Assessment of Global Sustainable Development, Environmental Sustainability, Economic Development and Social Development Index in Selected Economies

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ABSTRACT

This study assesses the association of sustainable development (*SD*) with environmental technologies, forest area and developmental indictors in selected 39 economies. It develops global sustainable development index (*GSDI*) as an integration of environmental sustainability index (*ESI*), economic development index (*EDI*) and social development index (*SDI*) during 2000-2016 using *composite Z-score* technique. Thereupon, it explores the influence of environmental technologies, deforestation, *ESI*, *EDI* and *SDI* on *GSDI* using country-wise panel data. The results infer that there exists a high inequality in *SD* due to diversity in socio-economic structure of selected countries. Most developed economies have a better position in *SD* due to their relatively better position in environmental, economic and social developmental related variables. India, South Africa and Tunisia have low values of *ESI*, *EDI* and *SDI*, thus, these countries are in worst position in *SD*. Empirical results exhibit that *SD* is positively associated with environmental, economic and social development, forest area and environmental technologies. It recommended that protection of forest area maintains the quantity and quality of natural resources and provide ecological security. Accessibility of electricity for all community, discovery of environmental technologies, use of green technologies in production activities may be effective to increase socio-economic, environmental and sustainable development.

1. INTRODUCTION

Deforestation has a negative impact on global climate and ecological system [1, 2]. Thus, it has a negative impact on livelihood security and human well-being. Deforestation increased due to high population growth, overwhelming urbanization, agricultural expansion, industrialization, infrastructural development and over pressure of population on natural resources at global level. Most economies are implementing polices to achieve high economic growth in term of gross domestic product (GDP) [3, 4]. Thus, these economies are using surplus natural resources and ecosystem services (i.e., forestry, water, land, air, soil) to produce goods and services to satisfy the needs of present and growing population. As environmental development is an essential component of sustainable development (*SD*) [4]. However, the concept of *SD* is very old and that is emerged in 1972. It has more than 100 different definitions and interaction with numerous indicators and socio-economic activities in a country [5]. Hence, it is projected that *SD* cannot be achieved without environmental development [3, 4]. Furthermore, quality and quantity of natural resources are adversely affected due to overwhelming deforestation in most countries. Thus, extensive deforestation created a complication to maintain *SD* especially in developing economies. *SD pursues to satisfy the demands of current generations without decline the ability of next generations to achieve their own necessities* [4-6]. In above perspectives, theoretical review has shown that *SD* is an integration of economic, human, social, technological and environmental development [3, 4, 7-12]. Thus, it creates an appropriate bridge between economic, social and environmental development [13, 14]. A group of studies have claimed that protection of environmental factors and ecosystem services, and economic and social development are the crucial determinants of *SD* [5, 15-18]. Basiago [19] reviewed that economic, social and environmental sustainability are the main dimensions of *SD*. Guijarro and Poyatos [20] noticed that *SD* includes income inequality, environmental sustainability, innovation, justice and sustainable consumption of available resources. Sathaye et al. [21] claimed that environmental and economic dimensions are the main determinants of *SD*. Furthermore, it is also reported that economic growth and economic development directly depend upon environment and natural resources conservation in a country [1, 4]. Howes et al. [22]; Dong and Hauschild [23] explained the factors of environmental sustainability which are also significantly associated with *SD*. Therefore, to achieve the different goals of *SD* must be a prime agenda of global economies.

Moreover, recycling, minimization of waste material, substitution of materials, pollution controls, efficient use and protection of natural resources through applications of technologies in production activities are conducive to achieve sustainable development (*SD*) [1, 3, 5, 7, 14, 24]. Conversely, most economies are framing their policies to attain high development in economic, social and technological sectors [4]

as paying low attention towards environmental development and ecological security. As forest area preserves the quality of environmental system and ecological services in term of water conservation and purification, air purification, nutrient cycling, atmospheric environmental purification, soil protection, erosion control, flood protection, carbon fixation, oxygen release and reduce solar radiation impact on human health [3, 23]. Thus, forest area protects the quality and quantity of environmental and natural resources [2, 4]. However, forest area is diminishing continuously due to overwhelming urbanization, high population growth, heavy industrialization, excessive infrastructure development and migration of population from rural to urban area and expansion in cultivated area [3]. Hence, there would be a difficult task to achieve SD without maintaining the environmental development at world-wide.

Also, there is urged to scientific research community, existing researchers and international development organizations to discover more environmental and Appropriate Technologies (AT) that must be useful to mitigate the adverse effects of deforestation on sustainable development (SD). Though, the movement of AT started in 1970, while it was an attempt to discover and design various types of technologies [7]. That time the main goals of AT was to solve the social and environmental problems efficiently [7]. Another aim of AT was to increase additional use of renewable resources and technologies in production activities to increase economic and social development [7]. Thus, use of AT in production activities work as a key driver to maintain economic, social and environmental development at micro level [25]. Hence, the necessary role of AT is to maintain environmental development and consequently is helpful to attain SD. At present environmental scientists and researchers are working to discover environmental and green technologies, and scientific process which can be used to produce goods and services. Environmental technologies are useful to reduce pollution that is generated due to production activities and provide new material, energy and resource-efficient production process [24]. As environmental technologies create a bridge between economic, social and environmental development [24]. Most researchers and scientists, therefore, claimed that environmental and green technologies are essential for environmental sustainability. Thus, applications of environmental and green technologies are helpful to decouple environmental pollution and resources, thus, both may be useful to achieve SD [5, 16, 24-27]. Gavin [28] also argued that extensive applications of environmental technologies will be conducive to reduce risk for environmental degradation. Matin et al. [29] have noticed that environmental and social development cannot be separated form sustainability. Shafiei and Abadi [30] have also mentioned that environmental and ecosystem friendly technologies would be supportive for SD. Nevertheless, a group of researchers claimed that technologies may be harmful for environment and ecosystem services, if it does not reduce or mitigates the negative consequences of production activities on environmental and natural resources [7]. Urban [31] have conceptually proved that innovation in the environmental field is beneficial to increase SD. Anadon et al. [32] have perceived that SD is positively associated with science & technological development. Armenanu et al. [6] have also highlighted the significance of technologies in SD.

Furthermore, several studies provided a hypothetical aspect on prominence of environmental and green technologies in sustainable development (SD) [20, 27, 30-33]. However, limited research could provide a scientific and empirical evidence on association of environmental and green technologies with SD [31]. Furthermore, existing researchers and research academia could not develop a scientific and universally acceptable method and indicators for measurement of SD. For this, previous studies have created global sustainable development index as an integration of economic, social and environmental development, sustainable development goal index and national sustainable development index using different methods [4, 14, 20, 25, 34, 35]. Based on estimated sustainable development index, most studies claimed that performance of a country in SD depend upon chosen method and undertaken indicators [25, 34, 36]. However, these studies could not assess the interconnection of SD with indicators of economic, social and environmental development. Also, existing researchers such as Singh et al. [3], Singh et al. [4], Armenanu et al. [6], Beder [7] Phimphanthavong [15], Kongoli [17], Singh and Issac [24], Miola and Schiltz [34], Nagy et al. [36] have addressed the answer on various research questions with regards to selection of appropriate indicators for assessment of sustainable development (SD) that are presented here:

- What must be the appropriate measurement of SD?
- What is interconnection of SD with its components?
- How environmental technologies are associated with SD?
- How global economies can achieve SD using environmental technologies in production of goods and services?
- What is the relative performance of economies in SD and its components as compared to others?

Based on aforesaid research question, the present study is accomplished following objectives:

- *To estimate the Global Sustainable Development Index (GSDI) as an integration of environmental sustainability index (ESI), economic development index (EDI), and social development index (SDI) for selected 39 global economies. For this, Composite Z-score technique is used to create country-wise GSDI, ESI, EDI and SDI.*
- *To provide the relative performance of selected economies in SD as compared to others based on estimated values of GSDI.*
- *To explore the influence of environmental technologies, deforestation and other socio-economic indicators on estimated GSDI using linear, non-linear and log-linear regression models.*

2. RESEARCH METHODS AND MATERIAL

2.1 Selection of countries and explanation of data sources

This study generates the global sustainable development index (GSDI) as an integration of environmental sustainability index (ESI), economic development index (EDI) and social development index (SDI). These indexes are created for 39 selected economies (Refer to Table 1) during 2000–2016. For above-mentioned investigations, all required data are segregated from World Bank, Food and Agriculture Organization United Nations Development Programme, Yale Center for Environmental Law and Policy (Yale University), Center for International Earth Science Information Network, Colombia University, World Intellectual Property Organization, and Organization for Economic Co-Operation and Development. Interpolation and extrapolation methods is

used to determine the missing values in time series for those variables which do not had the values for middle years [3, 4, 12, 24, 37]. Microsoft excel worksheet, C++ and SPSS statistical software are used for descriptive analysis, and STATA statistical software is used to run the proposed regression models.

Table 1. List of selected countries with region and income group

Region of the Country	Income group of the Country	Country
Northern European and Pacific oceans		Sweden, Finland
Europe and Central Asia		Switzerland, Norway
Southwestern Pacific Ocean		New Zealand
North America		Canada
Northern, Central and Southern European	High income: OECD	Estonia, Portugal
North-western and Northern European Europe		Netherlands, Australia
Western European		France, Germany, Denmark
Europe & Central Asia	Upper middle income	Lithuania, Latvia, Romania
North-western Europe	High income: OECD	United Kingdom
Central and South-eastern, Europe		Greece
Central and Southeast Europe	High income: non OECD	Croatia
Central & Western Europe	High income: OECD	Czech Republic, Poland, Hungary, Slovak Republic, Spain, Austria, Luxembourg, Belgium
Latin America and Sub-Saharan Africa	Upper middle income	Argentina, South Africa, Mexico
	High income: OECD	United States
	Upper middle income	Brazil
Europe & Central Asia	Lower middle income	Moldova, Russia
South Asia		India
East Asia & Pacific	Upper middle income	China
Middle East & North Africa		Tunisia
Asia and the Pacific	High income: OECD	Japan, South Korea

2.2 Overview of different indexes in socio-economic developmental activities

Index-based estimation is very important and vital concept in research and developmental field of all studies [3, 4, 14, 38, 39]. It is an effective policy tools in developmental field [3, 4, 14]. Scientific research community, existing researchers and international development organizations have created several indexes such as human development index, physical quality life index, small business optimism index, global happiness index, ease of doing business index, global competitive index, economic freedom index, corruption perception index, civil liberties index, global manufacturing index, business environment index, buyer sophistication index, firm level technology absorption index, logistic performance index, market potential index, entrepreneurship and development index, global peace index, food security index, livelihood security index, sustainable livelihood security index, global slavery index, global liveability index, economic development index, social development index, socio-economic development index, environmental sustainability index, environmental performance index, energy sustainability index, energy performance indices, consumer price index, insomnia severity index, climatological index, climate variability index, index system of agricultural sustainable development capability, agricultural sustainability index, water quality index, global sustainable development index, global sustainable development goals index and other indexes. Above indexes used as a proxy for assessing the relative or absolute progress of specific socio-economic and other activities for a county or across economies or across entities [3, 4, 12, 14, 20,

24, 35, 36, 38-44]. Any index can be developed using primary and secondary data for a specific socio-economic activity at micro to macro level.

Existing studies such as Singh et al. [4], Jin et al. [14], Guijarro and Poyatos [20], Miola and Schiltz [34], Negy et al. [36] developed sustainable development index as an integration of indicators related to environmental sustainability, economic development and social development. However, previous studies such as Miola and Schiltz [34] argued that country's performance in sustainable development depends upon chosen method and indicators. Thus, it is very important to select the most related variables in the area of environmental development, economic development and social development to develop sustainable development index. Available literature and theories are used to select the suitable variables and method to generates *GSDI*, *ESI*, *EDI* and *SDI* in this study.

2.3 Selected variables for estimation of environmental sustainability index (*ESI*)

Environmental performance or sustainability may not be measured through a single indicator of a country [3, 4]. Environmental sustainability is a very crucial for well-being of humanity in a nation [44]. It is significantly associated with CO_2 emissions from solid fuel consumption (% of total), CO_2 intensity (kg/kg of oil equivalent energy use), PM2.5 air pollution, mean annual exposure (micrograms per cubic meter), renewable electricity output (% of total electricity output), electricity production from natural gas sources (% of total), electricity production from coal sources (% of total),

combustible renewables and waste (% of total energy), energy use (kg of oil equivalent), access to clean fuels and technologies for cooking (percentage of population), forest area (percentage of total land area), agricultural land (percentage of total land area), fertilizer consumption (kilogram/hectare arable land), population growth (annual %), population density (in number), urbanization (ratio of urban population with rural population) and others [2, 3, 4, 9, 11, 44, 45]. However, scientific research community could not discover a universally acceptable measurement of environmental sustainability and its variables. In order to avoid the aforementioned inconsistency, Singh et al. [3] and Singh et al. [4] created an *ESI* to measure the environmental development for 22 Asian economies and selected global countries correspondingly. Sands and Podmore [40] developed environmental sustainability index (*ESI*) to measure the performance of agricultural system. Dash [44] also created *ESI* in Indian states. *ESI* measures the relative performance of environmental achievements of specific region or country as compared to others [3, 4, 44]. Thus, prior researchers used *ESI* as a best measurement of overall progress of environmental sustainability [3, 4]. *ESI* is the compilation of different factors which are useful to increase or decrease the quality of environment. In this study, 41 different variables are considered to develop *ESI*. Furthermore, these factors are divided into 8 different groups which are explained as: (i) Air quality and pollution, (ii) Energy management, (iii) Forest and bio-diversity, (iv) Human health and disaster, (v) Land use pattern and agriculture, (vi) Population pressures on ecosystem services, (vii) Demographic changes and (viii) Water generation management [3, 4, 23, 44, 45]. The brief explanation of selected 41 factors is presented in Table 2.

Table 2. List of factors to develop *ESI*

Symbol	Factors	Group of Factors	Unit	Source
AEPP	Access to electricity (% of population)		%	
COET	CO_2 emissions from transport (% of total fuel combustion)		%	
COEMIC	CO_2 emissions from manufacturing industries and construction (% of total fuel combustion)		%	
COEEHP	CO_2 emissions from electricity and heat production, total (% of total fuel combustion)		%	
PCCOE	CO_2 emissions (metric tons per capita)		Tons	
COEKPGDP	CO_2 emissions (kg/US$ of GDP)		Kg	
COEGFC	CO_2 emissions from gaseous fuel consumption (% of total)		%	
COERBCPS	CO_2 emissions from residential buildings and commercial and public services (% of total fuel combustion)	Air quality and pollution	%	
COESFC	CO_2 emissions from solid fuel consumption (% of total)		%	
COIKPKOEU	CO_2 intensity (kg/kg of oil equivalent energy use)		Kg	
COEOS	CO_2 emissions from other sectors, excluding residential buildings and commercial and public services (% of total fuel combustion)		%	
PMAPMAPCM	PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)		Microgram	
PMAPPELE	PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)		%	
EPCPC	Electric power consumption (kWh per capita)		KWh	WDI, World Bank (extracted year 2018)
TNRRGDP	Total natural resources rents (% of GDP)		%	
REO	Renewable electricity output (% of total electricity output)		%	
EPNGS	Electricity production from natural gas sources (% of total)		%	
EPCS	Electricity production from coal sources (% of total)		%	
EPHS	Electricity production from hydroelectric sources (% of total)		%	
EPNS	Electricity production from nuclear sources (% of total)		%	
EPOS	Electricity production from oil sources (% of total)		%	
EPRS	Electricity production from renewable sources, excluding hydroelectric (% of total)		%	
EPOGCS	Electricity production from oil, gas and coal sources (% of total)	Energy management	%	
CRW	Combustible renewables and waste (% of total energy)		%	
FFEC	Fossil fuel energy consumption (% of total)		%	
EUKOEPC	Energy use (kg of oil equivalent per capita)		Kg	
REC	Renewable energy consumption (% of total final energy consumption)		%	
ACFTC	Access to clean fuels and technologies for cooking (% of population)		%	
FA	Forest area (% of total land area)	Forest and bio-diversity	%	
FR	Forest rents (% of GDP)		%	
IMR	Infant mortality rate (per 1,000 live births)	Human health and disaster	Number	
PUBSS	People using at least basic sanitation services (% of population)		%	
PALEI	Percentage of arable land equipped for irrigation (in %)	Land use and agriculture	%	FAO (extracted year 2018)
AgLPLA	Agricultural land (% of land area)		%	

Symbol		Unit	Source
FCPHAL	Fertilizer consumption (kilogram/hectare of arable land)	Kg/Ha	WDI, World
PGR	Population growth (annual %)	%	Bank (extracted
TFR	Fertility rate total (births/woman)	Number	year 2018)
PD	Population density (in number)	Number	WDI, World
UR	Urbanization (Ratio of urban population with rural population)	Number	Bank (extracted year 2018)
RIFWRPC	Renewable internal freshwater resources per capita (cubic meters)	Cubic meters	WDI, World
PUBDWS	People using at least basic drinking water services (% of total population)	%	Bank (extracted year 2018)

Where the second column grouping shows: "Population pressures on ecosystem services" spanning PGR, TFR; "Demographic changes" spanning PD, UR; "Water generation management" spanning RIFWRPC, PUBDWS.

Source: Sathler et al. [2], Singh et al. [3], Singh et al. [4], Duran et al. [9], Tampakoudis et al. [16], Singh and Issac [24], Matin et al. [29], Siche et al. [41], Dash [44]

Table 3. Brief description on factors of *EDI*

Symbol	Sub-factors	Unit	Source
PCGDP	GDP per capita (constant 2010 US$)	US $	
PPGDPE	GDP per person employed (constant 2011 PPP $)	US $	
TVE	Total vulnerable employment (% of total employment)	%	
TWSW	Total wage and salaried workers (% of total employment)	%	
TSE	Total self-employed (% of total employment)	%	
FDINI	Foreign direct investment net inflows (% of GDP)	%	
AIGDPD	Inflation GDP deflator (annual %)	%	WDI, World Bank
EGS	Exports of goods and services (% of GDP)	%	
GCF	Gross capital formation (% of GDP)	%	
TLFPR	Labor force participation rate, total (% of total population ages 15+)	%	
GFCF	Gross fixed capital formation (% of GDP)	%	
TE	Employers, total (% of total employment)	%	
FCE	Final consumption expenditure (% of GDP)	%	
TUPTLF	Total unemployment (% of total labor force)	%	

Source: Sathler et al. [2], Singh et al. [3], Singh et al. [4], Armenanu et al. [6], Duran et al. [9], Singh et al. [12], Tampakoudis et al. [16]

2.4 Selected variables for estimation of economic development index (*EDI*)

As economic development is positively and negatively associated with several activities in a country, thus, it may not be measured with a single indicator [4, 46]. Hence, measurement of economic development is complex and debatable for academicians and researchers. Therefore, previous studies argued that integration of economic development related variables can be used to assess the progress of economic development. Thus, economic development index (*EDI*) may be an operative tool for assessment the economic development [4, 40, 46]. Singh et al. [4], Singh et al. [46] developed economic development index (*EDI*) to assess the relative performance of cross countries in economic development. In this study, *EDI* is defined as a relative index which shows the progress of a specific country in economic development as compared to others [4, 12, 46]. Therefore, following factors are included to create the *EDI* in this study: GDP per capita (constant 2010 US$), GDP per person employed (constant 2011 PPP $), total vulnerable employment (% of total employment), total wage and salaried workers (% of total employment), total self-employed (% of total employment), foreign direct investment net inflows (% of GDP), inflation GDP deflator (annual %), exports of goods and services (% of GDP), gross capital formation (% of GDP), total labor force participation rate (% of total population ages 15+), gross fixed capital formation (% of GDP), total employers (% of total employment), final consumption expenditure (% of GDP), and total unemployment (% of total labor force) [3, 4, 9, 6, 12, 14, 46, 47]. The brief explanation of above-mentioned variables is presented in Table 3.

2.5 Selected variables for estimation of social development index (*SDI*)

Social development is significantly associated with various factors and it may not be observed through one indicator in a country [4, 46]. Yet, earlier studies considered a single factor like literacy rate, sex ratio, women participation rate or other variable as a proxy for social development [4, 12, 46]. Therefore, earlier studies, such as Singh et al. [4], Singh et al. [12], Singh et al. [46], therefore, created social development index (*SDI*) to avoid aforementioned contradiction. *SDI* may be a best tool for measurement of social development [4, 12, 14, 46].

Existing literature defined *SDI* as a composite index of several factors which have significant influence on social development [4, 12, 14]. It is a relative index that makes the comparison of cross economies in social development [4, 12]. This study, therefore, considered most related factors which have significant implication on social development. Following variables are included to create *SDI* in this study: sex ratio at birth (male births/female births), ratio of female to male labor force participation rate (%), female labor force (% of total labor force), female unemployment (% of female labor force), mortality rate, female infant rate (per 1,000 live births), total life expectancy at birth (years), education expenditure (% of GNI), age dependency ratio (% of working-age population) and fixed telephone subscriptions (per 100 people) [3, 4, 14, 24, 47]. Aforesaid variables are the crucial variables to sustain the social equity and social development of country. The concise clarification of variables is presented in Table 4.

Table 4. Brief explanation on factors of *SDI*

Symbol	Factors	Unit	Source
SRB	Sex ratio at birth (male births per female births)	Number	
RFMLFPR	Ratio of female to male labor force participation rate (%)	%	
FLF	Female labor force (% of total labor force)	%	
FUPFLF	Female unemployment (% of female labor force)	%	
FIMR	Female infant mortality rate (per 1,000 live births)	Number	WDI, World Bank
LEB	Total life expectancy at birth (years)	Years	
EEPGNI	Education expenditure (% of GNI)	%	
ADR	Age dependency ratio (% of working-age population)	%	
FTSPPP	Fixed telephone subscriptions (per 100 people)	Number	

Source: Singh et al. [3], Singh et al. [4], Armenanu et al. [6], Singh et al. [12], Duran et al. [9], Singh et al. [12].

2.6 Integration of *ESI*, *EDI* and *SDI* as a *GSDI*

More than 100 factors of sustainable development (*SD*) discussed by scientific research community [4, 5, 7-9, 14-16]. Furthermore, existing studies used various factors which are helpful to meet the 17 goals of sustainable development (SDGs) and measurement of *SD* [14]. Furthermore, earlier studies have reported that *SD* is an integration of economic, social and environmental development [3, 4]. Kusdiantoro et al. [48] developed the sustainable development index as composite index of factors associated with economic, social, ecology and institutional development in Indonesia. Jin et al. [14] planned a national sustainable development index as an assessment of sustainable development in global countries. Hence, factors related to economic, social and environmental development must be comprised as an index for measurement of *SD* [4, 9, 14, 34, 35]. Global sustainable development index (*GSDI*) is used as a combination of environmental sustainability index (*ESI*), economic development index (*EDI*) and social development index (*SDI*) in this study. Hereafter, *GSDI* is considered as linear average sum of *ESI*, *EDI* and *SDI* [3, 4, 10, 20].

For above exploration, this study used *composite Z-score* technique which is based on *normalization-score* or *normalization-index* or *composite-index* of a specific variable across entities. *Normalization-score*, thus, shows the relative performance across entities in a specific indicator. Hence, if the specific variable is positively associated with output than *normalization-index* (*composite-index*) for corresponding variable is estimated as [3, 4, 12, 14, 38, 39, 41, 44, 46]:

$$[NI]_{i,c,t} = \{[(X)_{i,c,t} - Min\ (X)_{i,c,t}]/[Max\ (X)_{i,c,t} - Min\ (X)_{i,c,t}]\} \quad (1)$$

Here, $NI_{i,c,t}$ is a *normalization–index* (*NI*) for i^{th} variable in cross-sectional country (*c*) in time (*t*). $(X)_{i,c,t}$, $Min\ (X)_{i,c,t}$ and $Max\ (X)_{i,c,t}$ are the actual, lowest and highest values respectively in each series of a specific variable across countries (*c*) in time (*t*). Above-mentioned process recursively applied for each variable individually across years. Values of *normalization-index* (*NI*) lies between 0 to 1 for corresponding variables [3, 4, 12, 20, 24, 38, 39, 46, 48, 49]. If the specific variable is negatively associated with output than *NI* is estimated as:

$$NI_{i,c,t} = \{[X_{i,c,t} - Max(X_{i,c,t})]/[Min(X_{i,c,t}) - Max(X_{i,c,t})]\} \quad (2)$$

After creating *normalization–index* of all variables, *ESI*, *EDI* and *SDI* are considered as an average linear sum of all associated variables under each category of developmental indicator [4, 41, 49]. Accordingly, *GSDI* is estimated as linear average sum of *ESI*, *EDI* and *SDI*, which is estimated as:

$$GSDI = (ESI + EDI + SDI)/3 \quad (3)$$

Here, *GSDI* is global sustainable development index; *ESI*, *EDI* and *SDI* are the environmental sustainability index, economic development index and social development index respectively in Eq. (3).

2.7 Formulation of Empirical Model

This study is desired to assess the effect of developmental indicators on sustainable development (*SD*). For this investigation, *GSDI* is used as a representative indicator for *SD*. In this study, *GSDI* is used as a dependent variable and other indicators are used as explanatory variables. The proposed empirical model is adopted from exiting studies such as: Singh and Issac [3], Singh et al. [4], Singh et al. [12], Singh and Issac [24], Singh and Sharma [38], Samimi et al. [43], Mainali et al. [50], Kumar et al. [51], Kumar et al. [52], Ashraf and Singh [53] which also used estimated indexes as a dependent and independent variable for different purposes. Therefore, this study assumes that global sustainable development index (*GSDI*) is a function of environmental sustainability index (*ESI*), economic development index (*EDI*), social development index (*SDI*), percentage share of patented environmental technologies in all patented technologies (*PPAFET*) and growth in forest area (*GFA*). In mathematically, the aforesaid relationship can be specified as:

$$(GSDI) = f(ESI, EDI, SDI, PPAFET, GFA) \quad (4)$$

Here, *GSDI* is global sustainable development index, *ESI* is environmental sustainability index, *EDI* is economic development index, *SDI* is social development index, *PPAFET* is percentage share of patented environmental technologies and *GFA* is growth in forest area. After incorporating the linear regression model, the aforementioned function is used as:

$$(GSDI)_{ct} = \alpha_0 + \alpha_1 (ESI)_{ct} + \alpha_2 (EDI)_{ct} + \alpha_3 (SDI)_{ct} + \alpha_4 (PPAFET)_{ct} + \alpha_5 (GFA)_{ct} + \mathcal{A}_{ct} \quad (5)$$

Here, the explanation of *GSDI*, *ESI*, *EDI*, *SDI* and *PPAFET*, *GFA* are given in Eq. (4). Here, *PPAFET* used as a proxy for environmental technologies and *GFA* used as a proxy for deforestation. *c* is the cross-sectional country and *t* is time period. α_0 is the constant term, $\alpha_1 \ldots \alpha_6$ are the regression coefficients of associated variables and $\mathcal{A}_{ct}$ is the error term in Eq. (5). Similarly, non-linear and log-linear regression models also used to assess the association of *GSDI* with *ESI*, *EDI*, *SDI*, *PPAFET* and *GFA*.

As this study used country-wise panel of various indicators

during 2000-2016. Thus, the regression coefficients of explanatory variables are estimated using linear regression correlated panels corrected standard errors model to reduce the presence of cross-sectional dependency, heteroskedasticity, serial-correlation and auto-correlation in the panel data [3, 4, 12, 24, 51-56]. Also, *Ramsay RESET test* [37, 55, 56], and Akaike Information Criterion (*AIC*) and Schwarz Information Criteria (*BIC*) are used to check the validity of model and consistency of regression coefficients of explanatory variables in the proposed models [3, 4, 54-56].

3. RESULTS AND DISCUSSION

3.1 Descriptive results

Figure 1 shows the average values of *GSDI* for two periods i.e., 2000-2007 and 2008-2016 for selected economies. Accordingly, the ranking of undertaken countries in sustainable development, environmental sustainability, economic development and social development based on mean values (during 2000-2016) of *GSDI*, *ESI*, *EDI* and *SDI* respectively is presented in Table 5. As the estimated values of *GSDI* lie between 0.413-0.609 during 2008-2016, thus it infers that there is an existence of high variation in sustainable development (*SD*) across economies. Sweden, Norway and Switzerland, Finland, New Zealand, Canada, Austria, Australia, Denmark, France, Germany, Japan, Portugal, Estonia, USA, Luxembourg, Netherlands, Belgium, Lithuania, United Kingdom, South Korea, Latvia, Brazil, Croatia, Spain, Czech Republic, Greece, Romania and Hungry have the value of *GSDI* more than 0.5 during 2008-2016. Thus, these economies have a better position in *SD* as compared to other economies. These economies could create an effective ecosystem to maintain *SD* due to their consistent contribution to prevent the environmental and natural resources factors.

India, South Africa and Tunisia have 39th, 38th and 37th ranks respectively as per the estimated values of *GSDI* during 2000-2007. Thus, these economies have deprived position in *SD* among the 39 economies. High population growth, overwhelming urbanization, excessive industrialization, extensive dependency of population on agriculture sector, overwhelming deforestation, low applications of green technologies in production activities, extreme poverty, low per capita income, income inequality, low R&D expenditure, low literacy rate, low quality of education, ineffective mechanism of government policies, poor health and sanitation facilities and high gender discrimination are the crucial reasons for these economies to make their poor position in *SD*. Moreover, extreme poverty, low jobs opportunities, high income inequality, extreme corruption, high illiteracy and political instability are creating obstacles to achieve the goals of *SD* in these economies. Thus, these economies are required to implement an effective and conducive policy to increase the *SD*. Mexico, Poland, Slovak Republic, Moldova and China have better position in *SD* as compared to South Africa, India and Tunisia. Most developed economies like Sweden, Norway, Switzerland, Finland, New Zealand, Canada, Australia, Denmark, Austria, Portugal, France, USA, Germany, Estonia, Japan, Luxembourg, Netherlands, United Kingdom, and Belgium adopted effective and conducive social and economic policies to make their clean environment.

Accordingly, these economies have better position in *SD* as compared to developing and largely agrarian economies.

These economies could provide electricity to all population; thus, these are able to improve the quality and quantity of environmental and natural resources. Mainali et al. [50] suggested that more applications of electricity would be beneficial to maintain clean environment in developing economies. Moreover, these economies have a low population growth, urbanization and industrialization. Therefore, these countries are also able to maintain the balance in natural resources due to migration of population from rural to urban areas. Consequently, these economies could mitigate the adverse impact of urbanization, population growth and industrialization on natural resources. Accordingly, these economies could create an effective platform for *SD*.

Sweden, Finland and Norway have 1st, 2nd and 3rd position in environmental sustainability among the 39 economies, thus, these economies have better infrastructure to increase environmental development. South Africa, India and Luxembourg have 39th, 38th and 37th position respectively in environmental sustainability. Thus, there is essential for these economies to improve their position in environmental sustainability though implementing conducive policies such as water management and conservation, and protection of ecosystem services. Furthermore, the values of *ESI* lie between 0.623-0.418 for across countries. Therefore, it infers that there is high variation in environmental sustainability in the 39 countries. It is also seemed that Switzerland, Luxembourg and Australia have a better performance in economic development as compared to other economies. It is concluded that economic development is varied across countries due to diversity in social and economic development associated factors. As per the values of *SDI*, it is also found that most countries such as Sweden, Denmark, Norway, France, Switzerland, United Kingdom, New Zealand, Finland, Germany, Canada, USA, Lithuania, Australia, Belgium, Netherlands, Luxembourg, Portugal, Estonia, Latvia, Croatia, Hungry, Moldova, South Korea, Spain, Argentina and Czech Republic have better position in social development. India, Tunisia and South Africa have 39th, 38th and 37th position respectively in social development. These countries, therefore, need to increase their situation in social development. Moreover, it is observed that there exist is high variation in values of *GSDI*, *ESI*, *EDI* and *SDI* for all countries (except Sweden).

3.2 Viability and credibility of estimated indexes

Credibility of estimated index is an important task in academic research. It increases the unanimity among the existing researchers about estimated indexes [3, 4, 12, 24, 51, 52, 53]. Singh et al. [3], Singh et al. [4], Singh et al. [12], Singh and Issac [24], Kumar et al. [51], Kumar et al. [52], Ashraf and Singh [53] also argued that an index has viability or credibility when it has positive or negative but statistically significant correlation with its internal or external indicators. While, the internal and external indicators can be selected based on exiting literature review and theories. Thus, correlation coefficients of *GSDI* with *ESI*, *EDI*, *SDI*, percentage share of patent applications files in environmental technology and forest area (*FA*) are estimated to check credibility and viability of aforesaid indexes. Table 6 provides the results for Karl-Pearson correlation coefficient of *GSDI* with *ESI*, *EDI*, *SDI*, percentage share of patent applications files in environmental technology (*ET*) and forest area (*FA*). The estimates infer that the association of *GSDI* with *ESI*, *EDI*, *SDI* and *FA* are

positive and statistically significant. Thus, estimated indexes have credibility and these indexes also can be used to make a rational prediction. It also indicates that above-mentioned indexes may be used for further empirical investigations. Singh et al. [3], Singh et al. [4], Singh et al. [12], Singh and Issac [24], Kumar et al. [51], Kumar et al. [52], Ashraf and Singh [53] also used afore-mentioned technique to check the validity of estimated indexes. Additionally, the results recommend that *SD* to be improved as increase in environmental, economic and social development, and forest area at world-wide.

Figure 1. Performance of selected economies in sustainable development

Table 5. Values of *GSDI*, *ESI*, *EDI* and *SDI* for selected countries during 2000-2016

Country	GSDI Value	GSDI Rank	ESI Value	ESI Rank	EDI Value	EDI Rank	SDI Value	SDI Rank
Sweden	0.611	1	0.623	1	0.441	13	0.767	1
Norway	0.595	2	0.586	3	0.457	9	0.744	3
Switzerland	0.591	3	0.525	12	0.512	1	0.736	5
Finland	0.585	4	0.607	2	0.432	20	0.716	8
New Zealand	0.584	5	0.569	6	0.457	8	0.727	7
Canada	0.581	6	0.569	5	0.460	7	0.715	10
Australia	0.570	7	0.509	16	0.495	3	0.706	13
Denmark	0.569	8	0.505	18	0.447	12	0.754	2
Austria	0.566	9	0.547	9	0.455	10	0.697	16
Portugal	0.554	10	0.541	10	0.436	17	0.685	19
France	0.554	11	0.499	22	0.421	23	0.740	4
USA	0.551	12	0.501	20	0.441	16	0.710	11
Germany	0.548	13	0.499	23	0.428	21	0.716	9
Estonia	0.544	14	0.551	8	0.418	25	0.662	20
Japan	0.543	15	0.519	13	0.422	22	0.689	18
Luxembourg	0.543	16	0.434	37	0.504	2	0.689	17
Netherlands	0.535	17	0.453	34	0.452	11	0.701	15
United Kingdom	0.535	18	0.463	31	0.408	27	0.733	6
Belgium	0.534	19	0.459	32	0.441	14	0.702	14
Lithuania	0.533	20	0.512	14	0.380	36	0.707	12
Latvia	0.532	21	0.561	7	0.405	29	0.632	21
South Korea	0.527	22	0.492	24	0.475	5	0.615	25
Croatia	0.521	23	0.536	11	0.399	31	0.629	22
Brazil	0.516	24	0.578	4	0.405	28	0.565	34
Greece	0.514	25	0.501	21	0.441	15	0.600	29
Spain	0.513	26	0.510	15	0.419	24	0.611	26
Czech Republic	0.511	27	0.492	25	0.435	18	0.607	28
Hungary	0.503	28	0.475	28	0.411	26	0.623	23
Romania	0.498	29	0.506	17	0.399	32	0.590	32
Mexico	0.496	30	0.484	26	0.433	19	0.571	33
Slovak Republic	0.489	31	0.504	19	0.399	30	0.565	35
Argentina	0.485	32	0.475	29	0.373	37	0.609	27
Poland	0.485	33	0.474	30	0.389	35	0.592	31
Moldova	0.481	34	0.436	36	0.390	34	0.617	24
China	0.477	35	0.453	33	0.492	4	0.486	36
Russian Federation	0.474	36	0.479	27	0.350	38	0.593	30
Tunisia	0.416	37	0.446	35	0.393	33	0.409	38
India	0.413	38	0.433	38	0.463	6	0.343	39
South Africa	0.407	39	0.418	39	0.347	39	0.456	37

Source: Author's estimation.

Table 6. Linkages of *GSDI* with *ESI*, *EDI*, *SDI* and other indicators

Indicators	GSDI	ESI	EDI	SDI	PPAFET	FA
GSDI	1	0.719**	0.509**	0.919**	-0.077*	0.434**
ESI	0.719**	1	0.118**	0.517**	-0.034	0.700**
EDI	0.509**	0.118**	1	0.278**	-0.184**	0.075
SDI	0.919**	0.517**	0.278**	1	-0.02	0.260**
PPAFET	-0.077*	-0.034	-0.184**	-0.02	1	0.054
FA	0.434**	0.700**	0.075	0.260**	0.054	1

Source: Author's estimation. Note- ****:** Correlation coefficient is significant at the 0.01 level and *: Correlation coefficient is significant at the 0.05 level. *GSDI:* Global sustainable development index; *ESI:* Environmental sustainability index; *EDI:* Economic development index; *SDI:* Social development index; *PPAFET:* Percentage of patent applications files in environmental technology; *FA:* Forest area as a % of land area.

3.3 Influence of *ESI*, *EDI*, *ET* and forest area on *GSDI*

Table 7 shows the empirical results which examine the influence of *ESI*, *EDI*, *SDI*, *ET* and forest area on *GSDI*. Regression coefficients of explanatory variables are estimated using linear, log-linear and non-linear regression models. As log-linear regression model produce lowest values of *AIC* and *BIC* as compared to linear and non-linear regression models. Thus, this model provides consistent regression coefficients of explanatory variables. Accordingly, it explains the statistical interpretation of results based on log-linear regression model.

The estimates imply that *GFSI* has a positive and statistically significant association with *ESI*, *EDI*, *SDI*, *PPAFET* and *GFA*. Here, it is argued that sustainable development (*SD*) will improve as increase in environmental, economic and social development. Earlier studies have also claimed that *SD* in an integration of above-mentioned developmental related indicators [3, 4, 7-9, 12]. These results are also supported by *R-squared* value i.e., 1.00 and it shows that 100% variation in sustainable development can be captured through environmental, economic and social development related factors.

Table 7. Impact of *ET*, *SDEI*, *EDI* and forest area on *GSDI*

Model's Name	Dependent Variable: Global Sustainable Development Index (GSDI)					
	Linear Regression Model		Log–linear Regression Model		Non-linear Regression Model	
No. of Obs.	663		618		663	
Mean of VIF	1.26		1.29		172.63	
R-squared	1.0000		0.9976		1.0000	
Wald Chi^2(15)	1.19e+09		1.12e+06		1.45e+09	
Prob>Chi2	0.0000		0.0000		0.0000	
AIC	-11809.5		-4958.989		-11803.61	
BIC	-11782.52		-4932.43		-11754.14	
Ramsey RESET [F-Value]	0.11		151.20		0.30	
Prob > F	0.9555		0.0000		0.0000	
Variables	Reg. Coe.	P>|z|	Reg. Coe.	P>|z|	Reg. Coe.	P>|z|
ESI	0.3335	0.000	0.3185	0.000	0.333	0.000
(ESI)^2	-	-	-	-	-0.001	0.866
EDI	0.3334	0.000	0.2872	0.000	0.333	0.000
(EDI)^2	-	-	-	-	0.001	0.201
SDI	0.3333	0.000	0.3740	0.000	0.333	0.000
(SDI)^2	-	-	-	-	0.000	0.563
PPAFET	2.11e-07	0.770	-0.002	0.000	-0.001	0.536
(PPAFET)^2	-	-	-	-	0.000	0.427
GFA	2.87e-06	0.340	-0.001	0.826	0.000	0.136
(GFA)^2	-	-	-	-	0.000	0.261
Cons. Coef.	-0.001	0.134	-0.013	0.000	0.000	0.507

Source: Author's Estimation.

Environmental and green technology (*ET*) would be effective to maintain the path of *SD*. Furthermore, *ESI*, *EDI*, *SDI* are the integrated index of associated several variables. Hence, it is concluded that *SD* is an integrated component of economic, social and environmental development, and technological development. Singh et al. [4] also found similar results across countries. *ESI* is integration of various factors such as access to electricity, CO_2 emissions from various sources, air pollution, electric power consumption, electricity production form different sources, renewable energy consumption, forest area, infant mortality rate, irrigated area, agricultural land, fertilizer consumption, population growth, population density, urbanization, fresh water resources, basic drinking water and sanitation facilities. Therefore, there is requirement to abate CO_2 emissions from various sources using green and environmental technologies in production activities and adoption of best environmental practices to maintain the environmental sustainability in global economies [5]. Use of electricity in production activities is effective to reduce the CO_2 emissions in atmosphere. Therefore, access to electricity for all communities and production of electricity form water, solar and other renewable sources will be favorable to increase environmental sustainability. Renewable energy consumption is also a vital factor to preserve the quality of available resources. Furthermore, sustainable use of water in agriculture will enhance the water sustainability in near future. Forest area is found a significant factor to absorb CO_2 emissions from various sources and it is useful to increase the clean environment [3, 4]. Therefore, it is recommended that global economies are required to adopt an effective policy to ensure the forest area. It is also apparent that forest area preserves the quality and quantity of available natural resources. For this, global economies should control deforestation to protect the reserves forest area. Extensive use of fertilizer and pesticide in cultivation is also caused to increase environmental degradation. There are many demographical factors like overwhelming population growth, population density, urbanization and industrialization also have negative impact on environment and ecosystem services [4]. Therefore, aforesaid issues must be included to formulate a policy towards sustainable development at world-wide.

Economic development index (*EDI*) is a combination of GDP per capita, GDP per person employed, total vulnerable employment, total wage and salaried workers, total self-employed, foreign direct investment net inflow, price stability, exports of goods and services, gross capital formation, gross fixed capital formation and consumption expenditure. Thus, aforesaid factors have a greater contribution to maintain the economic development of a nation [4]. Countries like India, South Africa, Tunisia, Moldova, Argentina, Mexico, Hungry, Czech Republic and Greece needs to focus on aforementioned activities to increase their performance and success in economic development.

Social development index (*SDI*) is a combination of sex ratio, contribution of females in economic activities, female infant mortality rate, total life expectancy rate at birth, education expenditure, age dependency ratio and fixed telephone subscriptions. As sex ratio and female's contribution in economic activities are useful to maintain the social equality and development. Furthermore, literacy rate is observed a vital factor to increase social equality and social development. Hence, extensive education expenditure will be useful to increase literacy rate and social development as well. Social communication increases as increase in fixed telephone subscriptions. Thus, it a crucial determinant to increase social development. In brief, countries such as South Africa, India, Tunisia, China should include aforementioned activities in further policy formulation to improve their position in social development in global economies. Also, environmental technology (*ET*) has a positive influence on *GSDI*, thus, it would be useful to achieve *SD* in future. Therefore, it is requested for global economies to discover more environmental and green technologies for production of goods and services. Environmental and green technologies will be developed through strengthening the science & technological development, increasing the involvement of researchers and scientists in R&D activities and extensive R&D expenditure in environmental and natural resources sciences. Thereafter, applications of environmental and green technologies in production activities would be helpful to mitigate the negative

consequences of deforestation, natural disasters, climate change, other socio-economic activities and demographical change on *SD* [1, 4]. Furthermore, the empirical results based on non-linear regression model, indicate that sustainable development has a linear association with economic development, social development, and forest area. While, environmental sustainability and environmental technology have non-linear association with sustainable development.

Table 8. Correlation coefficient of error-term with its lags

Model's Name	Linear Regression Model		Log–linear Regression Model		Non-linear Regression Model	
Lags	Auto-correlation coefficient	Partial Auto-correlation	Auto-correlation coefficient	Partial Auto-correlation	Auto-correlation coefficient	Partial Auto-correlation
1	1.000	0.010	1.000	0.618	1.000	-0.008
2	-0.031	-0.059	0.948*	0.016	-0.037	-0.079
3	-0.079	-0.047	0.907*	-0.003	-0.084*	-0.067
4	-0.084	-0.093	0.875*	-0.067	-0.089*	-0.113
5	-0.054	0.011	0.847*	0.167	-0.058	-0.011
6	-0.001	0.022	0.830*	-0.074	-0.007	0.007
7	0.033	-0.002	0.809*	0.077	0.027	-0.013
8	0.041	-0.128	0.794*	-0.085	0.039	-0.141
9	-0.098	-0.094	0.787*	0.119	-0.103	-0.114

Source: Author's Estimation.   Note: * indicates the coefficient is significant at 5% level.

3.4 Viability and credibility of regression coefficients

This study used three different models to estimate the regression coefficients of explanatory variables. Hence, it is compulsory to check the credibility of regression coefficients to make the rationality in the prediction of results. For this, existing researchers like Singh et al. [54], Jyoti and Singh [55], Singh and Jyoti [56] estimated the correlation coefficients of error-term with its various lags under a well-defined regression model to check the credibility of regression coefficients. Further, above-mentioned studies claimed that if the correlation coefficients of error-term with its at least first two lags are statistically significant then the regression coefficient may be valid and have credibility as well. Accordingly, regression coefficients may be used to make the future prediction about the output. Therefore, the Auto-correlation coefficient and Partial Auto-correlation coefficients of error-term and its various lags for linear, log-linear and non-linear regression models is given in Table 8. Auto-correlation coefficient among the error-term and its various lags under log-linear regression model is found statistically significant. Thus, regression coefficients of explanatory variables under this model have credibility.

4. CONCLUSION AND POLICY SUGGESTIONS

The main aim of this study is to estimate the global sustainable development index (*GSDI*) as an integration of vital determinants of environmental development, economic development, and social development for selected 39 economies. Thus, environmental sustainability index (*ESI*), economic development index (*EDI*) and social development index (*SDI*) are created using *Composite Z-score technique*. Accordingly, it expresses relative position of undertaken countries in sustainable development, environmental sustainability, economic development and social development. Finally, it explores the effect of environmental technologies (*ET*), deforestation, environmental sustainability index, economic development index and social development index on *GSDI* using linear, non-linear and log-linear regression models at country-wise panel data during 2000-2016.

This study emphasized that sustainable development (*SD*) is multi-dimensional component and assessment which is directly and indirectly associated with socio-economic development and other activities of a nation. It is also highlighted that *SD* may not be measured with a single factor [4, 14]. Thus, index-based estimation is an effective tool for assessment of *SD* [4, 14]. Henceforth, this study argued that global sustainable development index (*GSDI*) may be a crucial mechanism for measurement of *SD*. Also, it must be included factors related to economic development, human development, social development, environmental development, technological development, industrial development, institutional development, infrastructural development and political stability [17, 32, 57]. The results infer that there is a high variation in sustainable development, environmental sustainability, economic development and social development in selected countries. Also, there is a significant diversity in these indicators in individual country.

As environmental development and ecological security are negatively associated with deforestation. Subsequently, deforestation have negative impact on *SD*. It is also found that *SD* is positively associated with economic, social and environmental development. Furthermore, this study provides a confirmation that environmental technologies and its applications in production activities would be useful to increase environmental development and *SD*. Existing studies also argued that technological development and innovation would be useful to achieve social and economic development [4, 7, 32]. Science & technological development also has a positive impact on income distribution, employment, industrial structure and social security. Environmental sustainability can be improved through technology transfer and extensive R&D expenditure across economies. Kongoli [17] also claimed that science & technological development, appropriate governance and management, education and civil society are the crucial pillars of *SD*. Furthermore, environmental sustainability will be improved as providing electricity to all community, production of electricity from renewable sources, protection of forest area, water management and conservation [4]. There is also requirement to control urbanization, population growth and population density to maintain environmental sustainability in developing countries like India and China. Consequently, it will reduce extensive pressure of population on ecological factors and additional use of natural resources in production activities. Highly industrialization countries like USA and United

Kingdom require to use green and environmental technologies in production of goods to abate CO_2 emissions from various sources.

It is expected that extensive pressure of population on natural resources will create more problems to maintain *SD* in developing economies [9]. Consequently, environmental quality and ecological resources will diminish due to high population growth, urbanization and labor migration from rural to urban area [1, 8, 28, 43]. Therefore, it is essential for developing countries such as India China, South Africa to adopt promising policies to control population growth, urbanization and labor migration to increase environmental sustainability. Furthermore, high population growth is caused to increase carbon emission and it is responsible for depletion of water and natural resources. So, there is desirable to maintain the negative consequences of overwhelming urbanization and population growth on environmental development in developing countries.

South Africa, India, Tunisia, Russia, Moldova, Poland, Argentina, Slovak Republic Romania, Croatia and Lithuania have relatively poor position in economic development among the 39 countries. Therefore, these countries should create extensive jobs for their population, conducive ecosystem for manufacturing sector to increase exports of goods and attract more foreign direct investment inflow and maintain price stability. Aforementioned initiatives will be positive for these countries to increase economic development at greater level.

China, Tunisia, India and South Africa have low position in social development. Thus, these countries should implement appropriate economic planning, effective education policy, better health and sanitation facilities, provision of clean drinking water and energy, adoption of poverty eradication strategies, extensive employment opportunities, gender equality, women empowerment, food security, social and environment justice, provision for protection of natural resources and climate action policies to increase social development and *SD* [15, 58]. As climate change is also created a barriers in path of sustainable development. Thus, global economies are needed to focus on climate change mitigation and adaptation techniques to achieve sustainable development in near future.

To maintain environmental development is a serious concern to achieve *SD* in developing economies. Therefore, environmental degradation and deforestation must be reduced through implementing an effective planning towards protection of natural resources and ecosystem services in these economies [8]. Environmental and green technologies bring several opportunities to reduce the adverse effect of deforestation in production activities [33]. Thus, it is proposed that high industrialized economies should use green and environmental technologies in production of goods. It would be helpful to abate GHGs emissions in atmosphere [3]. Also, environmental and green technologies may be discovered through more technological innovation and extensive involvement of scientist in R&D activities [32]. Also, innovative environmental technologies and technological development would be supportive to boost economic growth including *SD*. Global economies are essential to increase R&D expenditure, and extensive involvement of researchers and scientists in the area of environmental science will be useful to invent more environmental and green technologies for production activities. Hence, technological innovation may be useful to increase social and economic objectives of a country at greater scale [6, 32]. There is also requirement to provide better education and training to the people to increase their consciousness towards environmental related concerns and its implication in human life in developing countries [9].

5. POLICY PROPOSALS FOR DEVELOPMENTAL THINKERS

In this study, *ESI* is as an integration of several factors that is given as:

(i) Air Quality and Pollution: There is essential to abate CO_2 emissions from various production activities. Hence, it is urged to scientific community to discover a carbon sink which can be absorbed the CO_2 emissions from various activities [51]. It would be imperative to preserve the quality and quantity of natural resources, subsequently it may be helpful to achieve *SD* [14, 21]. Air quality also would improve as use of electricity in production activities. Thus, it is indispensable to provide the electricity to all community to increase environmental quality.

(ii) Energy Management: Appropriate energy management practices like use of electric power consumption, renewable electricity output from various sources such as natural gas, coal, hydroelectric, nuclear and renewable sources would be effective to increase environmental sustainability [3, 4, 16, 17, 50, 59, 60]. Also, renewable energy practices and clean fuel energy consumption would be useful to increase economic development with sustainable economic growth [33].

(iii) Forest and Bio-diversity: Forrest area is an ecosystem-adaption based technique which can be used to reduce the negative impact of carbon emission on natural resources [61-63]. Forest area mitigates the negative impact of climate change in agricultural production activities. It is also useful to increase the water level in ground and reduce the possibilities of natural disasters such as floods, hurricanes, drought, tornadoes, volcanic eruptions, hailstorms, earthquakes, tsunamis and other natural calamities.

(iv) Human Health and Disaster: There is also essential to maintain human health to control the infant mortality rate through providing better food security and livelihood security. It would be positive to achieve *SD*. Infant mortality rate can be reduced through providing basic sanitation and better health facilities to rural and urban dweller [3, 64].

(v) Land Use Pattern and Agriculture: Applications of fertilizer and pesticides in farming is a significant contributor of GHGs emissions. Thus, there is requirement to adopt organic farming practices to abate GHGs emissions from agriculture and allied sectors. Then, it would be beneficial to preserve the quality and quantity of natural and ecological resources [4, 14, 24, 65].

(vi) Population Pressures on Ecosystem Services: Natural resources and ecosystem services are diminishing due to over population growth and higher urbanization at global level [4]. Thus, it must be mandatory for policy makers to formulate a policy to control population and urbanization to maintain the balance of population pressure on ecosystem services.

(vii) Water Generation Management: Water resources is scare in nature and it is continuously decreasing due to population growth, urbanization, and extensive use of water in farming, industrial and other sectors [66]. Therefore, it is necessary to adopt water management and conservation policies to maintain water sustainability.

Population growth, urbanization, population density, access to electricity, deforestation, forest area, renewable source of

energy, water conservation and fertilizer consumption in cultivation, and science & technological development are seemed most influencing factors of environmental sustainability index [67, 68].

Economic development index (*EDI*) is an integration of GDP per capita, GDP per person employed, vulnerable employment, wage and salaried workers, total self-employed, foreign direct investment net inflows, inflation GDP deflator, exports of goods and services, gross capital formation, labor force participation rate, gross fixed capital formation, total employers, final consumption expenditure and total unemployment rate [12, 53]. As per capita GDP and labor participation rate generate a conducive path for economic development [14]. Foreign investment net inflow is useful to increase financial stability, create physical asset and it generates more jobs in a country. Consumption expenditure is also useful to increase the demand of goods and services. Accordingly, it provides incentive to manufacturing sector to produce additional goods and creates more jobs for skilled and unskilled labors in a nation. Hence, per capita GDP, labor participation rate, foreign direct investment net inflow, inflation and consumption expenditure are observed most influencing factors of economic development index. Furthermore, R&D expenditure is also significant driver to increase economic development [69].

Social development index (*SDI*) is a combination of sex ratio at birth, ratio of female to male labor force participation rate, female labor force, female unemployment, and female infant mortality rate, life expectancy at birth, education expenditure and fixed telephone subscriptions [6, 12]. It is found that education expenditure, female labor force, fixed telephone subscriptions, age dependency ratio, female labor force and employment opportunity for female will be useful to increase social development. Gender equity and female's participation in economic activities are useful to maintain social equity [4, 70]. Education expenditure is effective to increase the literacy rate. Thus, gender equity, female's participation and education expenditure are found most influencing factors of social development index (*SDI*). Also, the benefits of social and economic development must be effective for poverty eradication and abating inequality in the society to achieve *SD* [15].

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