Chapter 6
Questioning the Green Recovery: A Take on Post-COVID Scenario

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Abstract As the COVID-19 pandemic rampaged the world, many found solace in the improving air and water quality, more fabulous greener cover, and invigorating bio-diversity. However, the question arises whether these positive changes could be maintained in the post-COVID world, with an increase in economic activities alongside the unrestricted mobility of people and goods. The paper tries to gauge the situation beyond this short-lived moment of environmental rejuvenation, which seems quite grave. The entire work has been based on extensive literature review and perception studies. The adequate provision of sanitary landfills and medical incinerators for safe disposal of medical wastes was already in question in developing countries. The high usage of protective gear like personal protective equipment, gloves, masks, face shields, etc. will incite unscientific disposal and burning—leading to soil and air pollution. The quantum of air pollution may get higher due to avoidance of mass and para-transit modes of communication and over-reliance on personal vehicles to continue social distancing. Besides, maintaining self-hygiene at regular intervals, an antidote for corona infectivity, in a water-stressed world where 2.2 billion people do not have access to safe potable water will add to water scarcity. Further, indiscriminate usage of low-quality sanitizer to fight the virus causes serious health hazards and affects the environment detrimentally. For reaping the benefit of the current green environment, sustainable strategies have to be developed to cope with the new normal.

Keywords Environmental rejuvenation · Medical waste · Social distancing · Water scarcity · Self-hygiene · New normal
6.1 Backdrop

World Health Organization (WHO), on 30 January 2020, declared COVID-19 as a public health emergency of international concern. Globally, as on 7 August 2020, there have been 18,902,735 confirmed cases of COVID-19, including 709,511 deaths, across 213 countries reported to WHO; region-wise, the number of cases is highest in America, followed by Europe and South-east Asia and India registering 2,027,074 confirmed cases as of now (WHO 2020a). To date, when the chapter is being written, no sanctioned medication or vaccine is available to deal with this novel coronavirus, and the infection rate is increasing unabated.

COVID-19 pandemic is an enormous challenge to societies and economies across the world. The immediate priority for governments has been to deal with the health crisis and save lives. In the current setup, preventive measures and a healthy lifestyle with an efficient immune system have been suggested by WHO to fight and stay safe from COVID-19. So, to forefend the infection, countries have strictly regulated the movement of people and transportation, reduced human interactions, imposed strict quarantine, barred large-scale private and public congregations, encouraged social distancing, restricted private and public transportations and economic behaviour (Fernandes 2020; Wang and Su 2020). There is huge pressure on the health care sector, which is now challenged with the mammoth patient influx and limited medical infrastructure. Upgrading medical facilities, enormous testing campaigns, and recalibration of health policies are required to counter this public health crisis (WHO 2020b). As strict containment measures have resulted in a severe drop in economic activities (OECD 2020), another key priority has been to quickly adopt the support policies that minimize the destruction of jobs, incomes, value chains, and production capacity. These interludes will not just be an interim issue, but can also have long-term effects on the various cohorts.

Amid all the daily activities and business that the pandemic has impacted, the transport sector in general and travel behaviour of the people in particular which would likely drive the entire world shift towards the “new normal”. The unprecedented situation has impelled people to rethink their choices and behaviour. In this period of widespread lockdowns, i.e. complete cease of movements, the world has witnessed the positive environmental changes with cleaner rivers and clearer skies (Gardiner 2020a). As the popular saying goes, “Every crisis brings along with it an opportunity”—the COVID-19, despite posing specific difficulties, has provided us with the opportunity to let the Earth heal itself by switching to eco-friendly practices for the sake of the public health revival.
6.2 On Gauging the Crisis

Due to the highly transmissible nature of the disease, people have been left with no choice but to stay at home and take several safety measures at a personal level. The situation has been quite challenging from disinfecting every single material fetched for daily use to avoid social interfaces. This extremely tough situation has compelled everyone to think about managing nature and its resources differently and efficiently to cope with this pandemic.

This chapter’s main objective is to highlight the probable situations that are supposed to arise beyond this “short-lived moment” of environmental rejuvenation. Therefore, it is vital to reconsider the conventional principle of environmental sustainability. The unwarranted use of plastics, sanitizers, and water might lead to a severe crisis in the entire world. The study identifies the challenges exposed by the pandemic, which needs immediate redressal. New ideas for handling the environment post-COVID-19 have to be considered for sustainable development and safe living. For the purpose of keeping the focus on saving the green environment, safe living of the people for health security, the principle of sustainable development needs to be reinforced adequately by adding new controlling parameters. However, the critical question remains, “What needs to be prioritized or added or modified to the existing principle of protecting the environ?”

This study was conducted to gauge the probable crisis and environmental deterioration, especially in the developing world, that would ensue in the post-COVID period. Most of the research paper is based on secondary data with heavy reliance on available “online” materials. COVID-19, lockdown, environment, pollutants, biomedical waste, water scarcity/crisis, and hand sanitizer were the primary search theme, followed by associated terms. A systematic assessment has been carried out, based on available literature in PubMed, Google Scholar, and Scopus database up to August 2020. More than 69 million indexed documents were found, and the search was refined by specifying the language and the document type. The study’s theme, i.e. COVID-19 and environmental impact, was manually checked while scrutinizing the text.

Besides, a qualitative study was made, primarily relying on perceptions of randomly selected residents of several parts from the developing Global South countries to bring out how their daily behaviour trajectories were affected by the pandemic, which had an indirect bearing on their immediate environment.

6.3 Issues to Ponder Over

The interrelationship between COVID-19 and the environment is an evolving research topic. Though the present pandemic situation is showing a positive impact on the environmental condition, it is also pertinent to think about the world’s post-COVID scenario. The excessive use of plastics, their disposal, the shift in the choice
of the transportation mode—all these are likely to put a combined adverse impact on the environment. The health and hygiene norms that demand using water and sanitizer may pose a problem of water crisis along with health hazard. To highlight the grave situation that is likely to come up in the future, an in-depth literature review was done and based on that, four sections have been identified which need to be addressed. The four clusters are (a) waste generation, which is an important aspect of the current situation. The increased use of personal protective equipment, gloves, masks, face shields, along with sanitizer bottles made of plastics is exerting pressure on the waste management system and increasing environmental concerns. The improper disposal of waste materials will adversely influence the soil, groundwater, and air quality. (b) Air pollution is the other parameter that requires a thorough study. The unscientific burning of wastes will add to the particulate matters present in the atmosphere. (c) Water stress is likely to follow if strict health hygiene has to be maintained. The excessive use of water will reduce the groundwater level and also lead to chemical concentration in soil and (d) chemical exposure, highlighting the impact of sanitizers on health. A comprehensive replication of the study under each cluster has been done.

6.3.1 Waste Generation

Among several impacts of the current pandemic, municipal waste management is an important aspect (Smart Waste Report European Union 2020). This pandemic has completely altered the waste generation dynamics, giving way to a new “throw-away” culture, creating a dilemma regarding management practices among policymakers (Mallapur 2020). Few countries have already developed efficient municipal waste segregation, treatment, and disposal facilities. Japan, for instance, manages to incinerate 74% and recycles 17% of the country’s waste (Mollica and Balestieri 2020). Several European countries have also traced on technological innovations to facilitate energy recovery from wastes (Kyriakis et al. 2019; Istrate et al. 2020). On the other hand, the developing nations, lacking with the technologies, need to limit the huge amount of non-beneficial residual waste generated from different sources as an immediate action.

6.3.1.1 Plastic Waste

In modern society, plastics, with their enhanced physicochemical properties, play a pivotal role in various sectors (Geyer et al. 2017). However, the usage of single-use plastics (SUP) has raised environmental concerns because of their low recyclability (UNEP 2020b; Silva et al. 2020). According to Plastics Europe (2019) 359 million metric tons (Mt) of plastic were produced in 2018 while plastic waste generation reached 6.9 Mt. Out of the total plastic-based waste generated, a whopping 42% was inefficiently treated that raises the alarm (Hahladakis et al. 2018; OECD Statistics 2019).
Zheng and Suh (2019) highlighted that burning of plastic wastes contributed to 15% of the global greenhouse gas emissions.

The enforcement of total lockdowns and strict physical distancing makes going out for marketing, eating out very infrequent. As an alternative discourse, the reliance on online shopping increases remarkably (Hyun 2020). The home delivery of groceries and food items has surged, generating lots of plastic packaging waste involving mainly polypropylene, polyethylene, terephthalate, polystyrene (Tenenbaum 2020). Moreover, there is an increase in plastic packaging waste from medical industries which are trying hard to meet the demand for essential medical logistics worldwide (WHO 2020c). The concept of Plastic Waste Footprint (PWF) used to capture the environmental footprint of a plastic product throughout its entire life cycle proves how detrimental uncontrolled plastic use can be (Boucher and Billard 2019). The present pandemic further introduces disruptive changes creating “butterfly effects” on post-COVID-19 economies and environment (Klemeš et al. 2020).

Normal recycling of plastics has got reduced now (Kaufman and Chasan 2020), and handling of an increased amount of general plastic waste has become a challenge (Ferronato and Torretta 2019). Few countries like the US, Brazil, and few European nations have rolled back their usual waste disposal and recycling industry in this situation, fearing widespread contamination making the situation more critical. In contrast, nations like the UK, France, Spain, Italy, despite all odds, have continued business in the waste management segment (BIR 2020). The post-COVID-19 slump in oil prices is also hampering the growth of the plastics recycling sector, while the relatively high-priced recycled plastics has always been a concern for creating broader markets for waste recycling (Bell 2016). This pandemic has forced people to take two-steps back regarding rollback policies against single-use plastic bags (Sinclair et al. 2018). It is feared that with these temporary relaxations, the market again will be flooded with unsustainable plastic usage having a long-term influence on consumer behaviours (Tenenbaum 2020). Even WHO has urged to increase the production of plastics by 40% to meet rising global demand (WHO 2020d). However, Climate Action Tracker (2020) has harped that greener products like bioplastics should be incentivized. Long-yearned sustainability may be achieved if the principle of the 4-R Programme—Refuse, Reduce, Reuse, and Recycle is embraced by the citizens (Huang 2016).

### 6.3.1.2 Biomedical Waste

Infectious wastes are broadly classified into—bio-medical waste, regulated medical waste, and clinical waste (International Solid Waste Association 2020). WHO defines the waste generated by various categories of medical institutes as bio-medical (BMW) and healthcare waste (HCW) (WHO 2015). The BMW includes waste of sharps, infectious, pathological, pharmaceutical, chemical, and radioactive nature with hazardous compositions (WHO 2017).

The experiences from SARS-CoV, Ebola, and MERS-CoV disease outbreaks highlighted the requirement for safe bio-medical waste management for infection
prevention and control (Sharma et al. 2020b). Before this crisis, about 2 billion people worldwide lacked access to the waste collection, while 3 billion were out of the ambit of controlled waste disposal facilities (Wilson et al. 2015b). To handle the COVID-19-related infectious wastes, WHO, US Occupational Safety and Health Administration (OSHA), EU, and other agencies have issued a set of new handling guidelines (ACR + 2020). Indian Central Pollution Control Board (CPCB) has also issued a detailed course of action in this regard (CPCB 2020).

Public health advisories and recommendations from several sources tend to generate a high amount of bio-medical wastes, comprising the used and contaminated plastic-based gears like personal protective equipment (PPEs), face masks, gloves, wipes, and other protective equipment (UNEP 2020b). However, most of which, if not appropriately managed after disposal, might pose environmental and health threats (Kampf et al. 2020). Various studies indicate that the coronavirus can survive for quite a few days on different material surfaces, which seeks scientific management of bio-medical wastes as the utmost important (van Doremalen et al. 2020).

Though many governments across the world have existing legislation and regulations in place for proper disposal of infectious medical wastes, the increasing amount of bio-medical waste in the COVID-19 situation has overwhelmed existing medical transport and disposal infrastructure. In developed countries, green and sustainable waste management strategies are in place (Nzediegwu and Chang 2020). The scenario of most of the developing countries is quite different. The developing countries, which are limited by the lack of technologies and economic resources, treat the solid wastes unscientifically—dumping in the open. Landfills are poorly managed, and the waste-pickers are exposed to risks as there is lack of protective gear for them (World Bank 2019; Mol and Caldas 2020). The WHO model estimated that there would be a requirement of 89 million medical each month along with 76 million examination gloves. At the same time, international demand for goggles will clock 1.6 million per month (WHO 2020d). There must be a surge in the volume of single-use plastics due to growing concerns about personal health and hygiene.

The amount of infectious medical waste has been increased remarkably by 600%—from 40 tonnes per day to 240 tonnes per day in Hubei Province in the People’s Republic of China (Shi and Zheng 2020). It has been estimated by the Asian Development Bank (ADB) (2020) that in several cities of south-east Asia like Manila, Jakarta, Kuala Lumpur, Bangkok, and Ha Noi, the additional amount of medical waste would vary from 280 metric tonnes to 154 metric tonnes per day depending on population taking per head 3.4 kilogrammes of infectious medical waste as the general norm. To deal with such mammoth infectious wastes, the public authorities of Wuhan deploys mobile incineration facilities, which has increased the capacity by four-fold (Saadat et al. 2020).

The risk of contact transmission from bio-medical wastes is not the only concern. The improper disposal might cause physical injuries through sharps, and adverse environmental effects like soil and groundwater contamination through sludge flow, which are also quite common (Datta et al. 2018). If not managed soundly, uncontrolled incineration causes toxins release in the open-air, leading to the secondary
transmission of diseases to humans. However, installing the technology-based, highly automated infrastructure in short notice is difficult. So the short term responses are sensible alternatives. Creating detailed inventory from on-site, mobile, and off-site units, adopting 3S methodology (involving Sorting, Segregation, Storage) may be useful. Implementing the SAICM (Strategic Approach to International Chemicals Management) to study the impacts on wider environment may be solicited to handle the situation. As a stop-gap arrangement, special waste collection buckets can be arranged for collecting disposable bio-medical wastes following the Nigeria Centre for Disease Control (NCDC) guidelines (NCDC 2020). It will allow time to chalk out the strategies for long-term responses. Initiating legislative changes, creating robust systems for waste segregation, collection & management, investing on Sustainability Assessment of Technologies (SAT), opting for Best Available Technology (BAT) for source segregation, primary disposal, and destruction of waste or recovery of materials and carrying out Best Environmental Practices (BEP) to manage the environment soundly, in line with the Stockholm Convention can be carried out (UNEP 2020a) involving social viability alongside environmental and economic feasibility.

For safe disposal, it has been suggested that pandemic-related waste should be double-bagged, “swan neck” tied, and the outside sprayed with a 0.5% chlorine disinfectant solution (ACR + 2020). If the disposal system is under severe stress, then though not preferable, it has been suggested that the double-bagged waste should be stored for 72 h before being disposed of with the general household waste. Safe disposal of greywater or water from washing PPE, surfaces, and floors is also an area of concern (WHO 2020e). Stringent enforcement of air quality controls to limit toxic pollutants’ emissions requires increasing the capacity of advanced technologies (White 2020). Encapsulation, sanitary landfills, mobile incinerators, autoclave (steam sterilization) units, gas sterilization, industrial furnaces, thermal inactivation, and micro-wave or radio-wave treatment (Liu et al. 2015) has to be put in place following the guidelines of the WHO, the Basel Convention, and the United Nations Environment Programme (Sharma et al. 2020a). Life cycle assessment (LCA) and related approaches indicate that incineration with waste heat recovery is an alternative through which plastics’ chemical energy content can be recovered for useful purposes (Hong et al. 2018). But certain issues like trace emissions of dioxins and furans (Makarichi et al. 2018) are linked with the widespread use of incineration with heat recovery. A new technology, hydrothermal carbonization, is being implemented, coupled with high pressure and temperature autoclaving technique (Shen et al. 2017). When the period of normalcy returns, these ramped-up treatment facilities can be repurposed to treat municipal solid waste. Apart from the disposal, safe transporting of the wastes is also essential, which requires labelling, specific colour coding, sterilization, trained drivers and waste collectors, dedicated routes, waste tracking systems, and emission monitoring (Refer Fig. 6.1). As adopting and implementing of modern technologies is subject to affordability and adaptability United Nations Environment Programme (UNEP) has been proactive in managing the situation and assessing capabilities, and its director Inger Andersen pledged that:
Our response is to support Member States in addressing immediate challenges from the medical emergency, such as strengthening waste management systems. (UNEP 2020a)

Most urban areas in the developing world lack resources like vacant plots, technical know-how to tackle the increasing amount of waste generated (Hoornweg and Bhada-Tata 2012), and COVID-19 has created a further logistical challenge. In India, there is an infrastructural set up for recycling 60% of the plastic waste (Alpizar et al. 2020), but a substantial increase of infectious plastic waste is leading to uncontrolled landfilling and unscientific burning to avoid virus contagion (Corburn et al. 2020). It is estimated that India, facing the pandemic’s extreme wrath, needs 25 lakh units of Personal Protective Equipment (PPE) every day. For every 1,000 Covid-19 tests that are carried out, about 22 kg of plastic waste is generated, which is creating massive pressure on the disposal system (Mishra 2020). Basu (2020) discussed how the Council of Scientific and Industrial Research has planned to utilize the COVID-19 plastic surge by converting the single-use plastics of the PPE kits into standardized plastic pellets and utilizing them in road construction, plastic cover manufacturing, etc.
6.3.2 Air Pollution

Fresh air is the best ventilator and can serve as a unique natural remedial measure. The testament to that is not from COVID-19, but from SARS. A relevant case study to support this statement is the outbreak of SARS during 2003 in Vietnam. It was observed that there were deaths and extensive transmission in hospitals having a closed air condition system. On the contrary, in a hospital with spacious rooms, high ceilings, ceiling fans, and large windows kept open for cross-ventilation, there were no cases of transmission (Le Dang Ha et al. 2004).

Air pollution has become a topic of robust debate at all levels mainly because of the heightened anthropogenic activities, e.g. rapid urbanization, higher population growth, increased energy consumption, and vehicular emission and industrial emission (Dadhich et al. 2018; Ghose et al. 2005; Gupta et al. 2008). With this pandemic, nature is recuperating while people stay at home.

6.3.2.1 Vehicular Emission Scenario

Process of unlocking across the world the situation has started to show a change. Now, the fear is that the world faces perils with more traffic, more pollution, and climate change in the future that worsen faster than before (Gardiner 2020a). In April, with worldwide shutdowns, regular global carbon emissions went down by 17% in comparison to last year. As of 11 June, the fresh datasets show that it is only about 5% lower than at the same point in 2019, though usual activities have not yet fully resumed (Gardiner 2020b; National Geographic Channel 2020).

Most of the developing cities have witnessed a rapid rise in the pollution level. Due to densely distributed small-scale industries without any pollution controlling measures, unplanned traffic flow, and congestion, the Indian cities are to withstand higher pollution of ambient air (Gupta et al. 2008). Today, the utmost threat on Earth’s planet is the conquest by the tiny particle causing Corona Virus Disease (COVID-19). COVID-19 is transmitted via airborne droplets. Therefore, reducing the effective population density in public meeting places is the basic rationale behind the quarantine strategy favoured by most countries responding to the outbreak. The moral coming out from this discussion is to stay inside with open windows and not to flock so that the air can diffuse the germ. However, it is necessary to check the air quality as poor air quality with GHGs and SPM may give rise to several other health problems, which may intensify the infection.

The cumulative concentration of greenhouse gases (CO\textsubscript{2}, CH\textsubscript{4}, N\textsubscript{2}O, etc.) has led to global warming. Humans have been mainly responsible for this situation as they destroyed nature as per their own whims and desire. As an inevitable consequence, environmental pollution has become a big issue of the present day almost globally. The restricted movement has also led to a decrease in the industrial emission throughout the world and, therefore, a reduction in the use of fossil fuel (Bremer et al. 2019; Coutts et al. 2010). Various studies related to the environment have
been conducted, highlighting a drop in the particulate matters and a lower carbon dioxide (Agarwal et al. 2017; Steinle et al. 2013; IRENA 2020). The lockdown phase unveiled a significant decrease in CO₂ levels in all the developing cities of the world. The Indian cities are also showing signs of recovery in the pollution level. Due to pandemic COVID-19, industries have been shut; transport sectors are dwindling due to domestic and international flights’ complete shutdown. Tourism activities have stopped, and hence all hotels, tourism units, homestays, and other recreational activities related to tourism have been stationary. The running of trains, buses, and passenger-vessel services have also been ceased. All these have significantly abridged the consumption of fossil fuels; and, subsequent emission of CO₂ has also touched the trough in the existing CO₂ profile of the region. Just a week of lockdown had brought about a difference of nearly 20% in the values of particulate matter (PM₁ and PM₂.₅).

Figure 6.2 shows a drastic fall in the level of nitrogen dioxide during the lockdown phase in India’s metro cities. However, the year 2019 shows a high rate of increase of the same air element during the same period (i.e. the month of March). This scenario is quite alarming as it includes high usage of the mass transit system. The post-COVID scenario will, therefore, need a comprehensive management & supervision mechanism to implement. With the start of the unlocking phases, the situation is demanding to become normal. India’s road transport system has long been struggling in the city with inefficiencies, such as high congestion levels, limited multimodal integration, inadequate public transit systems, degraded footpaths, and non-existing cycle tracks (TERI 2020). The COVID-19 crisis will craft many new challenges for this sector, especially in urban areas with high travel demand. Increased risks associated with crowded places pooled with social distancing measures in public and shared transport are likely to influence commuters’ modal picks. People are most likely to change their mode of transport for work trips post COVID-19. A sharp decline can be assumed in the usage of bus and metro services, and cases of shared mobility might drop as well. Thus, a shift towards private vehicles and intermediate public transport (IPT) such as taxis and autorickshaws, seems inescapable. The percentage share of non-motorized modes of transport may also increase, especially for short-distance trips. Therefore, the problem of congestion and pollution that plague different cities of the country could worsen in the near future.

As cities begin to ease out lockdown restrictions, public transport services will need to play with limited capacity to conform social distancing norms. Even cabs and other shared services will be affected due to similar rules. People may try to shift from public and shared transport services due to higher professed risks, leading to increased use of private travel modes. As Indian cities are struggling to reduce the dependence on private motor vehicles, this crisis may further give way to adverse outcomes created by high motorization rates. Further, the increased demand for contactless services provided by e-commerce platforms indicates a rise in the number of light commercial vehicles and 2-wheelers. This could lead to adverse outcomes for congestion, pollution, and of course, road safety. These passenger and freight mobility sectors’ changes may impact the demand for energy and pollution levels in most cities of the country. The effect on greenhouse gas (GHG) emissions will also
depend on the technology used in these vehicles. Hence, the outlining of policies for the implementation of cleaner technologies will be crucial to boosting the sector’s sustainability in the long term.

Various past surveys (Nesheli et al. 2017; Bansal and Kockelman 2016; Banerjee et al. 2010) revealed personalized vehicles’ preference as the primary mode of travel to work and recreational places. Public transport was well represented, as a fair size of the population availed the metro rail and bus services. The intermediate public transport (IPT) modes, such as private taxis and autorickshaws, also played a crucial role as a feeder service. The high usage of public transport despite the availability of private cars suggests the prevalence of choice users, while a very small section of the people either walk or use a bicycle to the workplaces. Distance between home and workplace might hinder the efforts of cycling to work, but this
could also be attributed to the lack of cycling infrastructure in Indian metropolitan cities. The motorized two-wheelers were also representing a fair share. A modal shift seems inevitable post lockdown. The crisis would alter people’s choices. A sizeable decrease will be observed in the usage of public transport services. People will prefer to use private cars and two-wheelers. Substitution of metro services with intermediate public transport, such as autorickshaws, taxis, and even preference of shared cabs might be noticed. The decrease will also be witnessed in the use of local trains, mostly by residents in Mumbai. The decrease in the usage of mass transit systems will have an immense impact on the environment. This will not only increase the congestion but also further degrade the air quality of the urban cities of India. With the growing demand for online shopping, the increase in the number of motorized two-wheelers is unavoidable. Constrain of road space will surely seek proper traffic management as the congestion and road accidents are likely to increase. The internationally settled target is to reduce emissions by at least 7.6% every year up to 2050 to keep global warming below 1.5 °C (above pre-industrial levels). It seems distressingly unachievable. According to Simon Evans of climate science website Carbon Brief

It shows that the challenge of avoiding dangerous climate change and getting to zero emissions is unbelievably hard. (The Guardian 2020)

6.3.2.2 Air Travel Aspect

Unfettered carbon pollution from aviation is now a fast-growing source of greenhouse gas discharges, which is driving global climate change. This problem will only worsen as demand for air travel rises. In 2010, the aviation industry carried 2.4 billion passengers; in 2050, that number is forecast to rise to 16 billion (EPUK2012). Airport operations are a significant factor in the economy, for tourism, imports, exports, and business. However, these aids must be evaluated against air travel’s impact on the quality of life and the environment. Noise and air pollution, both from the aircraft and from airport ground operations, are sources of concern, especially in and around the airport. Noise parameters to delimit the pollution level have been introduced at the designated airports in India. The rules state that busy airports referring to a civil airport with more than 50,000 aircraft movements per year (take-off or a landing)—should not exceed noise levels beyond 75 dB(A) Leq (decibels) during the day time (6 am–10 pm) and 65 dB(A) during the night (10 pm–6 am) (Chatterjee2018). The combustion of fuel is generally efficient in aircraft engines, and smoke emissions from jets are fairly low. However, there has been a rise in pollutant emissions from aircraft at ground level with aircraft movement. In addition, a large amount of air pollution around airports is also generated by surface traffic (EPUK 2012). The key pollutant of alarm around airports is nitrogen dioxide (NO2). NO2 is formed by nitrogen oxide (NOx) emissions from surface traffic, aircraft, and airport operations (CBD 2000). PM2.5 is also a concern since particulate emissions from jet exhausts are almost all in this fine fraction. Now in this pandemic situation, the use of private jets is likely to increase, which will add to this pollution level.
Kolkata, unceremoniously called “the dusty city” (Haque and Singh 2017), is the second most polluted metropolis in India, next only to Delhi, and suffers from the highest pollution levels among eight tropical Asian countries (Mukherjee et al. 1998; Upadhyay et al. 2014; Roy et al. 2015; Financial Express 2020), typically a representative of Global South megalopolis. Apart from emission from the Kolkata-Howrah industrial belt, vehicular emissions from continuously increasing vehicles contribute a large in polluting air, and the number has increased 8 times from 1951 to 2001 (Chowdhury 2015) for the city. The PM$_{2.5}$ and PM$_{10}$ are taken to be the main pollutants and have a persistent concentration above the permissible level in Kolkata (Das et al. 2015).

The cluster analysis (Fig. 6.3) shows a massive change in the concentration of atmospheric pollutants in the city of Kolkata. It clearly distinguishes between the scenario of pre-lockdown and during the lockdown phase. Two distinct clusters can be seen in Fig. 6.3a. One is consisting of Victoria Memorial, RBU, and Ballygunge; the other being Jadavpur, Fort William, and Rabindra Sarovar. The scenario in Fig. 6.3b shows a complete transformation of clustering. The locations show almost equal values of concentration of pollutants. It is unreasonable at this situation to either rejoice or to think it to last forever, as due to the factors discussed above, the situation in the post-COVID time is again going to resume to the previous level.

### 6.3.3 Water Stress

Water is the foundation of life and livelihood as it is aptly said, “there is no health without water”. Initially, it was believed that freshwater is a renewable resource, but given the rate of consumption and residence time of several sources like streams, lakes, groundwater, it is clear that the replenishment rate is too low. The growing population and water demand-consumption have virtually made it to a finite one if one takes into account a smaller time-frame in mind. One of the aspirations of Sustainable
Development Goal was to ensure availability and sustainable management of water and sanitation for all by 2030, and this pandemic has kind of increased both the extent and consequences of the safe water access gap more than ever before (Butler 2020).

Singhal (2020) referred to the report “The Water Gap – Water Aid’s State of the World’s Water 2018”, which stated that the global population without access to clean water was around 844 million while Matto and Singhal (2020) reported that 2.2 billion people live with high water stress. About 4 billion population experience severe water scarcity at least one month in a year (World Water Development Report 2019). The fact that many areas, especially in North and South Africa alongside South and Central Asia, are getting water-stressed is not only due to population rise but also because of an increase in demand and usage. The expected rise was estimated by OECD (2012) as 400% in the industrial sector and 130% in the domestic sphere. In the twentieth century, the population tripled while water usage escalated remarkably to six-fold (FAO 2009). The drivers that caused the increase in water stress before the COVID-19 pandemic were population growth, rising per capita water requirement, global climate change, collapsing wetland systems, rapid urbanization, carbon-intensive technology, demanding high water requirements, and age-old infrastructure (Pegram 2010; Butler 2020). In water-scarce areas, resort to water trucks is taken to provide water access to the deprived ones, but during the pandemics like Ebola in 2014 (TKG 2016) and COVID-19 in recent times hampered the regular movements of the trucks and, in turn, that of the water due to the quarantine, lockdowns, containments (Cooper 2020a).

For the prevention of the spread of coronavirus, there is a need for frequent hand-washing, which demands access to clean water. It has been estimated that COVID-19 mitigation measures like more cleaning and disinfecting would lead to at least 5% average increase in water demand at the household level (United Nations ESCWA 2020). Senapati (2020) clarified that for washing hands an extra 4–5 times daily, a family of five members will need 20–40 litres of water more than normal. It was approximated that 1-second-dripping faucet wastes over 5 gallons of water per day and just less than 2,083 gallons per year. It was further roughly estimated that if a tap-water is left running during the twenty-second period of handwash, it leads to a loss of 1.5–2 litres of water, which can cumulatively go up to 15–20 litres of water for an individual daily. A section of experts is afraid that these extra litres of water used for handwashing in a nation that is already struggling with water scarcity may worsen the situation (Matto and Singhal 2020). Frequent washing of hands surely cannot be avoided through prudence and maybe by using taps with sensors, but the negligent wastage can definitely be curbed. This growing demand for water has occurred at a time when the potential for augmenting supply is limited, water tables are declining, and water quality issues have surfaced too. Apart from the depletion of groundwater, too much soap and detergent usage might lead to eutrophication in the surface water bodies.

Dobe (2020) carried out a study in seven India cities and found that the average per capita water consumption in domestic households was about 92 litres per capita per day, whereas 100 litres per capita per day is required to maintain a minimum standard of health and hygiene. It was predicted a few years back that cities like
Chennai in India, Cape Town in South Africa, and Mexico City in Mexico are at risk of running out of the water very soon (Matto and Singhal 2020). In the developing nations, including India, the section of people residing in abject poverty in informal urban settlements, rural interiors lack the adequate quality and quantity of water required in general and more so in this pandemic situation, making them susceptible to infection (International Commission of Jurists 2020).

To cope with this sudden surge in water demand, wastewater treatment has to be implemented at war-footing. Guppy and Anderson (2017) documented that 80% of the wastewater is left untreated. In low-income countries, only 8% of wastewater receives treatment, and in the lower-middle-income countries the treatment hovers around 28% (WWAP 2017). Moreover, through leakage, 30% of abstracted water is lost, and it is predicted that by 2030, there will be 40% gap between water demand and water available. The global water demand is supposed to increase by 50% (WWAP 2012). It is the time when wastewater and rainwater are increasingly considered a largely untapped resource to augment water supply that can ultimately reduce water stress.

Experts led by the UN Special Rapporteur on the Human Rights to Safe Drinking Water and Sanitation indicated that vulnerable persons “need to have continuous access to sufficient and affordable water” conforming to the hygiene measures required to combat COVID-19 (OHCHR 2020). Anim and Ofori-Asenso (2020) feel that strategies have to be implemented to ensure the provision of water for all stakeholders, regardless of any other factors like socio-economic conditions, legal status, through green solutions regarding the conservation of available water. Cooper (2020b) emphasized that the focus has to be on aspects like—sufficient water availability, satisfactory water quality, judicious water resources management, and affordable access to Water, Sanitation, and Hygiene (WASH), to strengthen water security in this troubled time. Butler (2020) added few other parameters like addressing historical gaps in water supply, emphasizing the construction of water utility infrastructure with a higher degree of automation, undertaking communication campaigns to raise awareness of the importance of good hygiene practices and water conservation too. While policymakers recognize that rationalizing the usage and pricing of water is necessary to curb wasteful practices, it remains politically contentious. Hoque and Wichelns (2013) conducted a survey in 60 cities across the continents to suggest effective water tariff policies like metering through price signals, keeping a minimum charge for all so that all the households use water wisely, and charging higher rates for the wealthier consumers who use greater volumes of water.

The effective management of water resources across the globe has been hampered by factors like—water wastage, infrastructural dysfunction, low accountability, and unethical practices. It can be hoped that the COVID-19 will act as a wake-up call to hasten the process of forming of water-smart society (de Melo et al. 2020), which would deliver improved water services during future infectious disease outbreaks.

Surie (2020) pointed out that in 2019 the Indian government formed a new integrated water ministry—“Jal Shakti” (Water Power)—merging the former ministries of Water Resources, River Development, and Ganga Rejuvenation, and Drinking Water and Sanitation to raise public awareness about water conservation. It involves
the initiatives like the Jal Shakti Abhiyan (for promoting water conservation in 256 most water-stressed districts in India), Jal Jeevan Mission (for providing piped water connections to 146 million rural households by 2024), and Atal Bhujal (Groundwater) Yojana (for improving groundwater management through community participation in seven Indian states). If these integrated and holistic measures are adequately implemented, then the water crisis, which is being further magnified by COVID-19 induced surplus water usage, could be managed efficiently, assuring access to water for all.

6.3.4 Chemical Exposure

This COVID-19 has also made people aware of health and hygiene. Hand washing is considered as a means to prevent serious diseases and infections. The Global Handwashing Partnership introduced the Global Handwashing Day, and it is being celebrated since 2008 (CDC 2020), on 15 October every year. It is a platform shaped to promote and create new ways to encourage people to wash their hands. It also advocates the fact that handwashing with soap and water is the easiest and best way to do the same. However, going by the ethos of this day, where people always opt for easier alternatives, hand sanitizers to clean hands have become highly popular. Adaptation of effective hand hygiene is vital, where one of the best advice by WHO is to wash or sanitize your hands frequently with soap or >60% alcoholic hand sanitizer, respectively. WHO suggested two alcohols-based formulations for hand hygiene in healthcare to sanitize the hands for reducing the spread of coronavirus (WHO 2020f). These recommendations are based on fast, effective, and broad-spectrum antimicrobial activity combined with easy availability and safety.

Hand sanitizers are commercially obtainable in various types and forms such as antimicrobial soaps, water-based or alcohol-based hand sanitizers. The different types of formulations involve—gel, foam, cream, spray, and wipes (Jones et al. 2000). WHO recommended that alcohol-based hand sanitizers are mainly made up of ethanol, isopropyl alcohols, and hydrogen peroxides in different combinations (Fig. 6.4).

These preparations may become toxic to human health and the environment when misused or overused. These chemicals have identified toxic and hazardous impacts on the environment when released by evaporation. It is recognized that the ingestion of a low concentration of hydrogen peroxide (3% solution) is responsible for minor gastrointestinal tract irritation. In a few cases, it is also responsible for portal vein embolism and mild mucosal irritating and vomiting. Ingestion of isopropyl alcohol accidentally or deliberately leads to severe respiratory or central nervous system depression (Slaughter et al. 2014). The active reagents of alcohol-based hand sanitizers are ethanol or isopropyl alcohol at 60–95% concentration. Langer et al. (2004) reported that alcohol-based solutions with ethanol, 2-propanol, and distilled water and disinfectant with octenidine dihydrochloride and phenoxyethanol are the vital reagents. The popular hand sanitizers, such as Dettol® contain Alcohol Denat,
and Purell® includes ethyl alcohol 70% v/v, isopropyl alcohol, and aminomethyl propanol.

This pandemic has fetched a shortage of hand sanitizers all around the world. WHO has directed the local manufacturers regarding the preparation of hand sanitizers. WHO suggested two formulations for lesser volume production; one with ethanol (96%) and the other with isopropyl alcohol (99.8%). Final product concentration suggested by WHO for household or local production is ethanol (80%) v/v, hydrogen peroxide (0.125%) v/v and glycerol (1.45%) v/v for formulation A and isopropyl alcohol (75%) v/v, hydrogen peroxide (0.125%) v/v and glycerol (1.45%) v/v for formulation B. (Refer Table 6.1).

As the motto of the Global Handwashing Day is to encourage washing hands with soap and water, what is it about hand sanitizers that many are ignoring? It is for the side-effects they have. Proper cleaning of hands using the liquid sanitizer is appropriate whenever washing hands is always not possible. It can save us from the infection by bacteria and viruses. When outside, riding, playing in a park or shopping, it is not always possible to use soap and water to wash hands. This is when we all have to depend on alcohol-based hand sanitizers. Sanitizer works extremely well for most of the bacteria and viruses, and that is how it keeps us safe from a variety of illnesses. However, sanitizers can affect the micro-biomes of the body, which can have a negative impact on health. These alcohol-based sanitizers can be beneficial for killing the bacteria but, in turn, can wreak havoc in our healthy bacterial community. Another issue, especially in India, is that due to the rising demand for hand sanitizers, often spurious products are flooding the market, and there is no procedure for stringent quality control. So, many physicians have suggested preparing a home-made variant
Table 6.1  Effects of acute and chronic toxicity by active ingredients of hand sanitizers

| Active ingredients | Acute harmfulness                                                                 | Chronic harmfulness                                                                 | Source |
|--------------------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------|
| Ethanol            | Central nervous system and respiratory depression, Lactic acidosis, Nausea        | Cardiac arrhythmia, Acute liver damage, Hypokalaemia, Hypocalcaemia, Hypophosphatemia, Cardiac arrest and death | Wilson et al. (2015a), Vonghia et al. (2008) |
| Isopropanol        | Alike ethanol including central nervous system and respiratory depression, skin and mucous membrane irritation | Ketosis, Osmolal gap ketonemia, Myoglobinuria, Acute renal failure and death          | Zaman et al. (2002), Jersey Department of Health (2016) |
| 3% H₂O₂           | Vomiting, skin infection, slight gastrointestinal and mucosal irritation          | Air embolism, death in few cases                                                   | Moon et al. (2006), New Jersey Department of Health (2016) |

*Source* Compiled by authors

that might be of much riskless (TOI 2020), but that too comes with certain conditions (Fig. 6.5).

Medical experts have started to warn against the excessive use of alcohol-based hand sanitizer as a preventive measure against coronavirus. Too much use of sanitizer against the virus is responsible for skin damage and reduce its ability to work as

![Fig. 6.5](image_url)  

**Pros**  
- Might be as effective as store bought ones  
- Harmful chemicals can be avoided  
- Temporarily removes unwanted germs  
- Convenient replacement for soap and water  
- The fragrance can be customised  

**Cons**  
- If the mixing is not done meticulously it can potentially burn the skin  
- There might be contaminated while making it  
- Procuring appropriate ingredients and tools might be a tough ask  
- Preservability is another issue

*Fig. 6.5*  Having one’s own mix—Pros and Cons of self-manufacturing hand sanitizer (*Source* Compiled by authors)
a barrier against other harmful viruses (Wang and Su 2020). Sanitizers have been frequently used all over the world as a disinfectant for better hand hygiene. Excessive use of alcohol-based sanitizer increases the skin’s permeability and deprives oil and water of the skin, leading to skin roughness and irritation. Dry and damaged skin is a hotbed for many diseases. Repeated exposure of disinfectant, antibiotics or other genotoxic chemicals to microbes tend to mutate through the natural process, making them resistant to survive from repeated use of hand sanitizer (Tachikawa 2020). Research reports have indicated that overuse of sanitizers in some cases may increase the risk of viral outbreaks (Larson 2001). CDC (2020) warns that the excess use of sanitizers may lead to hormonal disruptions and cause bacteria to adapt to its antimicrobial properties, which produce more antibiotic-resistant strains. The use might also weaken the immune system and make people more susceptible to allergies. The scented sanitizers are likely to be loaded with chemicals. Synthetic fragrances contain phthalates, which could alter genital development (Bonner 2017). Animal studies have shown that the compound could change the way hormones work in the body, raising concerns and necessitating further investigation to understand better how they might affect humans (Bonner 2017).

6.4 Instances of Behavioural Trajectories

The regulations levied by the countries from the global south in response to the pandemic have been relatively uniform when viewed from a distance—there is the imposition of quarantine, social distancing, encouraging the usage of protective gear, and sanitizers. However, these mandates have generated varied responses in different countries during the “crisis” and “new normal” (Table 6.2). On the factors like the severity of the virus outbreak, population characteristics, economic standings, and the way people handled the exceptional situation vary across the nations. But one thing that has been common for most of these developing nations is that all are fighting tooth and nail to stop the spread of the pandemic and are not really taking into account the immediate and far-reaching environmental impact of these measures at this point in time. Apart from governmental initiatives, it is also the responsibility of the aware and sensitized citizens to act judiciously in this hour of need so that sustainability is maintained.
Table 6.2  Facing the pandemic head-on: excerpts of ground reality

| Countries | Respondents’ views |
|-----------|---------------------|
| Respondent-1 | Respondent-2 | Respondent-3 | Respondent-4 |
| Female (40 years) Kuala Lumpur, Malaysia | Female (34 years) Bandar Seri Begawan, Brunei | Male (65 years) Singapore | Male (52 years) Delhi-NCR, India |

**Parameters**

| Waste Generation | Respondent-1 | Respondent-2 | Respondent-3 | Respondent-4 |
|------------------|--------------|--------------|--------------|--------------|
| Segregated waste disposal was already in place | Plastic waste generation has increased with compulsory mask usage and imposition of a hefty fine if not followed | Zero plastic waste initiative has been there for the last two years | Plastic use is very limited, as stringent laws are in place | No stringent waste segregation is done |
| All plastic use is restricted as far as possible | The use of plastics, even for the protective gear, is also restricted as far as possible | Even for the protective gear, the stress is on the use of recyclable plastics | SUP usage is back with a bang in the form of packaging material and protective equipment |
| **Air Pollution** | Respondent-1 | Respondent-2 | Respondent-3 | Respondent-4 |
| With lesser vehicular movements, during the lockdown, it has gone down | The level of pollution was low already | The level of air pollution was not pronounced beforehand too | Air pollution levels have gone down drastically during the lockdown phase |
| **Water Stress** | Respondent-1 | Respondent-2 | Respondent-3 | Respondent-4 |
| Water usage has increased way bit but not drastically | Water wastage is limited, as one needs to pay tax as per usage | Water usage has been on the rise, but there has been so widespread fear of scarcity | Due to hygiene issues, water use has gone up and is leading to an impending water crisis |
| **Chemical Exposure** | Respondent-1 | Respondent-2 | Respondent-3 | Respondent-4 |
| All are using sanitizers in both public and private spheres, so there is high demand in spite of the spike in price | Initially, sanitizers were not used; reliance was on soap and water. But from the month of May, sanitizer sales have picked up | Sanitizer usage is very high, and there is no strict quality control measure |
| Though initially sanitizer market did not pick up, gradually, it gained ground and was even sold at twice the market rate | | | |

*Source* Primary Survey, 2020
6.5 Ways Ahead

In this unprecedented crisis of COVID-19, the protection of lives and livelihoods has become the core of government decisions and actions at every level, with a specific focus on the health care sector (Prata et al. 2020). Various guidelines have been issued to control the spread of this highly communicable disease, which has emphasized social distancing, frequent hand washing, and practicing proper respiratory etiquette by wearing masks. Due to lesser mobility and limited economic activities the world has witnessed an ecological rejuvenation, which is going to be transitory if the disease control measures are not adequately chalked out. The COVID-19 crisis should not be solved at the expense of inviting a longer-term environmental crisis. The stakeholders like policymakers, scientists, and common people need to try to figure out innovative, holistic solutions in handling the existing challenges of the current crisis. For designing efficient management systems that would be viable in pandemic and post-pandemic world, holistic public-private initiatives have been encouraged. These efforts can be made as part of the broad disaster management planning in the new normal conditions to better comply with pollution standards and to ensure sustainability.

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