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Review

How Did the Pandemic Affect Our Perception of Sustainability? Enlightening the Major Positive Impact on Health and the Environment

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Abstract: Since the World Health Organization (WHO) declared the outbreak of severe acute respiratory syndrome COVID-19 virus 2 (COVID-19) virus disease 2 (SARS-CoV-2) on 9 January 2020, the entire world has been exceptionally interested in examining the impact of this pandemic on people and the environment. The pandemic led to unprecedented measures to halt air traffic and close factories due to lockdowns, economic closures, and the stopping of transportation of all kinds. The decline in the use of coal by power plants, oil refining, and steel manufacturing had a beneficial effect on air pollution and caused a decrease in carbon dioxide emissions. Moreover, the concept of sustainability has become more prevalent, reflecting the increasing awareness of the responsibility placed on every member of society. Sustainability is the quality and quantity of change that meets our needs without destroying the giving planet, which is the hope for the survival of future generations. We summarized and discussed the studies and research documenting these effects on the environment and health worldwide to come up with objective conclusions, and to draw some recommendations and concepts about the importance of sustainability. The significance of this article lies in that it aims to briefly review some of the positive and negative impacts observed and reported during the SARS-CoV-2 pandemic on health and the planet's environment for the duration of April 2020–October 2022, and finally discuss the challenges and prospects to endorse planet sustainability. While COVID-19 had many beneficial effects on the planet's recovery, there were also profound effects on health due to the disease itself. Government and policymakers must take measures to prevent this environmental healing process from being transient.

Keywords: pandemic; COVID-19; sustainability; environmental pollution; air pollution; pandemic; air quality

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1. Introduction

Sustainability is based on equal economic growth that generates wealth and happiness for all, without harming the environment or others. Scientists, activists, researchers, and world leaders are committed to protecting the planet through sustainable consumption and production, managing its natural resources sustainably, and taking urgent action on climate change, not only to secure the current generation but to support the needs of future generations as well. Scientists worldwide are increasingly endorsing programs, initiatives, and actions that aim to conserve resources. Hence, the term sustainability has been widely used in the past two decades to refer to the four human, social, economic, and environmental domains that represent the four pillars of the concept of sustainability [1–3].

Sustainability creates and maintains conditions under which humans and nature can live in developmental harmony without depleting or polluting the environment. The

COVID-19 virus pandemic has had many repercussions for future sustainability opportunities. The COVID-19 virus (COVID-19) pandemic crisis has had many repercussions on future sustainability opportunities. For this reason, the global impact of the COVID-19 virus pandemic on the indicators of achieving sustainability in the human, economic, social, and environmental dimensions and its unprecedented challenges to achieving sustainability is a crucial field of study and research [3–5]. This brief review article aims to highlight some of the positive and negative impacts observed and reported during the SARS-CoV-2 pandemic between April 2020–October 2022 on the health and environment of the planet to elicit some recommendations and concepts on the importance of sustainability.

1.1. Human Sustainability

Human sustainability aims to preserve and improve the safety of the human element in society through programs under the umbrella of human sustainability; investments in health and education systems; and access to services, nutrition, and knowledge. In addition to sustainability in the natural resources and available spaces, it balances continued growth and improvements in the health and well-being of all. Human sustainability focuses on the person who participates directly or indirectly in maintaining this sustainability [2,3]. Therefore, activities or businesses used to obtain basic materials and resources may affect individuals all over the world positively or negatively. Human sustainability promotes business values that respect human capital, as the goal is to develop and enhance the protection of the individual [4]. Therefore, the primary purpose of human sustainability is to support people to live healthier and promote well-being for all ages [2–4].

1.2. Social Sustainability

The concept of social sustainability accommodates a larger worldview regarding societies, cultures, and globalization. It aims to preserve social capital through the investment in and the creation of services that form the framework of our community. Social sustainability is based on perpetuating quality by supporting it with concepts that call for solidarity and societal cohesion, imparting a spirit of selflessness, reciprocity, and honesty, and allowing others to contribute to society [1,2,5]. The importance of relationships between people and consideration for others can create sustainability that extends its impact on future generations—realizing that what we are doing now has a significant effect on the planet and the future life of future generations represents the spirit of community sustainability. Of course, this needs to be supported by laws, information, and shared ideas about equality and rights [1,5].

1.3. Economic Sustainability

Economic sustainability is fundamentally about keeping capital healthy and improving the standard of living. Genuine sustainable development is more than just economic growth; it is the quality and quantity of change and the maintenance of high and stable levels of economic growth. Economic sustainability can be accomplished through the incorporation of environmental and social components. It challenges the mantra of capital that continued development is good and, more importantly, better if it risks harm to ecological and human systems [1,6–8].

1.4. Environmental Sustainability

Environmental sustainability depends on protecting natural capital such as land, air, water, minerals, and everything else that exists in nature and benefits humanity as a resource. The population's essential needs to live on the planet can be achieved without compromising the needs of future generations. When achieving positive economic results, companies must pay attention not to cause any collateral damage to the environment in the short or long term. Environmental sustainability aims at integrating all four pillars of sustainability and treating everyone equally. The four types present unique characteristics that must be preserved, although these may overlap in some cases. Thus, proper planning

and balanced, sustainable policies urge giant organizations and companies to incorporate the chosen strategic approach into their policies and procedures to identify a specific type of green business to focus on [9–11].

2. Effects of COVID-19

The COVID-19 pandemic caused by the emerging COVID-19 virus, severe acute respiratory syndrome 2 (SARS-CoV-2), has infected more than half a billion individuals, increasing daily and resulting in the death of several millions of people worldwide at the time of writing this article [12]. With its unclear nature, this highly contagious virus significantly impacts humans, their behavior, and the surrounding nature. Although studies have shown significant improvements in the environment and air quality, in many cities worldwide during these lockdowns (Figure 1). The global pandemic of the COVID-19 virus has caused many social, psychological, and economic problems worldwide, as most countries closed their borders and announced strict measures to eliminate the virus [13–19]. Nevertheless, this unprecedented pandemic had some positive aspects in many areas. The COVID-19 virus pandemic hugely affected the environment and climate in several parts. The sharp decline in travel, industry, social, and commercial activities all have resulted in a decrease in the level of air pollution in many regions all over the world. Since the beginning of the pandemic, the world has witnessed a severe decline in air pollution, specifically carbon monoxide and nitrogen dioxide, as most factories and the transport sector have closed due to the pandemic; therefore, this significant decrease has occurred [20–23]. The environment has also witnessed the purity of pollutants as the water in the channels became clearer and gained better flow [24].

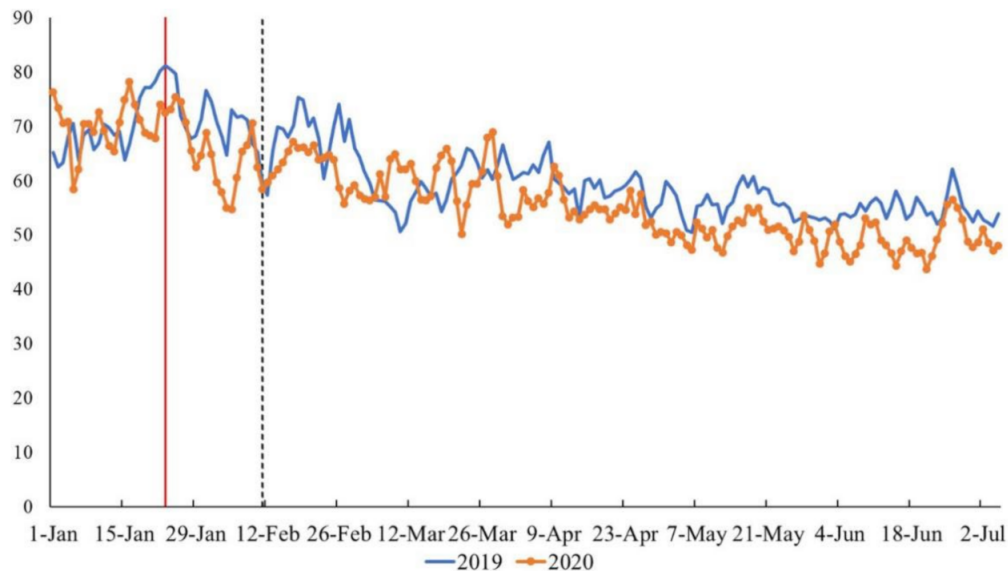

Figure 1. Shows the global trend of Fine Particulate Matter (PM2.5) which is the air pollutant that poses the greatest health risk globally. Notes: Reproduced with permission from Ref. [25]. Copyright 2022 Elsevier.

The increase in pure water is due to the stability of the sediments that are usually scattered due to the movement of the boats at the bottom of the canals, and the water pollution along the waterways has decreased. The shutdown of most industrial processes worldwide has resulted in a significant improvement in air quality. Satellite images showed a decrease in the concentration levels of nitrogen dioxide in the world, a toxic gas emitted mainly from car exhaust and factories and one of the most significant causes of air pollution in many cities [26–34]. Not all environmental changes in the recent period have been positive. One of the adverse effects of the pandemic is the significant increase in plastic waste, from medical gloves to packages and more [35–37]. The COVID-19 pandemic also

caused a drop in carbon dioxide in the air around the world. Due to the sizeable stopping of economic activity in most countries, the emission rate of this gas decreased, which also happened before during the global financial crisis in 2008 [38].

In addition, traffic restrictions in the streets saved the lives of many stray animals from being run over in road accidents.

The absence of humans led to the disappearance of breadcrumbs in the garden, forcing other animals, such as birds, to find food in a manner befitting its original nature. In addition, the lack of movement of tourist boats contributed to the purity of the water and the lack of impurities for the first time since it stopped moving sediment in the city's waters.

The lack of movement of transport ships in the seas gave marine creatures, such as whales, time to float quietly and undisturbed [25–34].

Yet, these latest improvements in air quality came at a high cost: communities have struggled with widespread lockdowns affecting the housing market, and requests for shelter have piled up due to the spread of COVID-19.

However, NASA satellite measurements revealed significant reductions in air pollution in metropolitan areas in the United States, with similar decreases observed in other regions [39]. The first table displays a list of several recent research papers in various countries that were published, along with a summary of aspects that have been covered in studies dealing with the link between the COVID-19 pandemic and air pollution (Table 1).

Table 1. Recent studies addressing the link between the COVID-19 pandemic and air pollution during 2020–2022.

Country/Region	Environmental Effects/Consequences	Research Papers
Major cities around the world	Various	[31,37,40–43]
	The analysis showed a decline in PM2.5 concentration due to the lockdown; the low concentrations of PM2.5 reflect the efforts made in the cities to curb the spread of infection that improves air quality.	[44,45]
	The study analyzed the effects of quarantine and social distancing policies implemented due to the COVID-19 virus Disease 2019 (COVID-19) pandemic on air pollution levels in four western megacities: São Paulo, Brazil, and Paris in France, Los Angeles, and New York in the United States.	[46–48]
	This study observed PM2.5 analysis in the world's 50 most polluted capital cities.	[13]
China	The effect of changes in the pattern of human activity on changing air pollution.	[49]
	Improved secondary pollution offset reduction for primary emissions during the COVID-19 lockdown.	[50]
	Reduced anthropogenic activities did not avoid severe air pollution events during the COVID-19 outbreak.	[51]
	Areas with poor air quality are associated with a higher death rate.	[52]
	In some cities, lockdowns have improved air quality and reduced premature deaths.	[53]
	It found a significant relationship between air pollution and COVID-19 infection.	[54]
India	The impact of restricted activities during COVID-19 on India's air quality, air quality gradations, and reduced excessive Allied risks was observed.	[27]
	The impact of lockdown and COVID-19 pandemic on Delhi air quality.	[55]
	The influence of COVID-19 on air quality in India.	[56]
	The impact of COVID-19 as an undesirable necessity on air pollution in India during the lockdown.	[28]

Table 1. *Cont.*

Country/Region	Environmental Effects/Consequences	Research Papers
Southeast Asia region	The impact of COVID-19 on the atmospheric environment.	[57]
Thailand	The improving air quality during the COVID-19 pandemic.	[58]
Taiwan	COVID-19 Prevention and Air Pollution in the Absence of a Lockdown	[59]
USA	Average temperature, minimum, and air quality were significantly associated with the COVID-19 pandemic.	[60]
	Changes in U.S. air pollution during the COVID-19 pandemic	[39]
	Global assessment of the environment, health, and economic impact of the novel COVID-19 virus (COVID-19)	[15]
Brazil	Impacts on the air quality during the partial lockdown in São Paulo state, Brazil	[61]
Ecuador	Has air quality improved during the COVID-19 pandemic?	[32]
Spain	A significant reduction of most pollutants and an increase in O3 concentrations during the lockdown	[62]
Italy	Rapid COVID-19 transmissions are mainly due to pollution.	[63]
	Effects of the COVID-19 pandemic lockdown on Milan's air quality.	[64]
Africa/Morocco	Impact of COVID-19 lockdown on PM10, SO2, and NO2 concentrations.	[65]
	Socioeconomic restrictions slow down COVID-19 far more effectively than favorable weather evidence from the satellite.	[29]

In a relatively short period, the worldwide dissemination of COVID-19 has dramatically declined manufacturing operations, road traffic, and tourism. At this time of crisis, controlled human contact with nature has become a blessing to humanity and the world. After the outbreak of COVID-19, environmental conditions, including air quality and river water quality, have improved worldwide [66–73]. Reports indicate that biodiversity was also thriving [74,75].

India has always been a pollution center with massive populations, heavy traffic, and polluting factories leading to high AQI values in all major cities. However, the air quality started to improve after the COVID-19 lockdown was announced. All other environmental parameters, such as water quality in the rivers began to give positive signs of restoration. India has always been a pollution center with massive populations, heavy traffic, and polluting factories leading to high AQI values in all major cities. Nevertheless, after COVID-19 announced the lockdown, air quality has begun to improve, and all other environmental parameters, such as water quality in rivers, have started to offer positive signs of restoration [27,28,55,56,76,77].

2.1. Effects on Air

Until 2020, the increase in greenhouse gases produced since the beginning of the industrial age has caused global average temperatures to rise, causing numerous impacts, including melting glaciers and rising sea levels. In addition, before the COVID-19 pandemic, measures expected to be recommended to health authorities in the event of the pandemic included quarantine and social separation. Independently, before the COVID-19 pandemic, researchers argued that lower economic activity would help reduce global warming and air and sea pollution, allowing the environment to prosper slowly. Due to the impact of the COVID-19 virus outbreak on travel and industry, many regions have experienced a significant decrease in air pollution and greenhouse gases [52,53,63]. Reducing air pollution can reduce both the risks of climate change and COVID-19, but it still needs to be clarified what types of air pollution (if any) present common risks to climate change and COVID-19. Researchers in New York told the BBC that the preliminary results of their research indicate

that the proportion of carbon monoxide gas—produced mainly by car use—has decreased by 50 per cent compared to last year. The balance of carbon dioxide, which causes high temperatures, has also been significantly reduced [46].

Nevertheless, there is a fear that the levels of these gases will return to rising after the end of the epidemic. Unsurprisingly, the percentage of gases produced by energy production, transportation, and transportation has decreased amid the global economic activity slowdown because of the epidemic outbreak. NASA satellite data revealed significant reductions in air pollution over major cities. NASA satellite measurements showed substantial reductions in air pollution over major urban areas in the United States, and similar reductions were observed in Europe and other regions of the world (Figure 2).

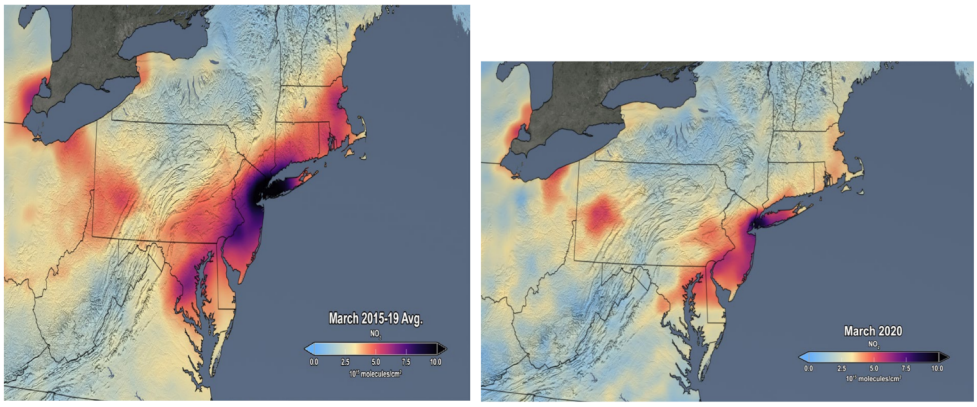

Figure 2. Satellite imagery showed a marked decrease in the percentage of air pollution over the United States measured in March of this year compared to the average concentration in March 2015–19. (Credit: NASA).

In China and Italy, significant reductions in nitrogen dioxide have been recorded because of reduced motor vehicle use and generally lower industrial activity.

Nitrogen dioxide is known to be a dangerous, polluting gas in addition to its contribution to rising temperatures [49–54]. Furthermore, with the movement of air transport towards a complete stop and the increase in the number of employees who take work from their homes, harmful emissions will likely decrease in many countries of the world. According to NASA and using satellites to monitor pollution, the measured air concentration of nitrogen dioxide (NO_2), a gas that mainly comes from vehicles and power plants, the images showed less air pollution due to the impact of the new COVID-19 virus outbreak and the lockdown measures that took place in China (Figure 3).

The Federal Laboratories for Materials Science and Technology (Empa) researchers concluded that nitrogen oxide concentrations decreased in most traffic-related sites in Switzerland by up to 50% due to the lockdown measures and despite the significantly low ozone concentrations. It should be noted that ozone at ground level is a harmful air pollutant. In general, ozone concentrations were low due to lockdown measures but increased across Switzerland due to the inverse relationship of this pollutant to nitrogen oxide, so it is not easy to draw clear conclusions. In China, closings and other actions have resulted in a 25 percent reduction in carbon emissions, which one Earth Systems scientist estimated might have saved at least 77,000 living creatures over two months. Despite this, the outbreak has hindered environmental diplomacy, including postponing the United Nations Climate Change Conference 2020, and economic repercussions from it are expected to slow investment in green energy technologies. In multiple forms, human activity has caused environmental degradation due to a fully human-made effect [49–54]. The Center for Energy and Clean Air Research reported that methods to contain the spread of the COVID-19 virus, such as quarantine and travel bans, had reduced carbon emissions by 25% in China [35,49,78,79].

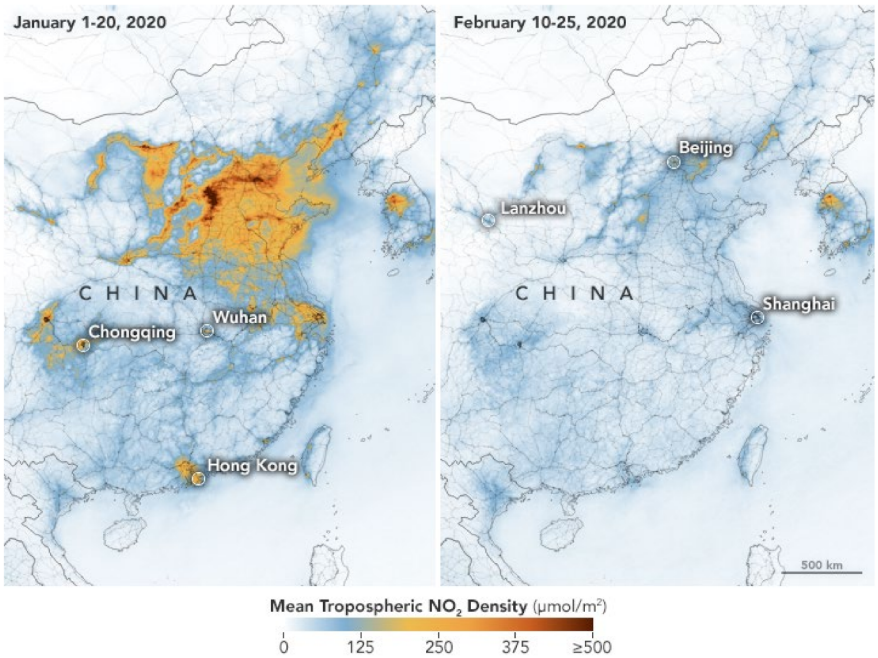

Figure 3. Satellite imagery from NASA shows an impressive effect in improving air quality and reducing pollution after the outbreak of the novel COVID-19 virus (COVID-19) and China's lockdown strategy (Credit: NASA).

China produced nearly 200 million metric tons less carbon dioxide than in the same period in 2019 due to reduced air traffic, oil refining, and coal consumption [66,80]. According to Earth systems scientists, this regression may have saved at least 77,000 organisms. NASA and the European Space Agency are watching how nitrogen dioxide gases decrease significantly during the first stages of the COVID-19 pandemic in China [66,80,81]. The economic slowdown caused by the virus has dramatically reduced pollution, especially in cities like Wuhan in China, by 25%. NASA uses the Ozone Monitoring Tool (OMI) to analyze and monitor the ozone layer and pollutants such as NO_2 and aerosol [35,49,79]. These tools have helped NASA to process and interpret data received due to lockdowns worldwide. According to NASA scientists, nitrogen dioxide pollution in Wuhan, China, has slowly spread to the rest of the world. The decline was also severe because the virus coincided with China's Lunar New Year [49–54,66,80–82]. Due to the festival, factories and companies are closed in the last week of January to celebrate the Lunar New Year festival. However, these closures were more comprehensive and extended due to procedures, so their impact was more evident. China's low nitrogen dioxide has not achieved standard air quality for what health authorities consider acceptable. Other pollutants remained in the air, such as aerosol emissions [83].

2.2. Effects on Water

The scientific interest in studies of COVID-19 viruses on one side and social and environmental systems, including the interaction between climate, water, and soil on the other side, is justified globally due to the joint influence of all these factors. In Venice, the water in the canals has become more apparent and has seen an increase in the presence of fish and waterfowl. The first impacts are divided between rapid and direct environmental improvements, which include fresh air and improved water quality due to less pollution. Other changes, such as those resulting from sewage disposal, are among those positive impacts, mainly short-term and long-term. The mayor's office of Venice explained that the increase in the purity of the water is due to the increased sedimentation, which is disrupted by the movement of boats, and mentioned a decrease in air pollution along the waterways [32–37]. On the other hand, the disposal of sanitary consumables, such as

personal protective equipment, facemasks, and gloves, is already raising concerns about the significant negative impact of this epidemic event on sewers, rivers, water bodies, and the environment in general.

By May 2020, many reports alleged severe damage to the aquatic environment, especially along beaches in Hong Kong, Canada, and other countries, due to sewage and disposal of medical activities or personal protection, including those that do not comply with approved global standards [32–37].

Venice's canals are cleaner and more transparent than they were after the quarantine imposed in Italy stopped normally polluting boats.

Nevertheless, as a positive side effect of the health crisis, the waterways are much cleaner since boat traffic stopped due to the COVID-19 pandemic. It became possible again to see fish swimming in the water [41,84].

White swans can also be seen swimming in city canals, in which usually crowded squares and alleys have become nearly deserted, while air pollution has decreased across northern Italy. People could view the waterways, where fish and pelicans are resting from the cruise boats and cruises throughout the day (Figure 4).

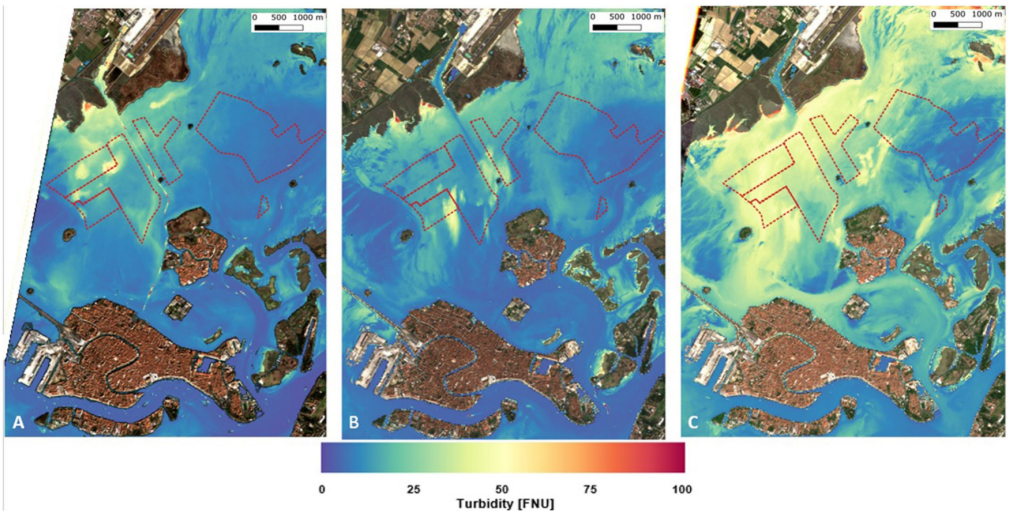

Figure 4. Turbidity maps in the North Lagoon, Venice, Italy: (**A**) February, (**B**) 19 March, and (**C**) April 2020. When the closure was in place, and boat traffic had almost ceased, turbidity in the canal and airport harbor was similar to that observed across the city. The red dotted lines indicate the clam harvest areas. Notes: Reproduced with permission from Ref. [84]. Copyright 2022 Elsevier.

Although human destruction of the environment seemed irreversible at first glance, studies have proven the opposite [41,84,85]. The pandemic has positively affected the environment around the world, as the canals of Venice were clean and clear again, and the air over Italy was less polluted. According to new data from the European Space Agency's Copernicus Sentinel-5b satellite, this is due to slowing emissions from power plants, cars, and other industrial sources [86].

2.3. Effects on Animals

The impact of the COVID-19 virus pandemic was not limited to humans, but extended to animals that also face the consequences of spreading the virus.

The virus evolved over long periods, perhaps millions of years, and appeared in other forms and types compared to the present time. This is known because it has appeared in bats and other wild animals, which are considered a delicacy in China.

All these things need pathogenic agents and other host species that stand between disease and infection from those diseases–not only humans but also animals and crops [87]. For the first time, it was confirmed that a tiger was infected with the COVID-19 virus in

Bronx Park in New York, and it is believed that one of the infected workers in the park transmitted the virus to him. Six tigers and other lions were also reported to show disease symptoms [88]. According to experts in bio-conservation science, the emerging COVID-19 virus can also threaten animals, such as wild gorillas, chimpanzees, and orangutans, and the transmission of the virus from animal to humans requires unfamiliar intermediate animals that can break several disease barriers between animals and humans [88]. Scientifically, many other viruses are found naturally in land mammals and birds worldwide. According to scientists, human activity leads to the emergence of new pathogenic viruses. Climate and environmental changes in the ecosystem lead to the development of new types of viruses through logging, killing wild animals, and destroying typical habitats [88–90].

The spread of viral epidemics in past ages affected the development of all life on Earth and intervention viruses in the human body composition. About 8% of the human genome consists of parts of viruses called retroviruses or retroviruses. These genetic "fossils" remain of the viral epidemics our ancestors survived [91,92]. Environmental experts recommend addressing the multiple and often interacting threats to ecosystems and wildlife to prevent the emergence and transmission of zoonotic diseases to humans, including habitat loss and extinction, illegal trade, and pollution. Thus, the impact of climate change and scientists cannot anticipate the spread and transmission of viruses to humans, so developing vaccines proactively is not an option. Moreover, according to the World Economic Forum website, there is talk about discovering a "comprehensive influenza vaccine" that would provide immunity against all influenza virus mutations. Nevertheless, this has not yet been possible, so humans must conserve ecosystems, including wildlife, for their intrinsic value and as a potential source of disease-causing viruses and epidemics [93].

A new study showed that mice sold in Southeast Asian markets and restaurants embrace several types of COVID-19 viruses known as COVID-19 Infection Rates with different strains of the COVID-19 virus have increased among these animals during their journey from their "environment in the fields to the tables", indicating they transmit the viral infection to each other during this process [94]. However, the COVID-19 virus strains discovered in these mice differ from the emerging COVID-19 virus currently spread among humans and cause COVID-19 disease. There is no conclusive evidence that they pose a threat to human health until the present time. However, scientists have long warned that the wildlife trade could increase disease rates because animals are incubators for many viruses. A research team from the United States and Vietnam has warned that the presence of several types of COVID-19 viruses in the animal supply chain of restaurants is indicative of the spread of these viruses among them. It is believed that the origins of the current epidemic lie in the trade of wild animals, as the disease appeared in bats and then transmitted to humans through other intermediate animals.

Although these are not yet known precisely, there are still first direct results in mice but they may apply to other wild animals, such as civets and pangolins, which are hunted and transported together in large numbers [94,95].

2.4. Effects on Seafood and Meat

Officials said that China had found extensive traces of the COVID-19 virus in the meat and seafood section of a wholesale food market in Beijing and suspects that high humidity and low temperature contribute to contaminating the market with the virus. The initial report comes as the Chinese capital faced a resurgence of COVID-19 cases linked to the Xinfadi Food Market, which includes stores and pallets over a vast area. More than a hundred people were injured in the new wave of outbreaks that raised fears of the spread of infection In China again [94,96,97]. Most patients at Xinfadi Market were workers in the seafood department, followed by those working in the beef and sheep meat departments. Wu Chunyuo, an epidemiologist with the Chinese Center for Disease Control and Prevention, said in a daily briefing that workers in the seafood department appeared to have symptoms before others. Wu noted that low temperatures and high humidity, which

constitute a fertile environment for the virus, may explain the start of the outbreak in the seafood markets, based on a preliminary assessment.

China halted salmon imports from European suppliers that week amid fears it was related to the recent outbreak in Beijing. Health officials also warned of reports of eating undercooked salmon after the virus was discovered on cutting boards used for imported salmon.

However, the source of the outbreak is not yet known. There is no doubt that bats assumed much of the blame during the search for the start of the emerging COVID-19 virus, and last March, researchers published a study that found a similarity of 96.2% between the COVID-19 virus that causes "COVID-19" and the virus found in the horseshoe bats family in Yunnan Province of Chinese. Yunnan province is about a thousand miles from Hubei Province, where Wuhan experienced the early virus outbreak [94,96,97]. Mixing potentially infected wild animals in wet markets may cause the virus to be transmitted from animals to humans. However, animal scientists, ecologists, and pathologists have suggested that human behaviors, such as destroying natural habitats, may cause disease transmission.

Bats have gained notoriety because of their association with "COVID-19" and other virus outbreaks and their cultural symbolism. Bats have been associated with dark topics such as vampires, magic, and death; however, in a special CNN report, experts make clear that these flying mammals play a critical role in our ecosystem, and there are many unique facts that many likely do not know about [98]. Nancy Simmons, the curator of the American Museum of Mammal History and co-author of the book titled "Bats: The World of Science and Mystery," said bats play a significant role in the ecosystem by controlling insect populations, and within an hour, a life-size bat can feed on what ranges from 500 to 1000 mosquitoes, which can carry diseases such as the Zika virus, dengue fever, or malaria. In addition, the bats' insect feeding habits save a lot of money for farming [99–103]. As for the US economy, bats are worth more than $1 billion each year "in terms of the number of pesticides we don't need to use", according to Canadian evolutionary biologist Dan Reskin. The Mexican free-tailed bat in Texas eats many insects and moths, protecting the area's corn crops. The droppings of fruit-eating bats, especially those found in the rainforests, contribute to dispersing the seeds, which helps to regenerate plants and trees that have been damaged or cut down. The droppings of bats are rich in nitrogen, which is a vital component of crops because it is a significant component of chlorophyll, the compound in which plants are used. Energy from the sun produces sugars from water and carbon dioxide. This process, called photosynthesis, generates oxygen gas. Nitrogen is also a critical component of amino acids, the building blocks of proteins [99–103].

2.5. Effects on Soil

In its natural composition, the ground generally contains a range of compounds that can be considered pollutants. The term soil pollution can be used when the percentage of these pollutants exceeds the average and acceptance rate. Every year, carbon dioxide is released into the atmosphere due to human activities, including burning fossil fuels and land use change. Gaseous pollutants and radionuclides reach directly into the atmosphere and then are transported to the soil by acid rain or steady rain. Car exhaust releases peroxide radicals into the air, mainly of the peroxyacetyl type, which combine with nitrogen dioxide to form peroxyacetyl nitrate (they belong to a "family of mutant molecules implicated in acid pollution" which affects the lungs but also participates in the "acid rain" phenomenon that leads to forest degradation). Traffic and the use of vehicles of all kinds are the second largest cause of air pollution after emissions from industrial activities. It also accounts for a quarter of global carbon dioxide emissions [31,37].

However, the quarantine measures imposed on most of the world's population to curb the spread of the COVID-19 virus have contributed to a decrease in air pollution in urban areas. Field research has monitored an improvement in the air of significant capital by more than 12%. The class of nitrogen and factory gases has also decreased, and the ozone layer has recovered after carbon emissions fell to their lowest level in 30 years. Healthy

soils can contribute considerably to ending hunger and creating a healthy planet, but only if global threats to soils, including nutrient imbalances, are addressed [40–43,69].

2.6. Effects on Plants

Crops have been affected in some countries because of the closure decisions taken by some governments to confront the COVID-19 virus outbreak, and crops have been destroyed. Some countries have benefited from the crisis, increasing their exports of vegetables and fruits, despite being affected on the other side by the shortage of workers and their inability to obtain what they need from their agricultural imports because of the virus outbreak in other countries. The lockdown imposed by the COVID-19 pandemic has affected many vital sectors. The farm sector is not an exception here; as of the industrial age, the agricultural industry was affected. Nevertheless, the virus has encouraged home farming, as it forced the farm sector workers to stay at home, and the number of people who go to produce some of their food in their gardens. This could be a positive development in the long run, especially since two-thirds of the world's population is expected to live in cities by 2050. Thus, urban agriculture may become more vibrant, consuming less fossil fuel for transportation and smaller land areas than traditional agriculture. The pandemic has affected the production chains that supply us with food. This industry provides the world with food in the era of globalization, often above the domestic production levels in many countries [32–37]. Today, farmers face the challenges of diminishing industrial animal feed and shrinking labor, forcing them to adapt to a new, less secure future. With the planet's population projected to reach 10 billion people by 2050, it is inevitable to face the reality of the need to increase food in the world. Paving and clearing more lands of trees and herbs for cultivating them were solutions to this problem [40–43,69]. Nevertheless, attention is turning to the cultivation of urban centers, and this trend is strengthened considering the risks imposed by the COVID-19 virus.

3. Discussion

The COVID-19 pandemic has made some aspects of the significance of the way we interact with the environment more visible. Nevertheless, it may also have indirect effects that will reveal themselves in the long run. However, the apparent impact on sustainability in its various health and environmental aspects is evident in the short and sustainable term. This pandemic has had, and still impacts, the environment both positively and negatively, and directly and indirectly. As a result of the pandemic, some greenhouse gas emissions have been reduced, which may slightly affect the overall concentrations of greenhouse gases that have been building up in the atmosphere for decades. The positive effects appear to reduce PM2.5 and NO_2 concentrations in many countries, such as the USA, India, China, France, Germany, Spain, and Italy [44,45]. Improving air quality and reducing environmental noise have been highlighted as having positive indirect effects. It is known that some disadvantages have benefits, as it is said that people's misfortunes have benefits. Studies have observed the association of long and even short-term exposure to polluted air with various adverse health effects, including acute respiratory disease, infections, asthma, chronic obstructive pulmonary disease, exacerbation of allergic diseases, and respiratory cancers. Therefore, the positive environmental effects of reducing pollution in the air effectively reduced the suffering from these diseases [95,104,105].

On the other hand, there were painful negative impacts that cannot be overlooked. The COVID-19 pandemic and associated social restrictions, such as lockdowns and restrictions on movement, have affected many areas of society and aspects of an individual's work and private life. The health status of many people has been negatively affected in varying ways, depending on socioeconomic status and other variables. People have witnessed different changes in their daily lives and varying degrees of adverse psychological, mental, and health effects. This greatly depended on the availability of medical care because of the different economic situations of other countries. The lockdown has made it difficult to obtain adequate health and medical care and increased its cost in many cases when

available [106–108], not to mention the many health damages of this disease, whose complications have not been studied, especially in the long term.

Furthermore, other adverse effects were reflected in the increase in household and medical waste, and restrictions on waste recycling in countries, such as the United States of America and Europe, had another significant negative impact. For a substantial downturn to occur, the economies of the nations must experience a long-term structural transition [40–43]. This outcome can be obtained by validating the contributions made regarding the climate. In addition, the recently reported decrease in greenhouse gas emissions in some countries is temporary only. Nevertheless, reducing greenhouse gas concentrations in a limited period is not a safe way of purifying our climate. In addition, the virus crisis brings other environmental problems that can last longer and be difficult to handle if countries ignore the effect of COVID-19 on the environment.

Governments will probably restore their economies when the epidemic is over, and greenhouse gas levels will rise again, but the lesson can be learned from rationing consumption. Another aspect that should be considered is dealing with polluted waste, as it is necessary to deal with household waste properly. During a COVID-19 pandemic, medical waste, such as infected masks, used or expired medicines, gloves, and other products, may have been quickly mixed with household waste. However, the correct procedure is to treat it as hazardous waste and dispose of it separately. It may be safer for municipal specialists or waste management operators to collect this waste. In the same way, the Environment Program of the United Nations (UNEP) urged governments to tackle waste management, including medical and household waste, as an urgent and essential public service for minimizing possible side effects on health and the environment [109].

Given that human activities are limited in most regions, the country's natural ecosystem has begun repairing itself. Industrial facilities and residences were closed, the movement was restricted, and air, land, and sea transport was almost suspended, except for extreme necessity. Carbon emissions were cut, and a remarkable increase was made in air quality. It is impressive to see a reduction of 85.1 per cent in the concentration of PM2.5 in one of the most polluted cities in India (Ghaziabad) compared to the attention only three months earlier. The other parameters, PM10, NO_2, and CO, have substantially decreased because of minimal human activities and mechanical movements. Indian atmosphere satellite images also reflect the same trend toward air pollution reduction following the COVID-19 outbreak [44,45]. After this lockdown, the Air Quality Index (AQI) has become relatively good, as in all states of India, it is in double digits. Air and India's rivers, such as Ganga, Yamuna, Cauvery, and more, have become clean and transparent, and aquatic life can be seen [27,28,55,56]. After reviewing many reports, it can be concluded that COVID-19 has undoubtedly brought humanity a devastating and terrifying disaster. Nevertheless, it has emerged as a blessing to the natural world, providing it with a "recovery period". We have also discovered that human-induced environmental destruction is not entirely irreversible. People have witnessed a "recovery of nature" in only 1–2 months. It is a signal to understand and to respond [40–65].

Undoubtedly, going through any crisis is challenging, as our generation is now experiencing a global threat that the world has not seen in many decades. The biggest lesson for human beings to learn from this crisis is to have a solid plan and strategy that are tried and tested to be resilient to any unforeseen event. The project will be the basis that will depend on it, as the widespread use of technology, increased productivity, and speed in making successful decisions contribute to the success of companies and prepare them for the upcoming obstacles. Governments must also prioritize investing in economic growth, such as education, research, and infrastructure, to help get through these trying times [110,111].

The COVID-19 pandemic can be seen as a "stress test" for the global community, with far-reaching effects on education, the economy, health, agriculture, transportation, and other sectors. Regarding the social pillar, the experts noted a high level of awareness about the measures needed to address the epidemic, noting that communication and awareness campaigns can effectively educate the population on the steps necessary to

stop the outbreak, which is essential—a lesson for combating climate change as well. The epidemic has led to a significant increase in unemployment rates, a shift in local migration patterns with the movement of the population from urban to rural areas and changing working conditions. It has significantly impacted the global economy in all sectors, including travel and supply chains [112,113]. This epidemic affects everyone, even though at different levels, paces, and scales, governments having to impose some unpopular but acceptable top-down measures can take all offer lessons in combating climate change. Consequently, there are essential comprehensive lessons that can be learned from the COVID-19 virus pandemic that can be applied to climate change, including the interdependence of social, environmental, and economic systems that need to be addressed through a socio-environmental approach. Post-pandemic recovery plans under the slogan "Build Back Better" are an opportunity to redesign these systems, with the goal of transformative change as a globally coordinated effort building on the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change [114]. What we learned from the pandemic and the perspective of societal transformation, its impact on sustainable development, and the correct measures that must be taken to deal with it are crucial. The repercussions of the COVID-19 pandemic on sustainability transitions and learning from it highlight the role of solidarity, governance, politics, extension, and the role of science in society [110–113].

The globe has largely witnessed improvements in the environment and air quality in several cities worldwide during the COVID-19 lockdowns. However, these changes may differ from place to place for multiple reasons and on many different levels. The pandemic's positive and negative global environmental impacts have yet to be fully identified. Our research paper is an invitation to a meta-level reflection on what sustainability research is and what we can learn from the research on COVID-19 about the themes of sustainability transitions, temporal dimensions, the role of researchers, and appropriate preparation for the current and future crisis. This is an attempt to understand the implications of the COVID-19 pandemic and the reduction in pollution in the environment now, as the whole world is still struggling to frame effective ways to confront COVID-19, as the early lockdown that was adopted showed an absolute path to restore the ecosystem and the climate.

4. Conclusions

The COVID-19 pandemic (2020–2022) has shaken societies out of ordinary life and may have created new conditions for sustainability transformations due to the scale of the crisis. Researchers should not only accelerate the pace of scientific production to provide much-needed knowledge about COVID-19, but also enhance research on the science of sustainability and the challenges that arise. During the lockdown, studies have shown an improvement in air quality. Extensive research is required on the impact of introducing such short-term closures as an alternative measure to reduce pollution and its effects on the economy. This calls for expert reflection on the location and direction of research to support sustainability transitions, especially sustainability research focusing on COVID-19 and how the pandemic affects it. Long-term transformations require multidisciplinary interactions. Government and policymakers should take the measures necessary to prevent this healing process from being transient.

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