mn).

Table 74. Trend of variation in UGDP and UGNRP (USD mn).

52005948	**<**	**62717503**
UGNRP (Revised) vs UGDP (Act) 2011	UGNRP (Revised) vs UGDP (Act) 2011	UGNRP (Revised) vs UGDP (Act) 2011
95361804	>	69649058
UGNRP (Revised) vs UGDP (Act) 2012	UGNRP (Revised) vs UGDP (Act) 2012	UGNRP (Revised) vs UGDP (Act) 2012
90726738	>	71117633
UGNRP (Revised) vs UGDP (Act) 2013	UGNRP (Revised) vs UGDP (Act) 2013	UGNRP (Revised) vs UGDP (Act) 2013
99033324	>	73023357
UGNRP (Revised) vs UGDP (Act) 2014	UGNRP (Revised) vs UGDP (Act) 2014	UGNRP (Revised) vs UGDP (Act) 2014
96082237	>	73850628

(values in USD mn)

Figure 8 shows the trend of variation in UGNRP, UGDP and their difference (2010–2014).

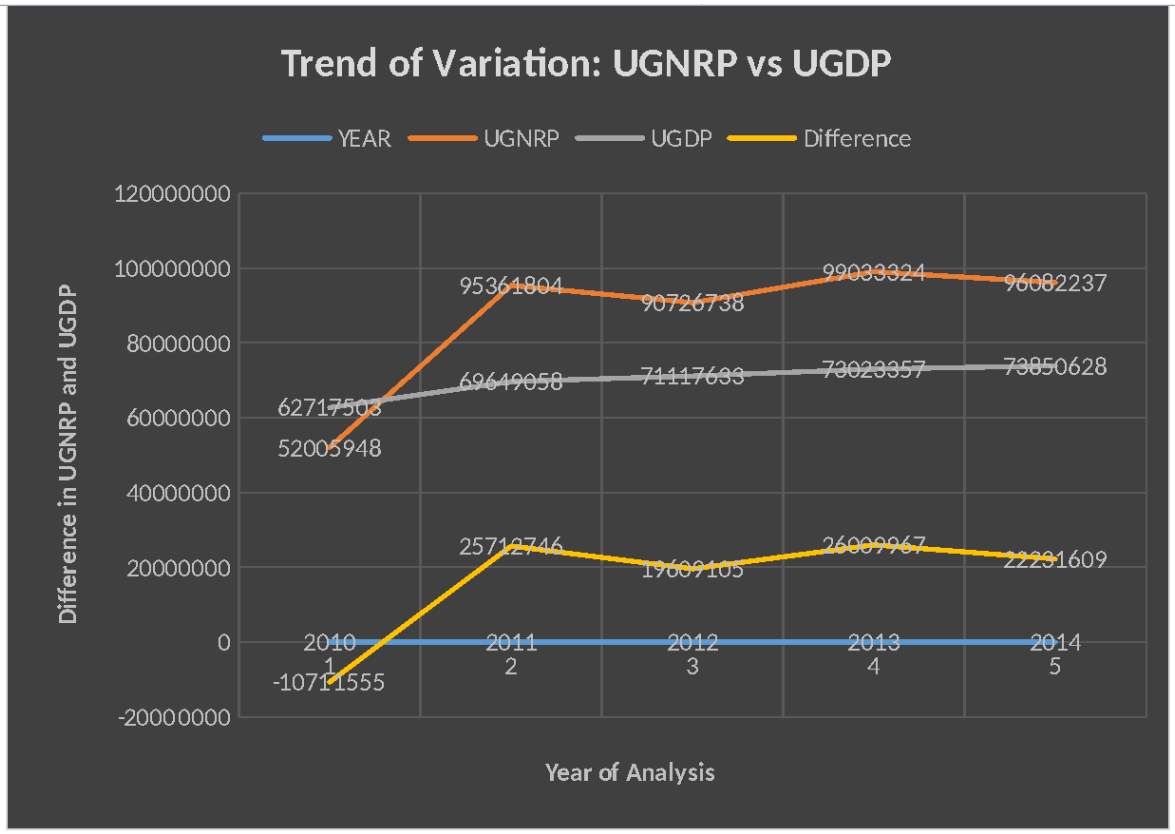


Figure 8. Trend of variation in UGNRP, UGDP and their difference (2010–2014).

13.2 Stage b: forecast analysis

The GDP (nominal as well as PPP) forecast as per StatisticsTimes.com for the year 2017 and 2022 is as tabulated below:

Table 75 presents the GDP forecast (nominal and PPP) for 2017 and 2022.

Table 75. GDP forecast (nominal and PPP) for 2017 and 2022.

Country/Economy	GDP Nominal (billions of $)	GDP Nominal (billions of $)	GDP PPP (billions of Int. $)	GDP PPP (billions of Int. $)	PPP/Nom
Country/Economy	2017	2022	2017	2022	PPP/Nom
World	77,988	99,956	126,688	168,202	1.624

Based on the growth rate calculated above, the cumulative GNRP for the sample size of 64 nations (UGNRP) is calculated for the year 2017 (97027202 USD mn).

Accordingly, the difference between the UGDP forecast and the derived UGNRP for the year 2017 is calculated as 22450256 USD mn.

Table 76 presents the difference between UGDP forecast and derived UGNRP for 2017.

Table 76. Difference between UGDP forecast and derived UGNRP for 2017.

YEAR	UGDP (USD mn)	UGNRP (USD mn)	Difference
2014	73850628	96082237	22231609

YEAR	UGDP (USD mn)	UGNRP (USD mn)	Difference
2017	74576946	97027202	22450256
Growth Rate	1.0098	(forecast)	(forecast)

The final aim of the research is to achieve zero difference between UGDP and UGNRP values, projected for the year 2022. The Forecast Table for 2017 and 2022 is presented below:

Table 77 presents the forecast of UGDP and UGNRP.

Table 77. Forecast of UGDP and UGNRP.

YEAR	DIFF (USD MN)
2010	-10711555
2011	25712746
2012	19609105
2013	26009967
2014	22231609
2015	
2016	
2017	22450256
2018	
2019	
2020	
2021	
2022	0
	Forecast

The Trend Analysis based on the forecast can be graphically depicted as follows:

- Moving Average Trend

Figure 9 shows the moving average trend of the difference between UGNRP and UGDP.

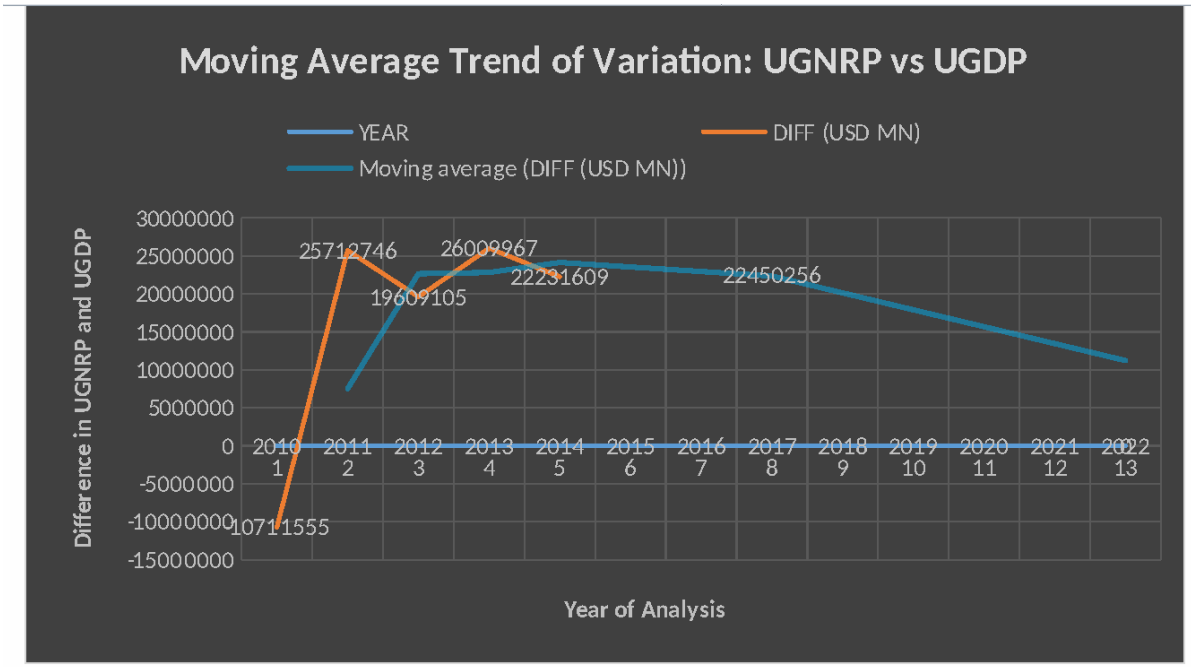


Figure 9. Moving average trend of the difference between UGNRP and UGDP.

- Linear Trend

Figure 10 shows the linear trend of the difference between UGNRP and UGDP.

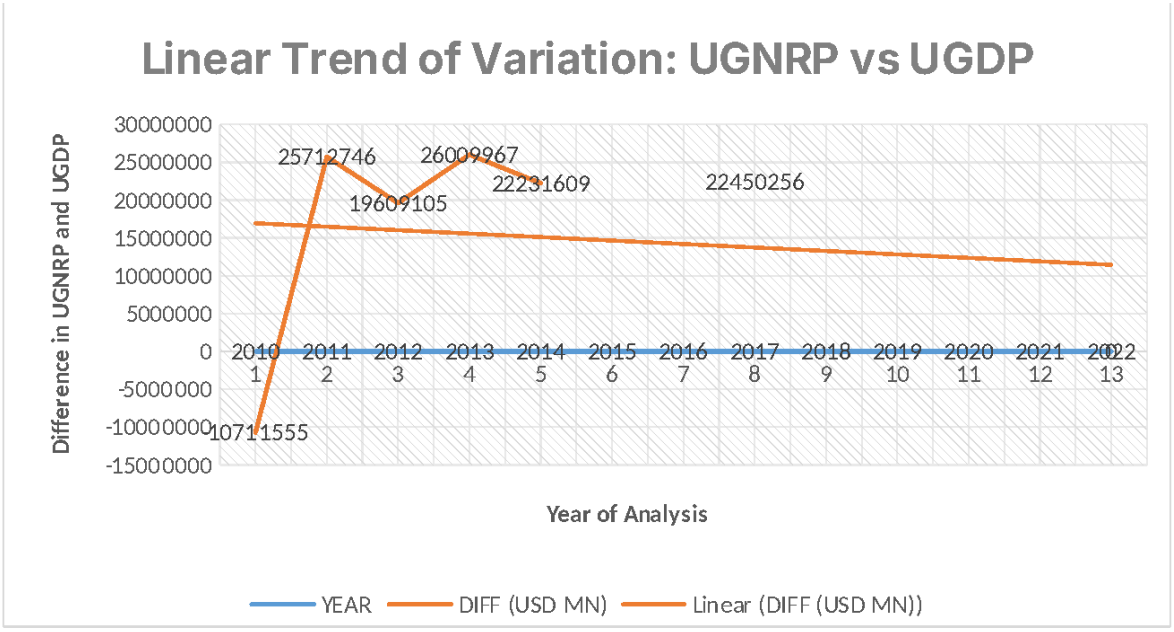


Figure 10. Linear trend of the difference between UGNRP and UGDP.

13.3 Stage c: projections

The Projected values of UGDP and UGNRP for the year 2022 based on the derived growth rate are as follows:

Table 78 presents the projected values of UGDP and UGNRP for 2022.

Table 78. Projected values of UGDP and UGNRP for 2022.

Projected UGDP 2022	95287011	Projected UGDP	Projected UGDP	95287011
Current UGDP 2014	73850628	Projected UGNRP	Projected UGNRP	72812695
Rate of Growth	29.0%			
Current UGNRP 2014	56432279			
Projected UGNRP 2022	72812695			

In order to achieve the target of "Zero difference" between UGNRP and UGDP, there are two ways that can be adopted

Method 1: UGDP value in 2022 equals the UGNRP value: Economic growth (UGDP) is planned first; natural resources are utilized to match this value. The natural resources extracted for economic growth must have an economic potential equal to a fixed growth plan.

In other words, Projected UGDP = UGNRP = 95287011 USD mn.

Method 2: UGNRP in year 2022 must be equal to the planned UGDP value: UGNRP value is determined first, the economic activity is planned and achieved accordingly. Economic Growth (UGDP) must be planned, regulated, and monitored in such a way as to equal the Economic Potential expected at the beginning of the economic cycle.

i.e. UGDP = Projected UGNRP = 72812695 USD mn

Method 1: In the first instance, the forecast table for UGDP (95287 USD bn) will be as follows:

Table 79 presents the forecast of UGDP towards USD 95,287 bn (method 1).

Table 79. Forecast of UGDP towards USD 95,287 bn (method 1).

YEAR	UGDP (USD bn)
2010	62718
2011	69649
2012	71118
2013	73023
2014	73851
2015	
2016	
2017	74577
2018	
2019	
2020	
2021	
2022	95287

Graphically, this can be depicted as follows:

The Moving average trend towards UGDP 95287 USD bn is depicted below:

Figure 11 shows the moving average trend of UGDP towards USD 95,287 bn.

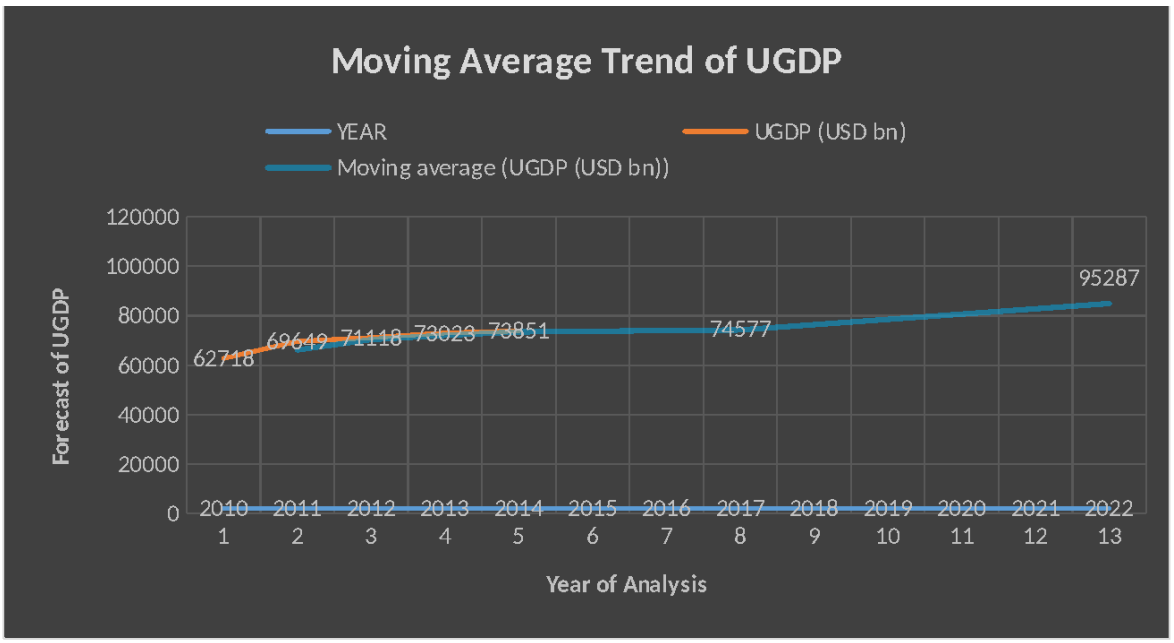


Figure 11. Moving average trend of UGDP towards USD 95,287 bn.

Linear trend towards UGDP 95287 USD bn is depicted below:

Figure 12 shows the linear trend of UGDP towards USD 95,287 bn.

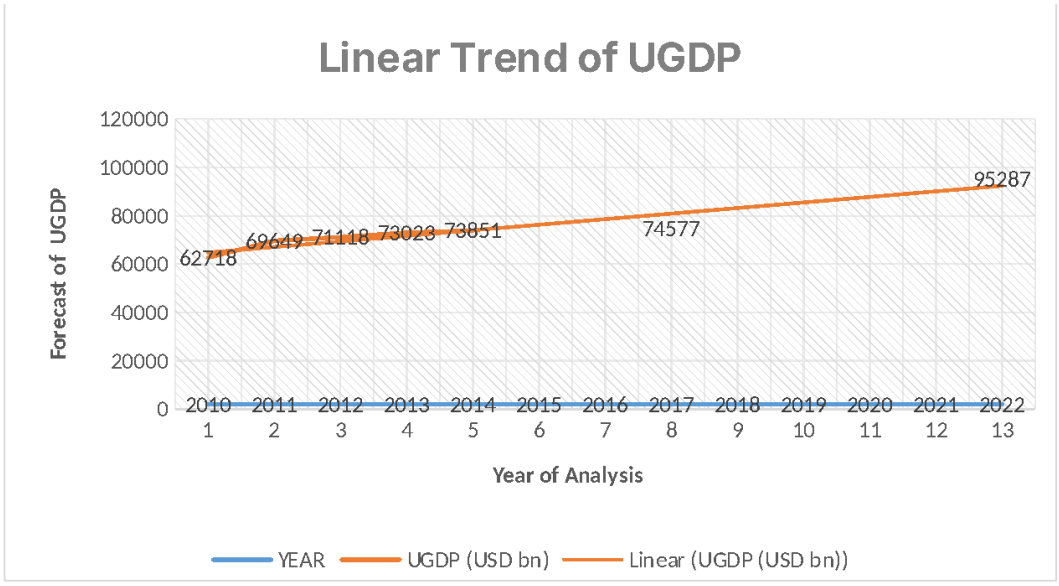


Figure 12. Linear trend of UGDP towards USD 95,287 bn.

Method 2: In the second instance, the forecast table for UGNRP (72813 USD bn) is as follows:

Table 80 presents the forecast of UGNRP towards USD 72,813 bn (method 2).

Table 80. Forecast of UGNRP towards USD 72,813 bn (method 2).

YEAR	UGNRP (USD bn)	YEAR	UGNRP (USD bn)
2010	52006	2017	97027
2011	95362	2018	
2012	90727	2019	
2013	99033	2020	
2014	96082	2021	
2015		2022	72813
2016			

Graphically, this can be depicted as follows:

Moving average trend towards UGNRP 72813 USD bn is depicted below:

Figure 13 shows the moving average trend of UGNRP towards USD 72,813 bn.

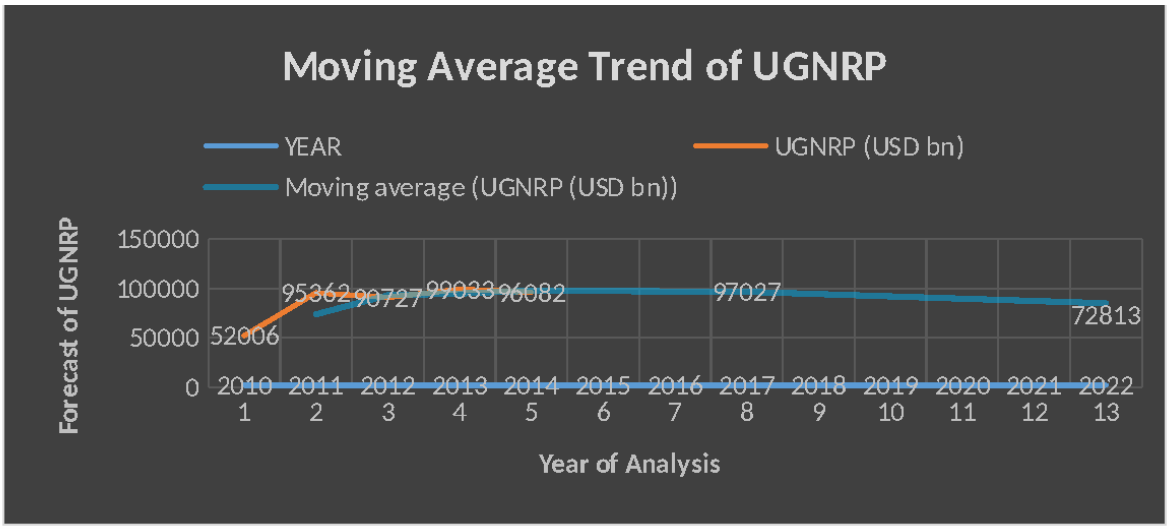


Figure 13. Moving average trend of UGNRP towards USD 72,813 bn.

Linear trend towards UGNRP 72813 USD bn is depicted below:

Figure 14 shows the linear trend of UGNRP towards USD 72,813 bn.

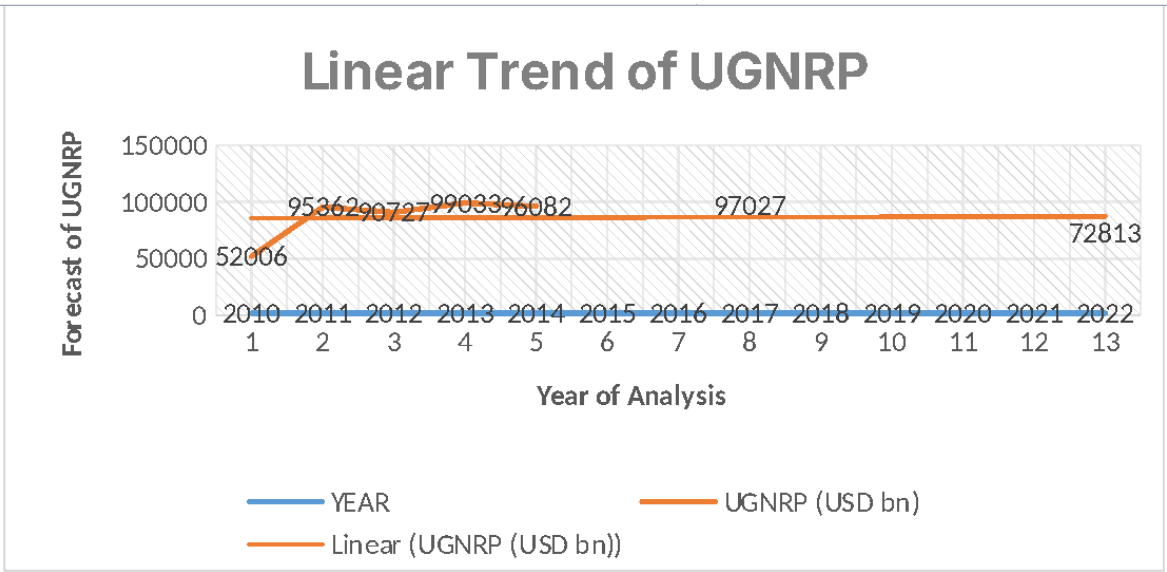


Figure 14. Linear trend of UGNRP towards USD 72,813 bn.

13.4 Stage d: interpretation of the results

Thus, in order to plan for achieving the Economic-Environmental Equilibrium point in the year 2022, we have two scenarios:

(1) UGDP value in 2022 equals the UGNRP value: Economic growth (UGDP) is planned first, natural resources are utilized to match this value. The natural resources extracted for economic growth must have an economic potential equal to a fixed growth plan.

In other words, Projected UGDP = UGNRP = 95287011 USD mn.

(2) UGNRP in year 2022 must be equal to the planned UGDP value: UGNRP value is determined first, the economic activity is planned and achieved accordingly. Economic Growth (UGDP) must be planned, regulated, and monitored in such a way as to equal the Economic Potential expected at the beginning of the economic cycle.

i.e. UGDP = Projected UGNRP = 72812695 USD mn

Table 81 presents the difference between UGNRP and UGDP towards equilibrium.

Table 81. Difference between UGNRP and UGDP towards equilibrium.

YEAR	UGNRP	UGDP	Difference
2010	52005948	62717503	-10711555
2011	95361804	69649058	25712746
2012	90726738	71117633	19609105
2013	99033324	73023357	26009967
2014	96082237	73850628	22231609
2015			
2016			
2017	97027202	74576946	22450256

YEAR	UGNRP	UGDP	Difference
2018			
2019			
2020			
2021			
2022	72812695	72812695	0
2022	95287011	95287011	0

13.4.1 Conclusion

It is easier to fix the planned economic growth (UGDP) first, and utilize the natural resources (UGNRP) wealth in such a manner as to equal this planned growth. The economic activity can be controlled at micro-level for each nation, so that there is no need for extraction of natural resources in order to achieve economic growth beyond the targeted UGDP.

The trend analysis of UGDP and UGNRP in linear and moving average form can be utilized to determine the various check-points for the coming years from 2017 onwards.

At this point, we can conclude that equilibrium has been achieved.

The following results and outcomes are derived from the study:

- Economic-Environmental Equilibrium model
- Wealth Distribution model
- Common Pricing mechanism
- **GNRP:** Economic Growth Potential indicator based on natural resource evaluation
- **UGDP:** Cumulative Wealth Productivity of nations
- **UGNRP:** Cumulative Resource-based valuation of nations
- Database about productive nations and minerals contributing to world economy
- Forecasting annual resource utilization model based on long-term GDP growth targets
- Current GDP inadequacy and SNA inconsistency
- Sustainable growth is possible with intervention of a global ombudsman agency
- Nations Role as Custodians, not Proprietary Owners of World's Resources.
- Growth Opportunity for Science of Calibrations and Measurements.

14 Interpretation of the results of the research process

The outcome can be interpreted in three different ways-

- Substantive (a potential new policy)
- Theoretical (a potential new understanding)
- Methodological (a potential new way of analyzing)

Note: An unbalanced social model undermines stability of the growth process. At equilibrium point, the GDP of the universe remains constant. There is no addition to the total intrinsic economic value of the environmental ecosystem, and there is no deletion from the human macro-economic subsystem. There is mere substitution of economic value from the natural resources to the utility-based goods

for consumption. Net worth of both parameters, the total natural resources of the world, and the total finished goods for consumption, are equal in value and remain constant. At this point, sustainable growth is achieved infinitely.

15 Recommendations: policy implications

Role of Government: Normally, the Government plays following three roles in economic development- provider of institutions, provider of income distribution, and promoter of economic growth. The Role of Government as a promoter of economic growth is in getting the nation into "the right business", as a supplier of infrastructure, in providing skilled labor and entrepreneurship, creating demand, and as an Entrepreneur and Capitalist of last resort.

The research aims at more involved role for the Government in Policy Formulation, based on the decision models and Key Industry concept for economic development.

16 Significance of the research study

The research is a comprehensive and all-inclusive research that adopts a holistic approach to the Economy-Ecosystem conundrum, and offers a long term sustainable solution to the problem of sustainability. The recommendations that are derived from the models are simple, workable solutions that require a developmental mindset. Economic progress based on inclusion of natural resources in growth mechanism will contribute to a better world. Greater transparency in reporting will ensure mutually beneficial growth.

Table 82 presents the comparative analysis of UGDP and UGNRP.

Table 82. Comparative analysis of UGDP and UGNRP.

Observation	Interpretation	Corrective Action	Action Plan
UGDP > UGNRP	Excess growth achieved	Output must be curbed in the next business cycle	i. by utilizing fewer resources ii. cut down agriculture production iii. curb population growth
UGDP < UGNRP	Excess natural resources utilized	Output must be curbed in the next business cycle	i. Extracting fewer resources ii. cutting down excess agricultural production

Inference: Since both scenarios of inequality between UGDP and UGNRP require the same action to be undertaken, that of curbing of the utilization of natural resources and decrease in output of agricultural produce, the cyclic activity will be allowed to continue till the perfect stage of macro-constancy is reached: when UGDP equals UGNRP.

Finally, consider the universe of all the nations, for all the minerals used for economic activity, with a fixed Common Price Index kept constant (the only necessary condition for macro constancy). When the Cumulative GNRP equals the Cumulative GDP, and no more injections into the common wealth pool is required, the Economic-Environmental; Equilibrium point is considered to have been reached. When UGDP = UGNRP, it can be concluded that the utopian state of economic equilibrium and sustainability of economic-ecological ecosystem has been achieved through the continuous process of optimal resource management.

At this ideal point, the total GDP of the Universe (total Economic Energy content) remains constant, and sustainable growth can be achieved under regulated macro-constancy.

17 Scope and limitations of the research

The scope of this research is ambitious enough to cover all nations of the world, and all minerals that contribute to the economic activity and growth of nations and of the world economy. The research opens up avenues for global collaboration with World Bank group, and the IMF and the UNO. The research urges to exploit the challenge for "Big Data Analytics" as a professional opportunity and for statisticians with the ability to collate humongous data for economic projects around the world.

Limitations of Research: The limitations of the research include data availability, data accuracy and data reliability, due to the very nature of the data: complex, dynamic, changing, and simply, huge. The economy of the world cannot be used as a laboratory for economic experiments, hence the approach has to be progressive, and prudent, taking into account the complex economic and socio-political structures of every nation involved.

- **Data Related:** As data accuracy and data constancy will depend upon the method applied by different nations for the system of national accounting.
- **Time Related:** Real time testing of data will be compromised by testing predicted data.
- **Government Related:** Perversity, Futility, and Jeopardy are obstacles to any active strategy on the part of the Government
- As the research contradicts established models of economy, hence global acceptance as a populist economy model is difficult. The principles of established economic systems like capitalism, socialism, communism, and mixed systems may have to be compromised with. All the 191 nations may not be considered due to time and data constraints.
- Sample size may be restricted to derive at clarity and simplicity in model formulation. Re-defining economics at macro level will involve a time lag before acceptance.
- Predictions may not be correct as unseen forces not accounted in main model may act. Real time testing of the proposed models may not be feasible, hence select time periods and select nations may have to be used for experimental model.

18 Managerial implications of the research

There is managerial scope in the process of Policy Formulation, both at institutional level and at Government level. The Research calls for the establishment of a global ombudsman agency to play the significant role of actualizing the recommendations of the research in the real world.

Note: The research rejects continuous institutional intervention and control, by proposing the application of mediating intervention only at the initial and final stages of global business cycle. In the interim, nations are free to pursue their individual economic policies and independent paths to achieve specific developmental goals and missions.

Figure 15 shows the tech4Good innovation framework.

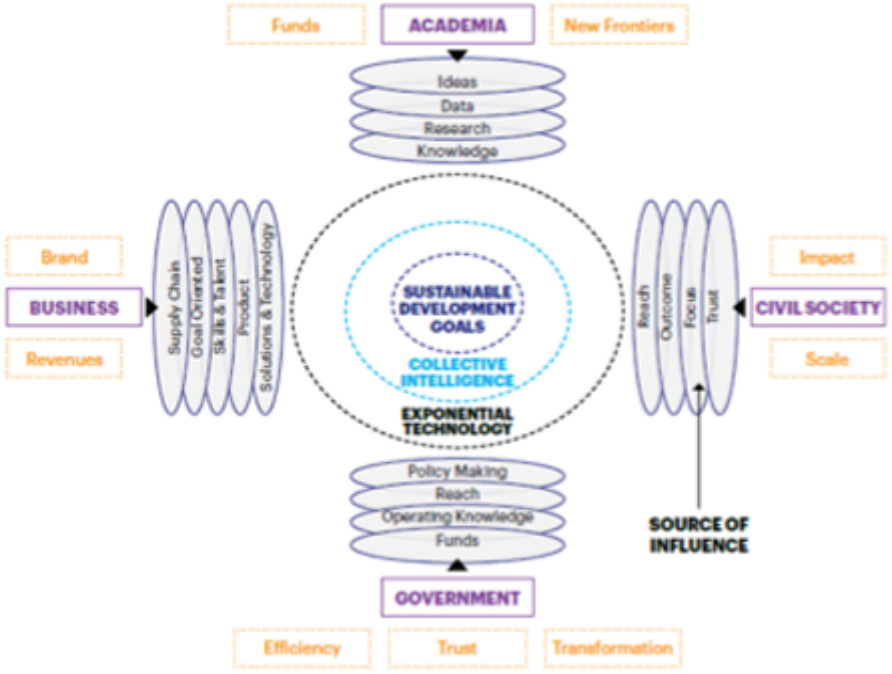


Figure 15. Tech4Good innovation framework.

Tech4Good Innovation Framework harnesses "collective intelligence". Each entity stands to benefit from the others, who fill key gaps in their own ability to deliver on social development goals.

Figure 16 shows the the 5Es framework for scaling Tech4Good: ethics, engineer, embed, enable, educate.

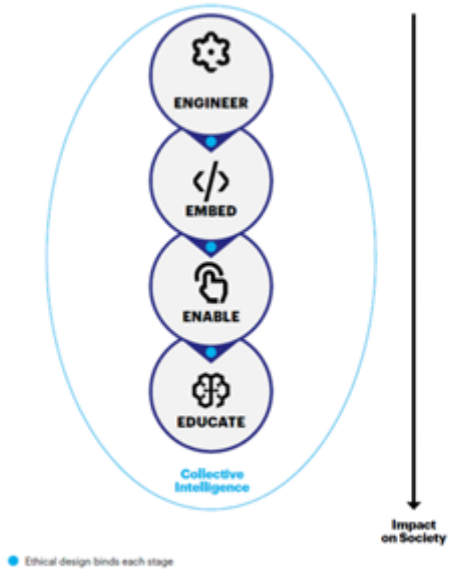


Figure 16. The 5Es framework for scaling Tech4Good: ethics, engineer, embed, enable, educate.

Figure 17 shows the the 5Es require synergistic coordination and collective intelligence for success.

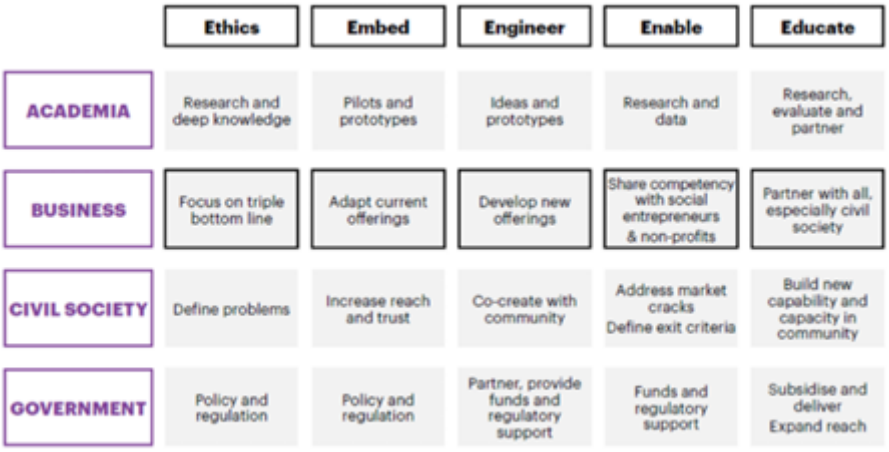


Figure 17. The 5Es require synergistic coordination and collective intelligence for success.