



Environmental and natural resource degradation in the wake of COVID-19 pandemic: a wake-up call

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Abstract

The study's objective is to examine the relationship between COVID-19 cases, environmental sustainability ratings, and mineral resource rents in a large cross section of 97 countries. The emergence of novel coronavirus 2019 (COVID-19) enlarges its magnitude across the international borders and damages social, economic, and environmental infrastructure with a high rate of human death tolls. The mineral resources are also devastated, which served as a primary raw input into the production system. The adverse effects of the COVID-19 pandemic on the environment and mineral resources are studied in a large panel of countries and found that mineral resource rents and population growth improve environmental sustainability rating (ESR). In contrast, an increase in coronavirus cases decreases the rating scale across countries. Further, mineral resources first decrease along with increased COVID-19 cases due to strict government policies, including the mandatory shutdown of economic institutions. Further, mineral resource rents increase later because of resuming economic activities in many parts of the world. The high rate of population growth is another important factor that negatively affects mineral resources across countries. Through impulse response and variance decomposition estimates, an exacerbated coronavirus cases and population growth would likely negatively affect ESR and mineral resources. In contrast, COVID-19 recovered cases will likely play a more significant role in securing mineral resources over time. Therefore, the global mineral resource conservation policies and improving ESR are highly needed during the COVID-19 to keep the significant economic gains in unprecedented times.

Keywords Environmental sustainability rating · Mineral resources · COVID-19 pandemic · Population growth · Markov switching approach · Innovation accounting matrix

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Introduction

Mineral resources played an important role in global productivity. It provides input to the industry to transform natural resources and decarbonize them through an efficient resource extraction process, cleaner energy technologies, and environmental regulations (Nassani et al. 2019). The effects of the COVID-19 pandemic are not limited to socioeconomic and environmental resources, while it negatively impacts mineral resource rents. The depletion of the high rate of mineral resources is confined to decrease economic resources; further, it affects the livelihood of the ordinary peoples working in this sector (Hilson et al. 2021 Lee and Bazilian, 2020). Further, the cost of carbon pollution negatively affects general public health, leading to more likely to affect contagious diseases because of the low immune system (Anser et al. 2020b).

The COVID-19 pandemic negatively affects the central commodity prices ranges from 5 to 25%. For instance, the thermal coal price drops down to 23%, followed by 21%

metallurgical coal, 19% gold prices, and up to 18% of iron ore. The 10 to 30% currencies devalued in the large mining countries (Azevedo et al. 2020). The ample amount of studies confirmed that the COVID-19 pandemic increases global poverty risk due to high healthcare expenditures, closures of essentials markets, strict lockdown, exacerbated unemployment rate, financial issues, and high disruption of the global food supply chain (Mann 2020; Galanakis 2020; Anser et al. 2020a, b). The economic and environmental resources are directly affected by the increase in global COVID-19 cases that need to be reduced by global strategic policies (Elavarasan et al. 2021; Hale et al. 2021).

The motivation of the study is to work on the stated topic to eye-opening the environmental specialists to devise sustainable and sustained healthcare and mineral resource policies across countries. For instance, Awan (2019) proposed a multilevel environmental governance mechanism for environmental protection that is likely to achieve carbon neutrality agenda. Awan (2020a) further endorsed the need to attain industrial ecology to harmonize the relationship between human and ecological systems for broad-based growth. Awan (2020b) argued that sustainable innovation helps resolve organizational environmental issues and governance issues to achieve a green growth agenda. Smith (2020) argued that the COVID-19 pandemic negatively affects energy and natural resources management. Energy grids and their supply load shifted to household consumption while strict government actions contain coronavirus pandemic temporary shutdown mining industries worldwide. The need to ensure energy supply and resource management is desirable to minimize financial crises during a current pandemic. Maliszewska et al. (2020) concluded that the COVID-19 pandemic largely declines worldwide economic growth below 2% of GDP, subsequently declining domestic and traded tourists' services. Helm (2020) discussed the short-term and possible long-term environmental consequences that prevail during the COVID-19 pandemic. The results argued that although short-term results show some positive impact of air quality improvement in GHG emissions reduction, its effect on biodiversity and environmental regulations remains in question in a given time. The negative impacts of the COVID-19 pandemic on global economic activities are primarily exhibited. Continued support to monetary and fiscal expansionary measures would likely increase asset pricing, debt levels, and consumption. Thus, the need for efficient economic and environmental policies is imperative to control coronavirus. Corlett et al. (2020) greatly emphasized the need to adapt biodiversity conservation policies to protect natural habitats. During the COVID-19 pandemic, travel and transportation restrictions supported the many precious wildlife animals; however, there are many more things to do to secure our biodiversity, including reducing air pollution, noise pollution, water pollution, and GHG emissions. All these factors would

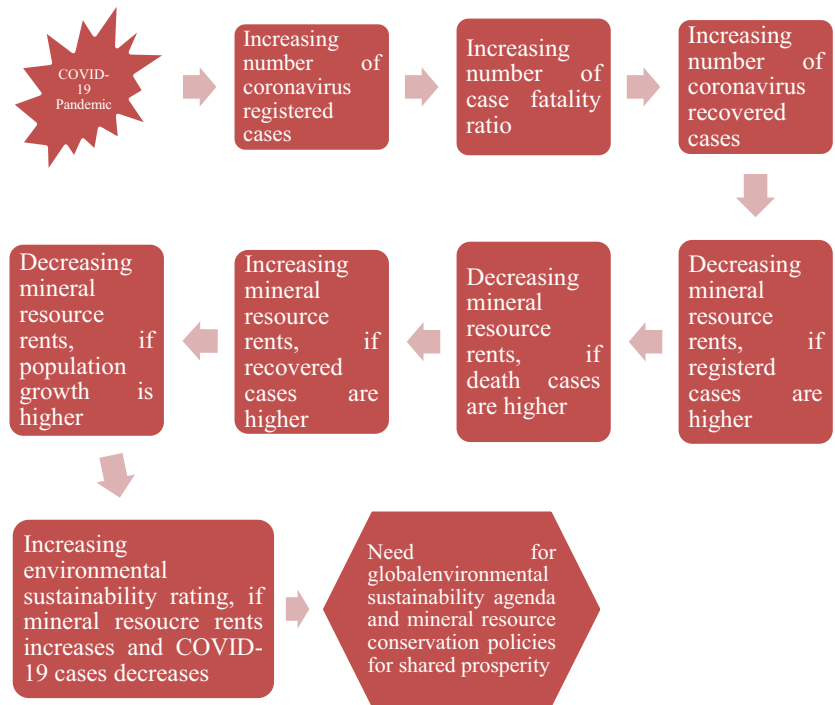
need urgent attention during and after the COVID-19 pandemic. Berchin and de Andrade (2020) concluded that due to becoming a global village, the impacts and intensity of the COVID-19 pandemic greatly exacerbated to all across the globe, which confined the economic infrastructure while its effect environmental sustainability agenda worldwide. Karatayev and Hall (2020) discussed the volatility of oil price shocks in resource-rich countries that negatively impact non-resource sectors. The COVID-19 pandemic also puts tremendous pressure on natural resources that need sound economic and environmental policies to contain the current pandemic and conserve natural resources. Pradhan et al. (2020) concluded that silver and gold are considered safe havens to Indian investors. They moved in a risk-off environment until it increases coronavirus cases in a country. Table 1 shows the earlier literature on environment and resource degradation during the pandemic crisis worldwide.

The contribution of the study is twofold. First, the study assessed the role of mineral resource rents and the COVID-19 pandemic on improving ESR. Second, it assessed the impact of COVID-19 cases and population growth on mineral resource rents in a large cross-section of 97 countries at one point in time. The earlier studies mainly included different environmental pollution in the COVID-19 framework (see Pei et al. 2020; Zhu et al. 2020; Frontera et al. 2020; Jiang et al. 2020) while ignored the more comprehensive policy variable related to ESR during the pandemic recession. This variable is essential, as it described the country's overall rating towards achieving environmental sustainability from a policy perspective (Anser et al. 2021b). Furthermore, the commodity-producing sector is also negatively affected by the high COVID-19 cases due to adopting strict lockdown measures and maintaining social distancing in the mining, which affects their working conditions and livelihood to escape poverty. Therefore, the following research questions need to be tested in both the given scenario; i.e., does efficient resource extraction support ESR? This question argued that the exhaustion of mineral resources and their waste negatively affects the environment that needs to deploy technological upgradation and knowledge transfer to extract mineral resources efficiently. Further, to what extent do COVID-19 cases negatively affect ESR? The question highlighted that contagious diseases could quickly spread in an atmosphere that affects the general public's health. Hence, it is vital to improving environmental quality to reduce the susceptibility of coronavirus cases across countries. Finally, does the growing population negatively affect mineral resources and ESR? The question argued that high population growth jeopardy for conserving mineral resources. In contrast,

Table 1 Environment and natural resource degradation during the pandemic recession

Authors	Country	Causal factors	Policy factors	Policy inferences
Ganguly et al. (2021)	India	Air pollutants, i.e., PM ₁₀ , NO ₂	Lockdown measures and public health	Lockdown measures improve air quality indicators and public health in a country
Gonzalez-Perez et al. (2021)	Latin America and the Caribbean region	Environmental degradation, financial debt, income inequality, governance indicator	Sustainable development	Socioeconomic and environmental factors exacerbate coronavirus cases in a region
Miller-Rushing et al. (2021)	USA	Resource conservation strategies	Resource policies	COVID-19 pandemic creates difficulty in managing economic and natural resources, which need to be managed through sustainable resource policies
Selvaranjan et al. (2021)	Six different countries	Plastic pollution	Face masks	The high use of face masks to prevent coronavirus disease led to increased plastic pollution across countries
Patterson Edward et al. (2021)	India	Coastal environmental health	Lockdown measures	The lockdown measures improved the life of coastal environmental species in a country
Ambika et al. (2021)	India	Health risks, environmental risks	Social distancing, lockdown	The strict compliance of coronavirus SOPs helps to reduce environmental and health risks in a country.
Mell and Whitten (2021)	UK	Natural environment, green financing	Lockdown, health risks, urban planning	Post-COVID-19 strategies, including urban planning and sustainable reforms, would be helpful to move forward towards global prosperity
Anser et al. (2021a)	17 countries	Financial development	Environmental reforms	Environmental reforms would be helpful to reduce carbon damages to tackle coronavirus cases across countries

Figure 1 Research framework of the study Source: Author’s extraction



due to social and close contact between the population members, coronavirus cases worldwide are likely to exacerbate.

Based on the significant discussion, the study has the following research objectives, i.e.:

- i) To examine the effects of the COVID-19 pandemic on environment sustainability rating and mineral resources in a panel of 97 countries
- ii) To analyze the role of mineral resources and population growth on environmental reforms across countries
- iii) To substantiate the hump-shaped relationship between COVID-19 cases and mineral resources
- iv) To investigate the forecast relationship between the COVID-19 pandemic and environment and resource degradation over time

The study used “Markov switching regression” on different regimes to assume a common factor of

COVID recovered cases to evaluate the dynamic relationship between COVID registered cases, death cases, and population growth using a broad panel of heterogeneous countries for sound inferences.

Data source and methodological framework

The study used the following variables, i.e., environmental sustainability rating (ESR) fall in the range of 0 and 6. The lowest value shows a low rating, while the highest value shows a high sustainable rating. Unfortunately, the data is missing in many sample countries that have been filled by the lowest obtain the value of 2.5 rating scale among the sample countries. The study further used coronavirus registered cases (denoted by CASES), death cases (denoted by DEATH), and recovered cases (denoted by RECOV) as regressors, whereas mineral resource rents (denoted by MRENT) (% of GDP) served as a “response variable” in

Table 2 Descriptive statistics

Methods	ESR	MRENT	CASES	DEATH	RECOV	POP
Mean	2.778	2.545	88315.23	3543.902	47912.24	68572175
Maximum	4	26.21	2637077	128437	1093456	1.44E+09
Minimum	2.5	5.73E-05	170	1	109	586594
Std. dev.	0.456	4.699	317794.5	14887.46	148094.8	2.10E+08
Skewness	1.319	2.783	6.468	7.096	5.228	5.798
Kurtosis	3.321	11.549	48.83	57.04	33.246	37.168

Table 3 Markov switching regression estimates for Eq. 1

Dependent variable: MRENT				
Variable	Coefficient	Std. error	z-statistic	Prob.
Regime 1				
(MRENT) _{t-1}	0.000194	0.009921	0.019532	0.9844
ln(CASES) _t	-0.675729	0.188888	-3.577408	0.0003
ln(SQCASES) _t	0.041041	0.008831	4.647178	0.0000
ln(DEATH) _t	0.067331	0.048721	1.381974	0.1670
ln(POP) _t	-0.015267	0.033225	-0.459507	0.6459
Constant	3.841027	1.059784	3.624348	0.0003
ln(SIGMA)	-1.373673	0.108982	-12.60464	0.0000
Regime 2				
(MRENT) _{t-1}	-0.379500	0.304902	-1.244661	0.2133
ln(CASES) _t	-9.999763	4.036975	-2.477043	0.0132
ln(SQCASES) _t	0.632328	0.237299	2.664691	0.0077
ln(DEATH) _t	-1.832940	1.285365	-1.426008	0.1539
ln(POP) _t	-2.582335	0.859351	-3.004982	0.0027
Constant	96.44001	20.82994	4.629874	0.0000
ln(SIGMA)	1.443525	0.141919	10.17149	0.0000
Common				
ln(RECOV) _t	-0.124071	0.085810	-1.445879	0.1482
Diagnostic tests: transition matrix parameters				
P11-C	0.760610	0.337127	2.256154	0.0241
P21-C	0.288126	0.440182	0.654562	0.5127
Statistical tests				
Mean dependent var	2.573028	S.D. dependent var		4.718024
S.E. of regression	4.692239	Sum squared resid		1673.300
Durbin-Watson stat	1.716064	Log likelihood		-147.6864

one equation while a regressor served in another regression equation. In addition, the total population (denoted by POP) was used as a control variable for the COVID-19 pandemic, ESR, and mineral resource rents in a panel of 97 countries. The data of the COVID-19 pandemic is taken from Worldometer (2020), whereas the latest data are available for mineral resource rents and ESPR taken from World Bank (2020). Table 9 in the appendix shows the sample of countries used in this study for ready reference.

The study used the following two equations to analyze the effects of the COVID-19 pandemic on ESR and mineral resources, i.e.,

$$\begin{aligned}
 MRENT_{i,t} = & \beta_0 + \beta_1 \ln(CASES)_{i,t} + \beta_2 \ln(SQCASES) + \beta_3 \ln(DEATH)_{i,t} \\
 & + \beta_4 \ln(RECOV)_{i,t} + \beta_5 \ln(POP)_{i,t} + \varepsilon_{i,t} \cdot \frac{\partial MRENT}{\partial CASES} > 0, \frac{\partial MRENT}{\partial SQCASES} < 0, \\
 & \frac{\partial MRENT}{\partial DEATH} < 0, \frac{\partial MRENT}{\partial RECOV} > 0, \frac{\partial MRENT}{\partial POP} < 0
 \end{aligned} \tag{1}$$

$$\begin{aligned}
 \ln(ESR)_{i,t} = & \beta_0 + \beta_1 \ln(MRENT)_{i,t} + \beta_2 \ln(CASES)_{i,t} + \beta_3 \ln(POP)_{i,t} \\
 & + \varepsilon_{i,t} \cdot \frac{\partial ESR}{\partial MRENT} > 0, \frac{\partial ESR}{\partial CASES} < 0, \frac{\partial ESR}{\partial POP} < 0
 \end{aligned} \tag{2}$$

where ESR shows environmental sustainability rating, MRENT represent mineral resource rents, CASES represent COVID registered cases, SQCASES represent the square of CASES, DEATH represents COVID total death, RECOV shows total recovered cases, POP represents total population,

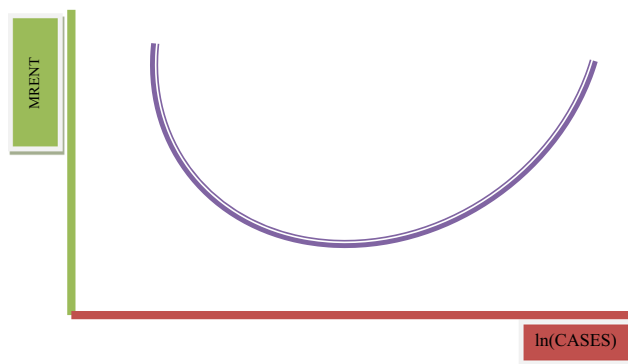


Figure 2 U-shaped relationship between mineral resources and COVID-19 cases Source: Author’s estimation

Table 4 Cross-sectional regression analysis for Eq. 2

Dependent variable: ln(ESR)				
Variable	Coefficient	Std. error	t-statistic	Prob.
C	0.525812	0.154894	3.394666	0.0010
ln(MRENT)	0.014358	0.005206	2.758031	0.0070
ln(CASES)	-0.041120	0.007655	-5.371830	0.0000
ln(POP)	0.052231	0.011121	4.696650	0.0000
R-squared	0.290821			
Adjusted R-squared	0.267944			
F-statistic	12.71252			
Prob(F-statistic)	0.000000			

“ln” represent natural logarithm, “i and t” represent 97 countries and 2020 time period respectively, and ϵ represents error term.

Equation 1 shows that COVID cases and their square term will expect to show an inverted U-shaped relationship between them. In contrast, COVID death cases and recovered cases will likely have a negative and positive impact on mineral resources across countries. The total population growth is assumed to decrease mineral resources. Equation 2 assumed that mineral resource rents improve ESR, whereas increasing COVID-19 cases and population growth decreases ESR across countries. Figure 1 shows the research framework of the study.

Figure 1 shows that the COVID-19 pandemic and population explosion are expected to have the main detrimental factors of mineral resource depletion. The higher the COVID-19 cases and population growth, the higher the likelihood of negatively affecting mineral resource rents, which need unified global resource conservation strategies to contain coronavirus pandemic across countries. Further, the greater increase in the case-fatality ratio is likely to bring down ESR while it improves by increasing mineral resource rents across countries.

The following hypotheses have been proposed under the COVID-19 pandemic, i.e.:

H1: ESR can likely be improved by increasing mineral resource rents and minimizing coronavirus cases.

H2: COVID-19 cases first increase and decrease mineral resource rents to exhibit an inverted U-shaped relationship between them.

H2: There will be an adverse effect of coronavirus death cases and population explosion on mineral resource rents.

H3: An increasing number of coronavirus recovered cases will likely resume economic activities that would be helpful to conserve mineral resources.

The study used cross-sectional regression and Markov switching regression to assess the relationship between COVID-19 registered cases, death cases, population growth, and mineral resource rents in one equation, while assessing the dynamic impact of mineral resources resource rents COVID-19 cases on ESR in another regression. Further, the study used impulse response function (IRF) and variance decomposition analysis (VDA) to analyze the forecast relationship between the stated variables over a time horizon.

Results and discussion

Table 2 shows the descriptive statistics of the candidate variables. The mean value of ESR is 2.778 that shows the overall environmental sustainability reforms are weaker, leading to a negative effect on the healthcare sustainability agenda across countries. The mean value of mineral resource rents is 2.545% of GDP with a positively skewed distribution and a prominent distribution peak. The maximum value of COVID-19 cases is 2,637,077 (USA), the minimum value of registered cases is 170 (Burundi), and the average value is 88,315.23. The

Table 5 IRF estimates for Eq. 1

Response of MRENT					
Months	MRENT	ln(CASES)	ln(DEATH)	ln(RECOV)	ln(POP)
June 2021	-0.457	-0.499	0.122	-0.770	-0.142
July 2021	0.920	-0.055	-0.527	-0.234	0.586
August 2021	-0.332	-0.307	0.016	-0.130	0.019
September 2021	0.166	-0.116	0.018	0.023	0.093
October 2021	-0.095	-0.142	0.023	0.012	-0.032
November 2021	0.047	-0.082	-0.020	0.032	0.026
December 2021	-0.032	-0.092	-0.019	0.010	0.013
January 2022	0.003	-0.080	-0.021	0.014	0.026
February 2022	-0.017	-0.083	-0.012	0.011	0.016

Table 6 IRF estimates for Eq. 2

Response of ESR				
Month	ESR	MRENT	CASES	POP
June 2021	-0.071740	-0.025133	-0.098481	0.008475
July 2021	0.064463	0.022951	-0.051719	-0.032975
August 2021	-0.005293	-0.013243	-0.036844	-0.014966
September 2021	0.019292	0.012209	-0.016941	-0.007531
October 2021	0.001992	-0.004981	-0.014548	-0.004503
November 2021	0.005832	0.005001	-0.008381	-0.002144
December 2021	0.001504	-0.001718	-0.007014	-0.002160
January 2022	0.002216	0.001906	-0.004245	-0.001065
February 2022	0.000913	-0.000541	-0.003341	-0.001029

Note: ESR shows environmental sustainability rating, MRENT shows mineral rents, CASES shows COVID-19 registered cases, and POP shows population

coronavirus death and recovered cases are higher in the USA, i.e., 128,437 and 1,093,456, respectively. The average value of the total population in the given sample is about 68,572,175.

Table 3 shows the Markov switching regression estimates and found that COVID-19 cases first decrease mineral resource rents in the early phase of exacerbation of coronavirus cases; later, when economic activities begin to resume, mineral resource rents essentially decrease, verifying the U-shaped relationship between the two variables. The death cases reported due to the coronavirus pandemic cannot signify its relationship with mineral resource rents at both regimes. The total population exhibits a negative relationship with mineral resource rents across countries. Lee and Bazilian (2020) showed that due to the COVID-19 pandemic, most resource-dependent countries are critical to fall out the supply

of critical minerals. For instance, the USA heavily relies on a transborder critical minerals supply chain disrupted in the current pandemic to develop domestic critical mineral resources through the defense production act. Chadha (2020) emphasized the need to ensure an efficient supply chain of critical minerals during the COVID-19 pandemic to advance the clean energy agenda. Sappor et al. (2020) showed the volatility in the prices of the base metals during the COVID-19 pandemic that substantially decreases since the beginning of the pandemic due to a more significant decline in the consumption of copper, zinc, iron, ore, lead, cobalt, lithium, etc., across the metals and mining industry. Copper prices have fallen larger than the other stated metals, i.e., 22% starting from the 2020 year, followed by nickel, ore, lead, zinc, and iron prices that fallen between the range of 10 to 20%, while lithium and cobalt prices are fallen to 8% and 5% respectively, over the same period. The number of earlier studies is also in line with the estimated results in different economic settings, for instance, Anser et al. (2021a), Everard et al. (2020), and Golar et al. (2020). These studies confirmed the volatility in natural resources in account of an increased COVID-19 pandemic worldwide.

Figure 2 shows the U-shaped relationship between the COVID-19 pandemic and mineral resource rents. The relationship confirmed that COVID registered cases initially decrease mineral resource rents due to mandatory lockdown industries and associated infrastructure nationwide. In contrast, mineral resource rents increase later due to resuming social and economic activities during the COVID-19 pandemic. The importance of the stated result yields sounds resource conservation policies that are imperative for long-term sustained growth.

Table 4 shows the cross-sectional regression estimates and found a less elastic relationship between mineral resource rents and ESR with an elasticity estimate of 0.014 percentage

Table 7 VDA estimates

Variance decomposition of MRENT						
Month	S.E.	MRENT	ln(CASES)	ln(DEATH)	ln(RECOV)	ln(POP)
June 2021	4.440	95.544	1.266	0.075	3.009	0.103
July 2021	4.609	92.663	1.190	1.378	3.051	1.716
August 2021	4.633	92.214	1.619	1.365	3.099	1.700
September 2021	4.638	92.125	1.678	1.363	3.094	1.737
October 2021	4.642	92.034	1.770	1.364	3.091	1.739
November 2021	4.643	91.996	1.801	1.365	3.094	1.742
December 2021	4.644	91.958	1.839	1.366	3.093	1.742
January 2022	4.645	91.924	1.869	1.368	3.093	1.744
February 2022	4.646	91.892	1.901	1.368	3.092	1.745

points. The result implies that mineral rents help improve ESR due to efficient resource extraction and minimizing resource wastes. On the other hand, COVID-19 cases disrupted the ESR agenda due to inadequate healthcare infrastructure and meagre environmental reforms. However, the greater increase in population growth positively changes the ESR agenda because of the population ingenuity principle. Arora and Mishra (2020) suggested improving environmental quality to prevent it from a future pandemic; further, it would help move towards green development. Praveena and Aris (2021) argued that achieving environmental sustainability is vital for healthcare sustainability to move forward to escape it from contagious disease. Rume and Islam (2020) concluded that the recent pandemic recession has positive and negative environmental benefits. On the one hand, the adoption of COVID-19 measures helps to improve environmental quality indicators because of the closure of industries. On the other hand, it increases untreated healthcare wastes, which affect the sustainability principles. Further, the number of studies confirmed the estimated results of improving environmental sustainability ratings in the wake of COVID-19 cases and natural resources (see Anser et al. 2021b; Quatrini 2021; Boston 2020).

Table 5 shows the IRF estimates for Eq. 1 and found the differential impacts of the COVID-19 pandemic on mineral resource rents over the time horizon. It is likely that coronavirus registered cases, death cases, and population growth will jeopardize mineral resource rents. In contrast, coronavirus recovered cases over most of the time in a year will likely conserve mineral resources across countries.

Table 6 shows the IRF estimates for Eq. 2 and suggested that coronavirus cases and population growth likely decrease the ESR agenda in the next coming year. In contrast, mineral resource rents are likely to cause a mixed impact on ESR across countries. The result shows that coronavirus cases are likely to negatively affect the environmental sustainability agenda because of high population growth and social compactness among the economic agents.

Table 7 shows the VDA estimates for Eq. 1 and found that the natural logarithm of recovered cases will have a greater magnitude in influencing mineral resource rents with a variance error shock of 3.092%, while the least influenced will be the natural logarithm of death cases on mineral resources over time. The proportion of variance error shocks of the natural logarithm of registered coronavirus cases, death cases, and the total population is about 1.901%, 1.368%, and 1.745%.

Table 8 shows the VDA estimates for Eq. 2 and suggested that coronavirus cases would likely cause a greater change in the ESR agenda, as its estimated variance value of 6.294%.

Table 8 VDA estimates for Eq. 2

Variance Decomposition of ESR					
Month	S.E.	ESR	MRENT	CASES	POP
June 2021	0.465636	95.20243	0.291341	4.473104	0.033124
July 2021	0.474617	93.47830	0.514262	5.492858	0.514581
August 2021	0.476494	92.75578	0.587461	6.047575	0.609181
September 2021	0.477401	92.56706	0.650630	6.150553	0.631757
October 2021	0.477674	92.46304	0.660760	6.236283	0.639920
November 2021	0.477814	92.42372	0.671326	6.263395	0.641559
December 2021	0.477876	92.40080	0.672444	6.283320	0.643435
January 2022	0.477905	92.39174	0.673953	6.290449	0.643854
February 2022	0.477919	92.38671	0.674042	6.294967	0.644280

This is followed by mineral resource rents and population growth with estimated values of 0.674% and 0.644%, respectively, for a subsequent year.

Conclusions and policy implications

Environmental and natural resources played a vital role in improving air quality indicators, ultimately increasing sustainable development reforms worldwide. Natural resources supported by economic production play a crucial role in providing raw inputs that help generate economic profit through industrial tradeoffs. The current pandemic disproportionately affects global economic and environmental infrastructure that leads to the economic downturn. The study is motivated to start working in the light of the vulnerability of coronavirus pandemic emerged by using a large panel of countries. The results show that mineral resource rents and population ingenuity principles help improve ESR, whereas an increasing number of coronavirus cases negatively affect the sustainability agenda across countries. Further, an increase in coronavirus cases suppresses mineral resource rents due to strict nationwide strategies. It is further impacting the conservation of mineral resources. In contrast, mineral resources support increasing countries' economic growth at the later stages by providing raw material to the industrial production that works under the government's strict guidelines to contain coronavirus; thus, it exhibits the U-shaped relationship between them. The total population is also the jeopardy of mineral resources across countries. The innovation

accounting matrix shows that coronavirus cases and population growth likely to cause a greater change in the environmental sustainability agenda. In contrast, coronavirus cases and the death rate will negatively impact mineral resource rents over time.

The COVID-19 pandemic affected the major industries of the countries; further, it affected the mining and resource extraction industries due to abiding by the strict government strategies to contain coronavirus. The minimal workers are engaged working during a pandemic due to maintaining the social distancing between them. Thus, the workflow of many critical mineral resource extractions is slowing down while some mine operators temporarily closed their sites. The mining industry is further dependent upon its logistics supply chain. During the COVID-19 pandemic, the mining industry is affected mainly due to the delayed supply chain of many critical mineral resources importing and exporting to other countries. The travel and transportation restrictions and ceased international borders increase the commodity and metal prices, putting a severe burden on mining industries. Thus, to minimize the supply chain risks of primary mineral resources, the high need for contingencies of resource policies is imperative to keep maintaining the flow of natural resources with the government's economic policies. The overall discussion comes to the following four policy outcomes, i.e.:

- i) Environmental sustainability is imperative for achieving healthcare sustainability and green growth agenda (see, Koondhar et al. 2021; Ahmad et al. 2021; Gyamfi et al. 2021).
- ii) An efficient use of natural resources and reducing resource wastes helpful for improving the livelihood of the low-income strata group (Salahuddin et al. 2020; Imran et al. 2021; Goswami and Nautiyal 2020).
- iii) The standardized operating procedures to control coronavirus cases required massive healthcare reforms worldwide (Park et al. 2021; Etafa et al. 2021; Mao et al. 2021).
- iv) Population ingenuity principle would likely be more supportive to the resource conservation agenda, while it remains needed to become viable in reducing coronavirus cases (Kelley et al. 2021).
- v) The use of green energy sources, supply chain management, governing issues, and resource eco-efficiency remains needed caution before adding to the sustainability agenda (Zaman et al. 2016; Awan 2019; Anser et al. 2020b; Awan et al. 2020; Alhawari et al. 2021).

Based on the stated policy recommendations, the study concludes that the environmental sustainability principle can be achieved by improving air quality indicators and resource conservation agenda, vital for better healthcare reforms.

Appendix

Table 9 List of countries

USA, Brazil, Russia, India, Spain, Peru, Chile, Iran, Mexico, Pakistan, Turkey, Saudi Arabia, South Africa, Canada, Colombia, China, Egypt, Sweden, Argentina, Ecuador, Indonesia, Ukraine, Portugal, Oman, Philippines, Poland, Panama, Bolivia, Dominican Republic, Afghanistan, Romania, Ireland, Armenia, Nigeria, Kazakhstan, Japan, Austria, Honduras, Guatemala, Ghana, Azerbaijan, Serbia, Algeria, Cameroon, Morocco, Malaysia, Uzbekistan, Australia, Finland, Senegal, North Macedonia, Tajikistan, Ethiopia, Guinea, Gabon, Kyrgyzstan, Bulgaria, Mauritania, Hungary, Bosnia Herzegovina, Greece, Thailand, Costa Rica, Croatia, Albania, Cuba, Nicaragua, Mali, Madagascar, Sri Lanka, Slovakia, Zambia, New Zealand, Sierra Leone, Tunisia, Malawi, Jordan, Niger, Cyprus, Burkina Faso, Uruguay, Georgia, Rwanda, Chad, Mozambique, Uganda, Eswatini, Liberia, Jamaica, Togo, Zimbabwe, Tanzania, Surinam, Vietnam, Guyana, Namibia, Burundi
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Availability of data and materials The data is freely available at Worldometer (2020) at <https://www.worldometers.info/coronavirus/> and World Development Indicators published by World Bank (2020) at <https://databank.worldbank.org/source/world-development-indicators>

Author contribution MKA, conceptualization, methodology, writing—reviewing and editing. AAN, supervision, resources, software. KZ, formal analysis, methodology, resources. MMQA, resources, visualization, formal analysis.

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Declarations

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Consent for publication All authors allow the publication of the paper.

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