Chapter 14
Biodiversity Conservation: An Imperial Need in Combatting Pandemic and Healthcare Emergencies

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Abstract The advent of COVID-19 has infected millions of people causing healthcare emergencies worldwide. Biologists and environmentalists have always stressed on the impact of habitat fragmentation, deforestation, and animal poaching on human health. The outbreak of various zoonotic scourges has incremented the levels of risk in human population because of direct and indirect interaction with human chain. Human health is directly associated with animal health and is one of the important part of an ecosystem, the balance of which is disrupted due to anthropogenic activities which has disrupted an ecological balance due to which biodiversity is greatly affected and is reducing at a faster pace promoting a spread of diseases through animals to humans. COVID-19 is a serious concern that puts human life to risk, however, strategies like Global Lockdown which is referred as the period of “Great Pause” has helped to recover rare species of Flora and Fauna with reduced pollution levels, cleaner air and water. In order to quell the further on-spread of pandemic or any other avant-guarded health emergency, biodiversity shall be preserved. This chapter highlights the vitality of conserving biodiversity to renounce the healthcare challenges addressing the scenario of novel coronavirus.

Keywords Habitat destruction · COVID-19 · Ecosystem · Anthropogenic · Biodiversity
14.1 Introduction

The Earth’s ecosystem plays an instrumental role in shaping human sustainance and curbing global issues. The menace of anthropogenic activities has been an issue for environment conservationalist. Since a long time anthropogenic activities which include excessive land use, new specie introduction, changing environment, habitat destruction, and thriving population indefinitely have greatly affected the biotic components of the Earth [1]. This has created a change in transmission swing of zoonotic pathogens, disrupting ecosystem health and putting life in danger. COVID-19 being an unmapped situation has impacted life in all spheres. The impact of perpetuating pandemic is yet to be fully evaluated but it has revolutionized the concept of medicine, treatments driven from biodiversity. In order to find the medication for the infection of SARS-2, the knowledge of traditional medicinal system across the globe has been systematically utilized. Traditional medicinal knowledge believes in the conservation and strategic utilization of biodiversity as a resource. Thus, the use of traditional knowledge based on ethanobotanic and naturopathic fundamentals has created an incessant need to conserve ecosystem [2].

To evaluate the biodiversity conservation as a relevant and viable strategy to curb public health on a global level, it is a necessity to find answers for the following questions: (i) What is the synergy between biodiversity and human health? (ii) What is the relation between pathogen transmission and biodiversity? (iii) How does biodiversity bring back strengthened immune system, in terms of traditional requisites? (iv) What is the current scenario in terms of COVID-19? (v) quantification of impact of pandemic on environment and future challenges? Here, we summarize the current available knowledge about biodiversity and its related interventions to address human health and a clear understanding of the five questions. This chapter highlights the relevance of biodiversity in human health. During the period of the coronavirus pandemic due to lack in the treatment measures, the conventional methods of treatment have been a great aid. This has encompassed the need to preserve and conservation of biodiversity to curb the unseen medical challenges. Also, the use of biodiversity as medical resource has displayed promising results in past for various infections and for coronavirus pandemic as well; preservation of biodiversity can also be the reason for meeting the treatment measures in the time of future outbreak of diseases. The use of various plants and their derivative extracts on the basis of docking scores have provided to consolidate the biodiversity preservation. One of the common measure adopted to check the perpetuating infection was quarantine and worldwide lockdown. The procedure of lockdown manifested various changes in the extent of environmental pollution. Huge improvization in the air, water quality, and territorial expansion for animals harboring in wild was seen. The measures of quarantine are adverse for the economy of nations and in order to recover the drift, the environmentalists have predicted the overexploitation of biodiversity in future. Thus need for legal policy changes are recommended to make the biodiversity preservation laws stringent to avoid the post-pandemic exploitation. The existential measures of biodiversity conservations are also to be further strengthened for future challenges.
14.2 Synergy Between Natural Environment and Human Health

The natural existing ecosystem and environment in proximity with humans have positive effects on the well-being of the individual [3]. The positive effects on physiology and psychology are in association with the natural ecosystems and manmade ecosystems; are highly dependent upon the time period and timings of duration. Sojourning to the forests, Parks in cities, gardens, and orchids for a shorter duration of time renounces anxiety, mental turbulence, stress, and helps in restoring strength. It also helps in apprehending a positive sphere of emotions, apprehending self-esteem of individual, and encompassing the overall health of person. The enhancement in the physical movement and activity is also seen when an individual is exposed to the natural environment. This leads to improvisation of physical health, thereby reducing the risk of type 2 diabetes [4]. The proximate visits to natural environments, such as harboring in areas with higher foliage or in the zones with higher diverse landscape are also pivotal in relinquishing the chances of respiratory, mortality, cardiovascular disorders, and cancer.

The actual repercussions of greenery on the health of an individual have been calculated by the implication of various spatial scales for a wide range of distance between 150 m and 5 km [5]. The weight of natal is also influenced by the exposure of mother to the natural environment during her pregnancy. The chances of occurrence of Schizophrenia, prevalence of obesity and atopic sensitization is also reduced due to the exposure to the green environment during childhood. It also helps in managing blood pressure during adolescence. The process of development of immunity is also highly influenced by exposing an individual to natural environment in early life. The environment has gargantuan of microbiota and exposing to which reduces the chances of chronic inflammatory diseases. The exposure in life to the greenery and foliage is amplified by the exposure in the other phases of life. This might include the monitory effects on stress reduction and the therapeutic immersion. There are copious catastrophic ailments which are associated with the deficient exposure to the natural environment. These are collectively called as “nature deficit disorder” (NDD). The various difficulties which arise in kids such as emotional disturbances, cognitive ailments, and various other chronic physical ailments [6].

On the basis of time period which an individual spends in proximate contact with the natural environment the services offered by the ecosystem can be categorized as short and long-term “ecosystem services.” Perturbing the vitality of ecosystem services these are the characteristic features, factors, and facets which directly or indirectly show its effect on the being hale and hearty of human. Ecosystem services are pivotal in the growth of an individual in various aspects. The variety of ecosystem services that have beneficiary impacts such as stress regulation quelling the toxicants and noxious elements present due to air pollution, temperature regulation, noise barging. Now conceding the investigations conducted on synergy between human health and biodiversity, the majority of effects are based on the presence of foliage, accessibility to greenery, seize of the gardens, proximity to the green spaces. The
natural environment comprises of humongous microbial diversity which is crucial in preventing chronic diseases. The variety of plant diversity present is supposed to have high impacts directly or indirectly on controlling air pollution. This pollution has an impact on health by aiding the prevalence of various diseases such as asthma, cardiovascular disorders, and pre-mature deaths [7] (Figs. 14.1 and 14.2).

Amalgamation of instigations displays that ecosystem comprising of rich biodiversity are highly supportive in the provision of the more efficient ecosystem services this concept has nomenclature of (“biodiversity-ecosystem-functioning theory.” Highly diverse ecosystem has higher resilience to the turbulence caused due to the anthropogenic actions which is known as “ecosystem-resilience theory” [8]. This resilience is pivotal for the ecosystem which is functioning in the proximity to the urban zones. Now conceding the evidences and the finding for encompassing the effect of the actual biodiversity on the various preliminary mechanisms that are responsible for the alignment of the human health to the natural greenery and foliage. These mechanisms are: “biophillic hypothesis,” “dilution effect hypothesis,” and the “biodiversity hypothesis.” The biophillic hypothesis is formulated on the belief that humans have intrinsic affinity for the other species and the natural environment which is the consolidated reason for the evolution of the species. As per the statuary of this hypothesis the
people are supposed to prefer and select an environment which is very diverse biologically for rendering the most of the mental and psychological benefits. This hypothesis has also formulated the “stress recovery theory” (this signifies environment helps in providing relief from the physiological stress) [9]. This hypothesis has also formulated “attention restoration theory” this signifies that environmental exposure helps in restoring mental fatigue and recovers the directed attention. While considering the statuary of biodiversity hypothesis it states that association with biodiversity strengthens the immunity of an individual by monitoring the species present in the human microbiome. As, the species present in the diminishing the prevalence of the various diseases such as allergies, asthma, and various other chronic inflammatory diseases [10].

The very resembling “hygiene hypothesis” and also the “microflora hypothesis” which implies that a controlled early life exposure to the pathogens and the parasites is related to the development of allergies, related diseases, asthma, and various other forms of the hypersensitivity disorders as because of its derogatory impacts on the human (intestinal) microbiome (dysbiosis) and also on the immune system development of the infant. Conglomerating the evidences of commensal microbiota and parasitic helminths on human health is very difficult to encompass. The “dilution effect hypothesis proposes that the risk of adhere infectious diseases circumspects for humans due to presence of the higher number of chordates as the dilution of the pathogens happens in the larger range of host chordates present in the same environment. The statuary of this hypothesis states that the dilution effect hypothesis, the furthering of the infectious diseases are expected to decrease and shrink where the prevalence of the infected vector organism as a carriage is low. Despite the higher
population of organisms having pathogenic activity the flow of the organism from various other hosts to human is decreased.

14.3 Impact of Worldwide Lockdown on Environment

To quell the perpetual outspreading of the COVID-19 pandemic, several containment measures were implemented across the globe. Despite the alarming health crisis generated due to the SARS-Cov-2 virus, there was a gargantuan of positive impacts that are seen in various facets of the environment [11]. There are significant improvisations evident for the air quality index, quality of water, reduction in buzzing noise pollution, carbon emission, and helped the wildlife to heal. Also; there is a diligent increase in the manifestation of plastic as it widely used for the manufacturing of sanitizer bottles, personal protection equipments, and masks in general. Alike all the other areas the waste management systems had no effective management strategy to combat this copious waste generation.

14.3.1 Air Pollution

Poor Quality of Air is a pragmatic root cause for various health constraints that are lethal at times across the world. These health constraints several disorders like asthma, bronchitis, respiratory allergies, and empyema. Scientific investigations have evaluated that nearly 4.6 million humans lose their life each year by such disorders. One of the main causes of air pollution is the exhaust eliminated from the Automobile and manufacturing industries [12]. The current ongoing condition of the pandemic has aided in the reduction of air quality especially in countries that implemented lockdown and quarantine measures. The index of pollution given by NASA and ESA has shown a decrease of 30% in the places of extreme outspread like Italy, Spain, and the USA, etc. There is a decrease in NO₂ and CO₂ which are majorly produced as exhausts by 30% and 25%, respectively [13]. The data given by ESA for the city of Italy has shown a 35% decrease in pollution during the course of lockdown. The lockdown was significant in decreasing the AOD (Aerosol Optical Depth) over the oceanic and sea region. The concentration of NO₂ in the tropospheric was also expected to be lowered. When a comparison was taken for the count of flowing gases concentration from 2018 to the present day. There was decrease in PM10, PM 2.5, NO₂, SO₂, and CO concentration by 26–31%, 23–32%, 63–64%, 9–20%, and 25–30%, respectively. The reduction in electricity consumption in Europe was 2–7% which has contributed to the reduction of CO₂ due to the lower fossil fuel exhaust emission. There was a study to conceptualize the relationship between the mortality of people due to COVID-19 and its association with air pollution in worsening the disease. The repercussions were highly catastrophe due to high traces
of air pollutants. It was figured out that air pollution has intensified the chorogenity of respiratory tract infections and diseases [14] (Fig. 14.3).

14.3.2 Wildlife

The pandemic has also caused a colossal impact on wildlife across the globe. The daily routine of humans is manifested as the anthropogenic actions for the wildlife. Noise causes the high-scale disturbance to the sensory systems of the animals. This affects the process of communication, the cues of certain gregarious animals lose track of location, finding mates, etc. [15]. This later impacts the quality of habitat animal population is harboring in. The stern lockdown measures adopted to check the transmission of the infection have actually depreciated the number of visitors sojourning the national parks and even their mobility out of the urban areas; thus quelling the count of human interventions in the wildlife. The habitat that has been fragmented by humans from decades has created a smaller circumference for animals, during the course of lockdown plenty of animals have been spotted in areas where they were not seen for years. There are various positive effects that have been seen on the wildlife due to this lockdown. It was seen that due to heavy automobile congestion and human activities during the daylight, various animals have been accustomed to the nocturnal pattern of living [16]. After the provision of this lockdown, such sensitive species can be seen during the course of the day even. Despite all these positive effects of lockdown on wildlife, there were adverse effects on those facets of life that are dependent on humans for food. Now various animals are seen be to be sojourning the urban areas in search of food; if the pandemic is persistent this may highly endanger the lives of certain species due to lack of food. Also, The food procured from wild sources is the major dietary item and even source of living for many societal sections in rural portions. The food shortage in these areas might be compensated by the
extensive killing of wild animals. The conservationist is suggesting that African nations may experience massive meat poaching due to lockdown. Due to economic struggle, rhino horns and ivory will be poached. While Gabon has banned the use of the bat as it was seen to be the root cause of the coronaviruses. The reduced tourism has also had an instrumental impact on the reduction of the sewage discharge into the canals which has improvised the quality of water. The decline seen for global and local shipping has manifested several positive impacts on the aquatic ecosystem as well. The population parameters measuring for the turbidity and murkiness of water caused by the boats and voyages have also been minimized [17]. Lockdown due to COVID-19 has highly renounced the noise parameters due to transportation and the industrial activities making the environment peaceful for co-existing species as well (Fig. 14.4).

### 14.3.3 Water Bodies

There is a gargantuan of improvement in the water quality of the water bodies. Since after the administration of lockdown measures the shutdown for the industrial setup and functioning has led to a decrease in water usage and demand. Also, there is a humongous reduction in the noxious and toxic discharge in the river bodies. The
demand for fishes has declined across the world as per the pandemic and fleets can be seen unoccupied. It has been proposed that the increase in the biomass of fishes will be seen as fishing is decreased. By the end of April 2020, it was noticed that the aquatic recovery was in a very anecdotal manner. People are quarantined in houses due to the lockdown measures reducing the tourism and sojourning of beaches as a recreation activity. Oviparous animals such as turtles are noticed to have been laying eggs on the beaches, which was not before due to pollution and human interference. The river Ganga and Yamuna were having alarming parameters of pollution, the condition for both the rivers have started to improve. Water quality in the rivers has improved massively including that of Ganga and Yamuna both. The clearing of water bodies is seen as per the stern enforcement of laws and the data obtained from the Central Pollution Control Board (CPBB) has manifested instrumental data in pollution decrease. The data collected at 27 reference points of river Ganga showed that the water now suitable for human use like bathing and also, the wildlife and fisheries can be propagated in the water. Another study conducted for the Lake of Vemba and also showed a decrease in the pollution and improvization in the water quality. The statistical data are taken through remote sensing images showed for surface water quality. The concentration of particles decreased by 15.9% which signifies 8 mg/L decrease which later turned to be decreased by 34% [18] (Fig. 14.5).

![Fig. 14.5 Effect of lockdown on the water bodies](image-url)
14.3.4 Medical Waste as Another Havoc

The mass breakout of coronavirus has also caused certain serious environmental concerns. One such concern is an uncharted and unmanaged medical waste as the repercussion of the increased clinical and precautionary activities. The very first epicenter of the pandemic was China where there was the production of nearly 200 tons of clinical waste each day. Each day with the on-spread of pandemic medically generated waste became the major issue globally. The movement of “Seas without Plastic” was conceptualized in Hong Kong, which stated that wearing masks based on plastic for fabrication is a part of environmental concern [19]. Plastics are a very vital section of the materials that are available and are inexpensive. Mismanagement of the widely used Personal protection equipments (PPE) during the pandemic, has been anticipated to generate 129 billion face masks and 65 gloves globally. As a repercussion it is a risk for the community, it is seen that the SARS-Cov-2 virus can survive for up to three days on the surface of the plastic and also has a broader impact on the health of organisms. Thus concerns over the reusable masks as the contagious vectors for the SARS-Cov-2 are placed. In several parts of the world the single used plastic manufacturing was prohibited which has been reversed to meet the demand of plastic masks and gloves and others. This has also underlined a need to look for the possible alternative for the use of plastic. Also, proper awareness regarding the disposal of this waste is also needed [20]. This unmapped need for the use of plastic has created the need for the strict plastic reduction policies compelled reinforcement. There is a need for a dynamic responsive waste management system and is the perspective for novel research for environmental policies. The concept of Plastic Waste Footprint (PWF) is formulated to capture the environmental impact of plastic made products on the environment. This is another bilateral problem along with the clinical crisis of the Pandemic (Fig. 14.6).

14.4 Traditional Health and Immune System

The unprecedented outbreak of the pandemic of COVID-19 that created a menace worldwide has no prophylactic measures. The unabated chain of cases of the epidemic has been enormous along with extensive fundamental research. Despite experimental isolation of potential chemical and herbal antiviral targets and prior experience with SARS respiratory syndrome, the knowledge seems to be insufficient and therefore calls for conventional medicinal approaches. The study of Ayurveda, Unani, Naturopathy, Siddha, and Homeopathy can serve suitable interactions to answer the public health discourse as well as develop strategies and bring concern toward adopting available traditional knowledge and practices in today’s time to help curb the problem. There are historical shreds of evidence of traditional knowledge for managing epidemics and they have also been listed by AYUSH, Government of India for COVID-19 management discussed in Table 14.1. Although the central
government brought together these sectors for managing the pandemic of COVID-19, several challenges stand at the forefront. The first is the general thought of modern rationalists who reject the idea of traditional knowledge and the second is the development of a holistic ayurvedic system in conjunction with modern scientific approach [21].

There was an advisory released as a precautionary measure for COVID-19 by the ministry of AYUSH that led to remarks like “placebo” and “myths,” ludicrously criticizing the traditional healthcare approach as farce and baseless. The advisory focused on boosting the immunity of every individual to be healthy and fit to combat any disease. Even Siddha came up with management protocols for the pandemic including economical herbal drinks and concoctions for different intensities of progression of COVID-19 that were distributed in Tamil Nadu.

Asymptomatic or individuals at high risk of encountering the coronavirus need to build a strong and efficient immunity [23]. To develop Vyaadhikshamatva, Ayurveda emphasizes social distancing, building resistance against infection, and fumigation of individual residents [22]. Using herbs like turmeric, garlic, carom, and loban can aid in disinfecting inhabited areas while consuming home-made herbal drinks and Rasayana which includes Brahma Rasayana, Chyavanprasha, or Amrit Bhal-lataka acts as antioxidant and helps in immunity building [24]. Another intervention of ayurvedic treatment is for a group of home-quarantined individuals who have
Table 14.1  Historical evidence of traditional knowledge in epidemic management [22]

| S. no | Medicinal plant | Extract | Trade name | Traditional medicinal practice | Treatment                                                                 |
|-------|-----------------|---------|------------|-------------------------------|---------------------------------------------------------------------------|
| 1     | Tinospora cordifolia | Aqueous | Samshamani Vati | Ayurveda                      | Chronic fever                                                             |
| 2     | Andrographis paniculata | Aqueous | Nilavembu kudineer | Siddha                        | Fever and cold                                                            |
| 3     | Cydonia oblonga | Aqueous | Behidana Unnab | Unani                         | Antioxidant, immune-modulatory, anti-allergic, smooth muscle relaxant, anti-influenza activity |
| 4     | Arsenicum album 30 | Tablet | Arsenicum album 30 | Homeopathy                    | Effective against SARS-CoV-2, immune-modulator                            |
| 5     | Agastya Haritaki | Powder | Agasthya Rasayanam | Ayurveda                      | Upper respiratory infections                                               |
| 6     | Anuthaila | Oil | Sesame oil | Ayurveda                      | Respiratory infections                                                    |
| 7     | Adathodai Manapagu | Aqueous | Adathodai Manapagu | Siddha                        | Fever                                                                     |
| 8     | Bryonia alba | Tablet | Bryonia | Homeopathy                    | Reduce lung inflammation                                                  |
| 9     | Rhus toxico Dendron | Tablet | Rhus tox | Homeopathy                    | Viral infections                                                          |
| 10    | Atropa belladonna | Tablet | Belladonna | Homeopathy                    | Asthma and chronic lung diseases                                          |
| 11    | Bignonia sempervirens | Tablet | Gelsemium | Homeopathy                    | Asthma                                                                    |
| 12    | Eupatorium perfoliatum | Tablet | Eupatorium perfoliatum | Homeopathy                    | Respiratory symptoms                                                      |
| 13    | Vishasura kudineer | Tablet | Poly-herbal formulation | Siddha                        | Fever                                                                     |
| 14    | Kaba sura kudineer | Tablet | Poly-herbal formulation | Siddha                        | Fever, cough, sore throat, shortness of breath                            |

encountered COVID-19, can consume Sanjeevani Vati, Chitrakadi Vati, and combination of Guduchi, Shunthi, and Haridra which prevents the progression of disease at an initial level [25]. They can also be consumed with a combination of the herbal concoction of Guduchi, Shunthi, Turmeric, Basil, Liquorice, Malabar nut, Green chiretta, Drumstick, Triphala, and Trikatu which have antiviral properties [26].
14.5 Ayurveda—Aid in the Prophylaxis of Pandemics

As mentioned in the previous section, Ayurveda plays a pivotal role in developing a strong immune system in a host and can also control the progression of infection at a primary stage. It works on the principle of Chakra Samhita which aims at bringing stability and refining the immune system. Similar to the principle and concept of clinical immunology, Ayurveda functions as both innate and acquired immunity which includes mutualistic and separate interaction of personal and environmental factors. To combat respiratory problems, local and systemic strategies have been advised for its management. Coronavirus manages its invasion into the host through droplets via eyes, mouth, and nasal cavity. The local strategy involves the prevention of virus transmission to the lungs by improving immune response through steam inhalation, repeated gargles, and consuming hot food and water. Herbal concoction of water is an old practice of consuming warm water and food to relieve pain in the throat and is used as homeopathy for many diseases. Ayurveda helps to improve digestive problems which are the major promoters of infections. The herbal concoction of water is prepared by adding spices, like ginger, khus, fennel, coriander, and cinnamon in water, and then boiling it. This is a popular remedy in most parts of India which is usually used to treat problems related to digestion, allergy, and inflammation [27]. Cleansing the oral cavity and throat using warm water and oil induces a systemic effect and creates a barrier on the mucosal lining to prevent any oxidating or microbial activity. Medicated solutions are prepared by using herbal extracts or regular iodized salt for gargling and cleaning mouth. Several herbs that are reported to have been used are turmeric, licorice, neem, and catechu bark. A reported active constituent of *Glycyrrhiza glabra*, Glycyrrhizin is more functional in inducing antagonistic behavior than other antivirals, preventing replication of SARS virus. Randomized controlled trials have reported that cleaning nasal cavity with salt water helps in eliminating any upper respiratory infection but, there is no strong ground to hold this evidence [28]. This practice has been traditionally used to relieve nasal congestion, sinusitis, and bronchoconstriction through improved nasal cleansing and entangling nasal mucus constriction. There is evidence of using medicated oils prepared from animal fat and butter to limit pathogen invasion in the host via nasal passage. Oiling nasal passage performs a similar function to what is performed through mouth rinsing and hence it is advised to be used for preventing infection via SARS-Cov2. The study of Ayurveda supports the importance of a healthy body that is achieved through non-pharmacological approaches. A healthy lifestyle which includes regular sleep patterns, a balanced diet, mental relaxation through yoga, and exercises play a pivotal role in optimum health. Studies suggest that pre-existing mental illness like anxiety and depression leads to respiratory illness. In the current scenario of COVID-19, the lockdown has immensely resulted in the rise of anxiety and depression cases, merely because they are living aloof. Yoga postures and techniques like pranayama and meditation have proved to improve lung functioning and mental well-being, respectively. A healthy diet mainly includes consuming shorba (soup) cooked or steamed vegetables which includes vegetables like radish, Trigonella leaves, and drum sticks.
Several pulses like lentils, green gram, and chickpeas are also consumed along with added spices such as ginger, garlic, cumin seeds, and mustard seeds. Along with it, colors play an important role in easing mental pressure and illness that is even supported by scientific evidence. Color therapy is widely used to cure psychological problems of people dealing with a mental breakdown which in turn influences the mood and mental well-being of an individual. The color green is a representation of nature and signifies harmony, effective decision-making, and promotes concentration. Therefore long walks, jogging, and exercising in nature boost mental well-being and helps to cure depression.

Rasayana is a specialized branch of Ayurveda that uses herbal formulations, a balanced diet, and a disciplined lifestyle with systemic functioning of the human body to bring about an equilibrium in body and soul. The human body develops immunity such that it gets unaffected by etiological changes and hence also develops an acquired mechanism to combat premature aging which is regarded as an illness. It works as immunomodulators and rejuvenators enhancing growth and promoting immunity, providing resistance against various diseases. A research study presents Withania somnifera (Ashwagandha), Tinospora cordifolia (Guduchi), Asparagus racemosus (Shatavari), Phyllanthus emblica (Amalaki), and Glycyrrhiza glabra (Yashtimadhu) as potential botanicals for COVID-19 prophylaxis. Ashwagandha is reported to exhibit an antioxidant effect through upregulating Th-1 levels in a prepared extract, proving as a broad-spectrum dose I solved in regulating the immune system [29]. Several clinical effects have been compiled on the potential mechanisms involved in antiviral, immune-boosting, vascular integrity, and management of related clinical targets of COVID-19. However, there is a need to check the clinical efficacy of these botanical targets.

14.6 Herbal Inhibitors as Antiviral Targets

Human civilization dates the application of herbal medication [30]. Herbal medication includes plant extracts and plant derivatives that are prepared from plant parts like the seed, barks, stem, roots, pulp, food, and flowers. It provides an integral alternative to treat viral diseases depending on severity, one such example is of Traditional Chinese medicine that aids in boosting the immune system through herbal medicines and acupuncture. Human beings of developing nations depend on traditional plants for their health, reports WHO. Evidence supported in research papers suggests the efficacy of herbal preparations against viral diseases. Natural and herbal medicines have low toxicity levels and this becomes a ground for bioinformatics research to look for potential targets against viral diseases like it is extensively been studied for COVID-19 by using molecular docking tools [31]. Refer Table 14.2 for potential docking results of natural products in terms of binding affinity (kcal/mol), the interaction of natural products with the COVID-19 main protease (PDB ID:
### Table 14.2 Docking results in terms of interaction of natural products with the COVID-19 main protease (PDB ID: 6LU7) [36]

| S. no | Natural products   | Molecular formula       | Molecular weight | Log P  | H-bond donor | H-bond acceptor | Violations |
|-------|--------------------|------------------------|------------------|--------|--------------|-----------------|------------|
| 1     | Glycyrrhizin       | C_{42}H_{62}O_{16}     | (<500 Da): 822.93 | (5): 1.55 | 3            | 6               | (continued) |
| 2     | Bicylogermecrene   | C_{15}H_{24}            | (<500 Da): 204.35 | (5): 4.15 | 1            | 0               | (continued) |
| 3     | Tryptanthrine      | C_{15}H_{6}N_{2}O_{2}  | (<500 Da): 248.24 | (5): 2.16 | 0            | 3               | (continued) |
| 4     | β-sitosterol       | C_{29}H_{50}O          | (<500 Da): 414.71 | (5): 7.19 | 1            | 1               | (continued) |
| 5     | Indirubin          | C_{16}H_{10}N_{2}O_{2} | (<500 Da): 260.26 | (5): 2.69 | 1            | 3               | (continued) |
| 6     | Indican            | C_{14}H_{17}O_{6}      | (<500 Da): 295.29 | (5): 0.16 | 6            | 0               | (continued) |
| 7     | Indigo             | C_{16}H_{10}N_{2}O_{2} | (<500 Da): 262.26 | (5): 2.63 | 3            | 0               | (continued) |
| 8     | Hesperetin         | C_{16}H_{14}O_{6}      | (<500 Da): 302.28 | (5): 1.91 | 6            | 0               | (continued) |
| 9     | Cryosophanic acid  | C_{15}H_{10}O_{4}      | (<500 Da): 254.24 | (5): 2.38 | 4            | 0               | (continued) |
| 10    | Rhein              | C_{15}H_{8}O_{6}       | (<500 Da): 284.22 | (5): 1.48 | 6            | 0               | (continued) |
| 11    | Berberine          | C_{20}H_{18}NO_{4}+    | (<500 Da): 336.36 | (5): 2.53 | 4            | 0               | (continued) |
| 12    | β-caryophyllene    | C_{15}H_{24}            | (<500 Da): 204.35 | (5): 4.24 | 1            | 0               | (continued) |
| 13    | Lopinavir          | C_{37}H_{48}N_{4}O_{5} | (<500 Da): 628.8 | (5): 4.37 | 5            | 1               | (continued) |
| 14    | Nelfinavir         | C_{32}H_{45}N_{3}O_{4}S| (<500 Da): 567.78 | (5): 4.33 | 5            | 1               | (continued) |
| 15    | Luteolin-7-glucoside| C_{21}H_{20}O_{11}    | (<500 Da): 448.38 | (5): 0.16 | 7            | 11              | (continued) |
| 16    | Demethoxycur cumin| C_{20}H_{18}O_{5}      | (<500 Da): 338.35 | (5): 3 | 2            | 0               | (continued) |
| 17    | Apigenin-7-glucoside| C_{21}H_{20}O_{10}   | (<500 Da): 432.34 | (5): 0.55 | 6            | 1               | (continued) |
| 18    | Oleuropein         | C_{10}H_{22}O_{8}      | (<500 Da): 378.37 | (5): 1.57 | 3            | 8               | (continued) |
| 19    | Epicatechin-Gallate| C_{22}H_{18}O_{10}    | (<500 Da): 442.37 | (5): 1.23 | 7            | 10              | (continued) |
| 20    | Catechin           | C_{15}H_{14}O_{6}      | (<500 Da): 290.27 | (5): 0.85 | 5            | 6               | (continued) |
| 21    | Curcumin           | C_{21}H_{20}O_{6}      | (<500 Da): 368.38 | (5): 3.03 | 2            | 6               | (continued) |
Table 14.2 (continued)

| S. no | Natural products | Molecular formula | Molecular weight | Log P  | H-bond donor | H-bond acceptor | Violations |
|-------|------------------|------------------|------------------|--------|--------------|-----------------|------------|
| 22    | Zingerol         | C₁₁H₁₆O₃         | (<500 Da): 196.24 | (<5): 1.86 | (5):2 | (<10): 3 | 0          |
| 23    | Gingerol         | C₁₇H₂₆O₄         | (<500 Da): 294.39 | (<5): 3.13 | (5):2 | (<10): 4 | 0          |
| 24    | Allicin          | C₆H₁₀O₂S₂        | (<500 Da): 162.27 | (<5): 1.61 | (5):0 | (<10): 1 | 0          |
| 25    | Kaempferol       | C₁₃H₁₀O₆         | (<500 Da): 286.24 | (<5): 1.58 | (5):4 | (<10): 6 | 0          |
| 26    | Quercetin        | C₁₅H₁₀O₇         | (<500 Da): 302.24 | (<5): 1.23 | (5):5 | (<10): 7 | 0          |
| 27    | Naringenin       | C₁₅H₁₂O₅         | (<500 Da): 272.25 | (<5): 1.84 | (5):3 | (<10): 5 | 0          |

6LU7) and the drug-like properties. The antiviral targets proposed for treating nCoV-2019 include glycyrrhizin, bicylogermecrene, tryptanthrine, β-sitosterol, indirubin, indican, indigo, hesperetin, crysophanic acid, rhein, berberine, and β-caryophyllene. Glycyrrhizin, a compound commonly found in liquorice [32] has been isolated for its known antiviral potency against human immunodeficiency virus Type 1 (HIV-1) and Herpes Simplex Virus Type 1 (HSV-1), Hepatitis C virus, Varicella-Zoster virus, and SARS Coronavirus [33]. Bicylogermecrene, a compound found in Lantana Camara, and Lantana species have been found exhibiting antimicrobial, antibacterial, and antifungal activities. Major compounds in Acanthaceae, Tryptanthrine, and β-sitosterol and indirubin are found in India and Bangladesh. Other potential targets include β-sitosterol, which has an inhibitory function against SARS coronavirus 3C-like protease [34, 35], and anti-HBV (hepatitis B virus) activity. It is also reported for its antibacterial, anti-inflammatory, and antitumor activities. Ethnobotanical studies have enabled to carry out a search for potential targets based on its pharmacological and phytochemical properties that can be used for drug development. The synthesis of these molecules and the evaluation of their in vitro and in vivo activity against SARS-Cov-2 main protease could be interesting, before clinical essay. Table 14.3 tabulates all plants with their antiviral mechanism.

14.7 Biodiversity Conservation: Post COVID-19 Context

With the declaration of 2020 as the “super year” for the facet of biodiversity conservation, there was not an insinuation for the occurrence of the pandemic. The biodiversity underwent proliferation to a greater extent by the screening halt practiced worldwide. With the different species and ecosystems has been on the verge of dangerous decline over (IPBES 2019), there is serious scrutiny that the previous conservation measures and, practices are largely inadequate to combat and tackle the
| S. no | Name of plant and medicinal properties | Mechanism of action |
|-------|--------------------------------------|---------------------|
| 1     | Maca (*Lepidium meyenii*)             | Antiviral mechanism against Flu-A and Flu-B viruses |
| 2     | *Eucalyptus camaldulensis Dehn*       | Antimicrobial activity, and mixture with extracts of *Annona senegalensis* and *Psidium guajava* have accentuated effects |
| 3     | *Betula papyrifera*                   | Antiviral mechanism of against coronavirus (BCV, Coronaviridae). The 80% methanolic extract fraction showed significant antimicrobial activity |
| 4     | *Zanthoxylum piperitum*               | Antiviral agent against influenza A/WS/33, A/PR/8, and B/Lee/4 viruses |
| 5     | Sunflower (*Helianthus annuus L.*)    | Flowers and seeds extracts of sunflower at various concentrations may treat different human infectious diseases |
| 6     | *Codonopsis lanceolata*               | It constitutes chlorogenic acid, luteolin, benzoic acid, and apigenin having activity against infectious diseases |
| 7     | *Verbascum pterocalycinum var. mutense Hub.-Mor* | Saponins used for the treatment of infected diseases |
| 8     | *Limonium densiflorum*                | Flavonoids and saponins having antiviral activities |
| 9     | *Robinia pseudoacacia cv. Idaho*      | Used in antiviral therapeutics |
| 10    | *Isatidis Radix*                      | Glucosinolate isomers and constituents like progoitrin, goitrin, epigoitrin, and epiprogotrin have antiviral mechanism |
| 11    | Licorice (*Glycyrrhiza uralensis* Fisch.) | Activity against H5N1 influenza through its antioxidant activities. Also used for SARS coronavirus |
| 12    | *Houttuynia cordata Thunb*            | Its antiviral activities extract such as quercetin, quercetrin, and cinanserin has antiviral activities and effects on murine coronavirus and dengue virus infection |
| 13    | *Isatis indigotica Fort*              | Isatindigotropicamides A and B exhibited antiviral activities |
| 14    | *Toona sinensis* Roem                | TSL-1 which is an extract from its tender leaf has an evident effect against SARS-CoV |
| 15    | Compounds of *A. annua*, *L. radiate*, *P. lingua*, and *L. aggregate* | Herbal extracts and the compound lycorine can be used as a treatment of SARS-CoV |
| 16    | *Fructus arctii*                      | Arctigenin inhibits viral replication. Arctigenin also exhibit hemagglutination inhibition |

(continued)
Table 14.3 (continued)

| S. no | Name of plant and medicinal properties | Mechanism of action |
|-------|---------------------------------------|---------------------|
| 17    | Sinupret, a herbal medicinal product made from Gentian root, Primula flower, Elder flower, Sorrel herb, and Verbena hers | Concentration-dependent antiviral activity (EC\(50\) between 13.8 and 124.8 \(\mu\)g/ml) is against RNA and DNA viruses independent of a viral envelope, so it is a good treatment of acute and chronic rhinosinusitis and respiratory viral infections |
| 18    | Bioaron C, an herbal medicinal product consisting of an aqueous extract of Aloe arborescense Mill, vitamin C, and Aronia melanocarpa Elliot | Its aqueous extract has been proved as a selective antiviral treatment against influenza viruses |
| 19    | Plant kingdoms like Clusiaceae, Umbelliferae and Rutaceae | They contain coumarin which has antiviral activity against a wide range of viruses, especially influenza viruses |

challenges, and hence that something efficient is required [38]. The outspread of the COVID-19 virus had a perpetual impact in course of all the facets. Efforts implied to curb the spread of the advent of novel SARS-Cov-2 virus have caused confinement of close to two-thirds of the world population in their homes. The process of quarantine as the only possible aid in time caused the great shift can it can be addressed as the Global population confinement experimentation. This experimentation has been a method to juxtaposition the advantages and disadvantages of human presence on a plethora of natural systems, inclusive of wildlife, and conservation areas, and study the underlining mechanisms of biodiversity. This is an opportunity bestowed in environmental scientists to analyze and empanel the impact. As a repercussion, the value-based conservation strategies can be formulated adjoined with the functional framework. In the context of developing countries, they are vincible in the post era of a COVID-19 pandemic, in order to ensure progress toward the sustainable development goals (SDGs) [39]. There is an incessant need for observation policies that are more efficient in the process of conserving and safeguarding the biological diversity across the world.

### 14.7.1 Consolidation of Local Agriculture Systems

The pandemic circumscribed the trade of fast-moving items like agricultural rearing and the reliance upon native food products increased. This made it evident the positive subsidies as consequences on the natural systems can be elaborated in COVID-19 recovery. This may encompass strengthening the farmers who are conserving with better provisions. This brings about the need for the Conservation Reserve Program and Agriculture Policies to be formulated to safeguard the health of the ecosystem on the lands. The positive subsidies can be accentuated in order to do so environmentally friendly farming practices—be it conservation set-asides, organic agriculture,
low-intensity systems, integrated farm management practices, and conservation of high-value habitat. There is a gargantuan pressure on these practices for overproduction as the process is eased by governmental subsidies majorly. During the course of the pandemic so far it has become evident that the local supply chains are more irrepressible and are the tool for the local food provision, which might be seen as the alternative to verticals of global trade in agricultural products [40]. There can also be another type of subsidy that can be instrumental in strengthening the status of local foodsheds through procuring public consolidation. Just as there was an incessant need of developing the healthcare system during the course of the pandemic. There is also a need to formulate the system to meet food demand by the use of biodiversity protecting agroecological methods that can apprehend the crop and goods production. These systems can accentuate the dependence upon local production and also apprehend the local production, encouraging an up-scaling of systems that are environmentally sound investments [41].

14.7.2 Expand New Taxation Policies for Environmental Harms

While considering the history of environmental policies that have imposed taxation for reduction of pollution and increase the efficiency of utilization of resources, such as gas taxes or plastic bags fees; however the taxes on direct consumption or related taxes designed to conserve biodiversity are really low. Various kinds of taxation on various services or products exerting negative impact (also the collateral effect) exerted on the ecosystems and biodiversity. The policies may include pay on pollution or pay on user principle, this can be effective in accustoming people toward a certain type of behavior (Such as bottle recycling fees, and to introspect the duty fee and taxes imposed for negative impacts are really low. Presently, considering the need that rapidly raises sources of revenue for local, state, and national government; the taxation policies related to the ecosystem should be increased and more elaborated in the framework, including charges on polluting water, air, and also the gasoline taxes. As the pollutants from these services cause severe damage to the ecosystem through acidification and eutrophication of inland waters; carbon emission. The tax policies shall also be made for waste and packaging taxes. Considering the imposition of the carbon tax in France, which was brought as the result of protests from the Yellow vests movement might be an infective example of taxation for environmental harm but the well-drafted and formulated taxes that include a way to address equity may concern so that they do not pose pressure but are wildly supported by the people. Pondering upon the examples of plans for a carbon fee/tax that is aligned with the dividend may be an aid to solve the problems. Since the maximum of the lowest and middle-income population will receive more dividends in comparison to what will be spent upon the higher taxes. Doing an antagonist to this might be a cause for prolonged environmental damage [42]. The government can also undergo demodulation of
the policies in an era of tightening belts to retain higher revenue generation. Another evident study of taxation has catered to the data that 70% of known vessels implicated in illegal fishing are flagged in a tax haven, and increasing the soya and beef in the Amazon, the prime drivers of deforestation. So modified channels should be chosen for the process of taxation.

14.7.3 Greener Investments as a Seminary for Biodiversity Support

While pondering upon the private sector, it is seen that sector seeks financial support and prop by grants to ensure the possibility of longer-term sustainability, the government should prioritize to support that business that does not pose a threat to biodiversity, and put restrictions on those which pose the same. A study regarding the context of the USA for the year of 2008–2009 it was seen that the American Recovery and Reinvestment Act provided gargantuan loans and tax credits to the company for greener vehicle development [43]. Similar plans are needed to strengthen the businesses receiving bailouts and raising funds for firms that mitigate the biodiversity risks involved. In the scenario of Canada, there were lofty provisions that bailout funds to giant firms will require aligning to the disclosure standards. The investments are made in those sectors and technologies that actually reduce the pressure on nature. Private establishments in land-scale land acquisition in the area of many tropical countries, specifically for the case of the export commodities, have landed us in a situation of massive deforestation, even outside the investment lands. The increase in the financial profit in other sectors has increased the conversion of farmlands into the specialized sections. This expansion of these domains is the major cause of the ecosystem alteration.

14.8 Recommended Environmental Approaches

Conserving Biodiversity can be a win–win strategy for maintaining an equilibrium in the ecosystem and human health. The services provided by the ecosystem are declining at a rapid rate and nearly 12% of the land surface is under protection in the form of Bioreserves, National parks, and Herbal gardens. Besides food security and regular clean water, conservation of biodiversity is important for mitigation of disasters and diseases thereby promoting mental and physical health [44]. The general view of preservation in terms of wildlife protection and maintaining tourism needs to evolve and transform emphasizing its influence on human health and its implications, where protected areas maintain the services provided by the ecosystem and promote effective immunity and boost the health of the population. It is important to squander...
the conservation strategies in practice rather than in theory and the need for conservation has to be ensured in a jiffy as it lays a caveat over human survival. It is achieving optimum human health through a radical change that protecting biodiversity represents via traditional and modern approaches like Bioremediation, herbal gardens, seedbanks, and national parks. Environmental contamination poses a great threat to the deterioration of the environment and involves the use of microbes and higher non-crop plants to remediate the threats posed by pollutants and contaminants [45, 46]. The bioremediation technique has an immense potential of eliminating health risks by upgrading knowledge and skills to augment a desirable environmental effect. Both ex-situ and in situ remediation approaches are enlisted as biological methods that eliminate contaminants from both below and above the ground. It is the most economical technology and has tremendous benefits in comparison to any existing traditional technology. Rhizobial inoculants are involved in active defense mechanism against any potential pathogenic infection caused either by bacteria or viruses. Genetic engineering has improved the utilization and eliminated toxicity of unwanted contaminants by creating genetically modified organisms involving R-DNA technology [47]. GEMs have been reported with potential capacities to bioremediate several chemical toxicities by manipulating metabolic pathways and incrementing degradation rates of several bacterial strains which are greatly influenced by various biological agents like pH, aeration, moisture, temperature, and bioavailability of the pollutant [48]. Furthermore, herbal and medicinal plants are diminishing at a rapid rate because of the loss of flora at a global level which was reported to develop during the pandemic lockdown. Both ex-situ and in situ conservation and cultivation practices aid in resource management and accounts for sustainable use through tissue culture, micropropagation, and seed technology. The aim of preserving herbs and medicinal plants is because they serve as a valuable source of drugs and around 1300 medicinal plants have found wide applications in Europe, 90% of which are harvested from wild sources [49, 50]. There has been an excessive loss of plant species at an unexpected rate and Earth is losing at least one potential drug every two years. China, India, Kenya, Nepal, Tanzania, and Uganda have experienced an increased risk of extinction of medicinal plants. Natural reserves and wild nurseries provide natural habitat to the wild species and prevent overexploitation, habitat fragmentation, and extinction [51, 52]. The botanic garden is one such form of ex-situ conservation where a wide species of plants are grown together and contains diverse flora.

Seed banks are a strategy of preserving genetic diversity through seeds and is often referred to as “Gene Bank.” This strategy became popular due to the need to increase the yield through crops, developing plant resistant varieties to diseases and droughts. The Millenium Seed Bank Project at the Royal Gardens in Britain is the most popular and allows rapid access to plant samples [53]. Extensive protected areas were created to preserve the natural habitat of rare and endangered species of flora and fauna for present and future generations. These areas prohibit further exploitation of natural resources which are environmentally feasible and compatible. National parks account for a maximum protected area, roughly 23% of total protection. They not only help to mitigate climate impact but the greenery also contributes to better air quality and water. There is evidence that suggests how parks are linked to health, for example;
Long walks and jogs in nature for 120 min a week impact effective health and mental well-being and influence lower cortisol level and blood pressure to relieving stress and anxiety. Nature also promotes many benefits beyond mental health like a swift and vigorous response. Providing natural habitat to species under risk reduces caveat of human survival and bridges disparities between human health and conservation. There are around 103 national parks in India and the largest national park of India is Hemis National Park, Jammu and Kashmir; the smallest national park in South Button Island National Park, Andaman, and the Nicobar Islands; largest wildlife sanctuary is Rann of Kutch, Gujarat, and smallest wildlife sanctuary is Bor Tiger Reserve, Maharashtra. Nature also promotes many benefits beyond mental health like a swift and vigorous response. Providing natural habitat to species under risk reduces caveat of human survival and bridges disparities between human health and conservation. Therefore, there is a need for healthy environment which can be possible with the aid of bioremediation, germplasm conservation through various cryopreservation techniques and other biotechnological approaches.

14.9 Conclusion

Scientists have been trying hard to discover the root cause of coronavirus infection for several years. The outbreak of the COVID-19 pandemic has influenced the urge further leading to extensive research involved in isolating prophylactic measures. Soon after the embarkation of the pandemic, a diligent step back is taken by quarantine measures, leading to an increase in the correlation of humans with the environment. The scientific investigations have been conducted to manifest the instrumental role of humans in safeguarding from diseases. The process of quarantine has also avant-guarded the subject of quantification of the impact of pandemic-be it considerable drop in air pollution, water pollution, wildlife, or increase in the usage of plastic. While this pandemic remains a primary concern for public health, efforts have been put to combat this global issue through countrywide shutdown and self-quarantine steps which reduces the risk of its transmission. The use of traditional knowledge through Ayurveda. Unani and Siddha have also helped in the timely recovery of several patients by using home remedies. Also, the successful docking results of listed medicinal plants and herbs enable a breakthrough of various drugs and vaccines for the treatment of respiratory conditions and in specific COVID-19. Traditional Chinese medicine also summarizes the prevailing mechanistic herbs that have been used anciently to treat various diseases and the influence of nature in promoting optimum health and vitality to an individual. This indicates how Biodiversity greatly influences an individual’s mental and physical health. Also pandemic has been a major setback for economic provisions across the globe, in the era of post-recovery, there is fair anticipation to restore the economic setup by the exploitation of biodiversity. This is birthing the need for the consolidation of environmental policies and other conventional conservative measures for safeguarding the environment and biodiversity. The chapter encompasses COVID-19 and various facets of environment
involved which is a state-of-art subject for sustainable environment. Biodiversity is a renewable form of resource in many aspects but the equation of demand or these resources with regeneration is unbalanced. There have been enormous measures to equate it but the pandemic has proven to be instrumental tool one way but on the other way it has brought other crisis to the surface. The use of single use plastic as PPE material has created a need for proper disposal methods and economic recovery at cost of biodiversity loss is a future predicted challenge. It highlights the major changes in the environmental conditions and predicts the future challenges of future exploitation of biodiversity. It gives a significant review for the environmentalist to conglomerate the total impact of pandemic on environment; heath care as synergy to the human health; augmentation of various medicinal systems in healthcare; future preservation needs for biodiversity; changes in the legal framework for environmental policies; environmental taxation for commercial use; and strengthening of existing conservation measures to combat future environment curbing challenges.

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References

1. Ting D, Carin L, Dzau V, Wong T (2020) Digital technology and COVID-19. Nat Med 26:459–461
2. Paital B, Das K, Parida S (2020) Inter nation social lockdown versus medical care against COVID-19, a mild environmental insight with special reference to India. Sci Total Environ 728:138914
3. James P, Banay R, Hart J, Laden F (2015) A review of the health benefits of greenness. Curr Epidemiol Rep 2:131–142
4. Annerstedt van den Bosch M, Mudu P, Uscila V, Barrdahl M, Kulinkina A, Staatsen B, Swart W, Kruize H, Zurlyte I, Egorov A (2015) Development of an urban green space indicator and the public health rationale. Scand J Public Health 44:159–167
5. Demoury C, Thierry B, Richard H, Sigler B, Kestens Y, Parent M (2017) Residential greenness and risk of prostate cancer: a case-control study in Montreal, Canada. Environ Int 98:129–136
6. Louv R (2008) Last child in the woods. Algonquin Books of Chapel Hill, Chapel Hill, NC
7. Hirabayashi S, Nowak D (2016) Comprehensive national database of tree effects on air quality and human health in the United States. Environ Pollut 215:48–57
8. Cardinale B, Wright J, Cadotte M, Carroll I, Hector A, Srivastava D, Loreau M, Weis J (2007) Impacts of plant diversity on biomass production increase through time because of species complementarity. Proc Natl Acad Sci 104:18123–18128
9. Ulrich RS (1983) Aesthetic and affective response to natural environment. In: Behavior and the natural environment, pp 85–125
10. Rook G (2013) Regulation of the immune system by biodiversity from the natural environment: an ecosystem service essential to health. Proc Natl Acad Sci 110:18360–18367
11. Lalit G, Emeka C, Nasser N, Chinmay C, Garg G (2020) Anonymity preserving IoT-based COVID-19 and other infectious disease contact tracing model. IEEE Access. https://doi.org/10.1109/ACCESS.2020.3020513
12. Jatzlauk G, Bartel S, Heine H, Schloter M, Krauss-ETSchmann S (2017) Influences of environmental bacteria and their metabolites on allergies, asthma, and host microbiota. Allergy 72:1859–1867
13. Ostfeld R, Keesing F (2017) Is biodiversity bad for your health? Ecosphere 8:e01676
14. He L, Zhang S, Hu J, Li Z, Zheng X, Cao Y, Xu G, Yan M, Wu Y (2020) On-road emission measurements of reactive nitrogen compounds from heavy-duty diesel trucks in China. Environ Pollut 262:114280
15. Airborne nitrogen dioxide plummets over China. https://earthobservatory.nasa.gov/images/146362/airborne-nitrogen-dioxide-plummets-overchina?utm=carousel
16. Ogen Y (2020) Assessing nitrogen dioxide (NO2) levels as a contributing factor to coronavirus (COVID-19) fatality. Sci Total Environ 726:138605
17. Finch D, Schofield H, Mathews F (2020) Traffic noise playback reduces the activity and feeding behaviour of free-living bats. Environ Pollut 263:114405
18. Chen H, Koprowski J (2015) Animal occurrence and space use change in the landscape of anthropogenic noise. Biol Cons 192:315–322
19. Fok L, Cheung P (2015) Hong Kong at the Pearl River Estuary: a hotspot of microplastic pollution. Mar Pollut Bull 99:112–118
20. Mandal I, Pal S (2020) COVID-19 pandemic persuaded lockdown effects on environment over stone quarrying and crushing areas. Sci Total Environ 732:139281
21. Ergülu H (2020) Effects of Covid-19 outbreak on environment and renewable energy sector. Environ Develop Sustain
22. AYUSH Ministry of Health Corona Advisory—D.O. No. S. 16030/18/2019—NAM; dated: 06th March, 2020
23. Prata J, Silva A, Walker T, Duarte A, Rocha-Santos T (2020) COVID-19 pandemic repercussions on the use and management of plastics. Environ Sci Technol 54:7760–7765
24. Rastogi S, Pandey D, Singh R (2020) COVID-19 pandemic: a pragmatic plan for ayurveda intervention. J Ayur Integra Med
25. Shankar A, Dubey A, Saini D, Prasad C (2020) Role of complementary and alternative medicine in prevention and treatment of COVID-19: an overhyped hope. Chin J Integra Med 26:565–567
26. Bhatwalkar S, Shukla P, Srivastava R, Mondal R, Anupam R (2019) Validation of environmental disinfection efficiency of traditional Ayurvedic fumigation practices. J Ayur Integra Med 10:203–206
27. Rege A, Chowdhary A, Evaluation of Ocimum sanctum and Tinospora cordifolia as probable HIV-protease inhibitors. https://www.semanticscholar.org/paper/Evaluation-of-Ocimum-sanctum-and-Tinospora-as-Rege-Chowdhary/aabd18c8c2108819595a9cb3a7650f57b618b92e?p2df
28. Balasubramaneni S, Venkatasubramanian P, Kukkupuni S, Patwardhan B (2011) Plant-based Rasayana drugs from Ayurveda. Chin J Integra Med 17:88–94
29. Agarwal A, Gupta D, Yadav G, Goyal P, Singh P, Singh U (2009) An evaluation of the efficacy of licorice gargle for attenuating postoperative sore throat: a prospective, randomized, single-blind study. Anesthesia Analgesia 109:77–81
30. Cinatl J, Morgenstern B, Bauer G, Chandra P, Rabenau H, Doerr H (2003) Glycyrrhizin, an active component of liquorice roots, and replication of SARS-associated coronavirus. Lancet 361:2045–2046
31. Muktidhansana S (2002) Hatha yoga pradipika: light on hatha yoga. Bihar School of Yoga, India, pp 202–205
32. Singh N, Bhalla M, De Jager P, Gilca M (2011) An overview on Ashwangandha: a Rasayana (Rejuvenator) of Ayurveda. Afi J Trad Complemen Alter Med 8
33. Diwanay S, Chitre D, Patwardhan B (2004) Immunoprotection by botanical drugs in cancer chemotherapy. J Ethnopharmacol 90:49–55
34. Lin L, Hsu W, Lin C (2014) Antiviral natural products and herbal medicines. J Trad Complement Med 4:24–35
35. Ye C, Park JG, Oladunni F, Platt RN, Anderson T, Almazan F, Martinez-Sobrido L (2020) Rescue of SARS-CoV-2 from a single bacterial artificial chromosome. bioRxiv
36. Qiao X, Song W, Ji S, Wang Q, Guo D, Ye M (2015) Separation and characterization of phenolic compounds and triterpenoid saponins in licorice (Glycyrrhiza uralensis) using mobile phase-dependent reversed-phase × reversed-phase comprehensive two-dimensional liquid chromatography coupled with mass spectrometry. J Chromatogr A 1402:36–45

37. Fiore C, Eisenhut M, Krausse R, Ragazzi E, Pellati D, Armanini D, Bielenberg J (2008) Antiviral effects of Glycyrrhiza species. Phyto Res 22:141–148

38. Venkateshbabu N, Anand S, Abarajithan M, Sheriff S, Jacob P, Sonia N (2016) Natural therapeutic options in endodontics—a review. Open Dent J 10:214–226

39. Costa J, Sousa E, Rodrigues F, Lima S, Braz-Filho R (2009) Composição química e avaliação das atividades antibacteriana e de toxicidade dos óleos essenciais de Lantana camara L. e Lantana sp. Revista Brasileira de Farmacognosia 19:710–714

40. Parvez M, Tabish Rehman M, Alam P, Al-Dosari M, Alqasoumi S, Alajmi M (2019) Plant-derived antiviral drugs as novel hepatitis B virus inhibitors: cell culture and molecular docking study. Saudi Pharma J 27:389–400

41. Lee C, Wang C, Hu H, Yen H, Song Y, Yu S, Chen C, Li W, Wu Y (2019) Indole alkaloids indigolodes A-C from aerial parts of Strobilanthes cusia in the traditional Chinese medicine Qing Dai have anti-IL-17 properties. Phytochemistry 162:39–46

42. Shahrajabian M, Sun W, Shen H, Cheng Q (2020) Chinese herbal medicine for SARS and SARS-CoV-2 treatment and prevention, encouraging using herbal medicine for COVID-19 outbreak. Acta Agriculturae Scandinavica, Section B—Soil Plant Sci 70:437–443

43. Corlett R, Primack R, Devictor V, Maas B, Goswami V, Bates A, Koh L, Regan T, Loyola R, Pakeman R, Cumming G, Pidgeon A, Johns D, Roth R (2020) Impacts of the coronavirus pandemic on biodiversity conservation. Biol Cons 246:108571

44. Fletcher R, Buscher B, Massarella K, Koot S (2020) ‘Close the tap!’: COVID-19 and the need for convivial conservation. J Aust Politi Econ

45. The Global Risks Report 2020. https://reports.weforum.org/global-risks-report-2020/

46. Hepburn C, O’Callaghan B, Stern N, Stiglitz J, Zenghelis D (2020) Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? Oxford Rev Econ Policy

47. Eskew E, Carlson C (2020) Overselling wildlife trade bans will not bolster conservation or pandemic preparedness. Lancet Planet Health 4:e215–e216

48. Sumaila U, Skerritt D, Schuhbauer A, Ebrahim N, Li Y, Kim H, Mallory T, Lam V, Pauly D (2019) A global dataset on subsidies to the fisheries sector. Data Brief 27:104706

49. Jakovljevic M, Jakab M, Gerdtham U, McDaid D, Ogura S, Varavikova E, Merrick J, Adany R, Okunade A, Getzen T (2019) Comparative financing analysis and political economy of noncommunicable diseases. J Med Econ 22:722–727

50. Sodhi N, Koh L, Brook B, Ng P (2004) Southeast Asian biodiversity: an impending disaster. Trends Ecol Evol 19:654–660

51. Urgun-Demirtas M, Stark B, Pagilla K (2006) Use of Genetically Engineered Microorganisms (GEMs) for the bioremediation of contaminants. Crit Rev Biotechnol 26:145–164

52. Hamilton A (2004) Medicinal plants, conservation and livelihoods. Biodivers Conserv 13:1477–1517

53. León-Lobos P, Way M, Rosas M, Sandoval A, Pritchard H (2010) The contribution of the Millennium Seed Bank Project to ex situ plant conservation in Chile. Kew Bull 65:595–601