Feature Article

Origin and Transmission of Covid-19 as a Negative Outcome of Anthropogenic Ecocide

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Abstract

COVID-19 has become a global health burden that costs millions of human lives and causes collapsing health systems due to overcrowded hospitals, emergency services, intensive care units and exhausted staffs during last two years. There are plenty of scientific studies published on the origin, transmission, spread and emergence of pathogenic agent of COVID-19 as well as the prevention, diagnosis, management, prognosis of the clinical conditions of the infection. The relationship between ecosystem degradation and biodiversity loss associated with anthropocentric development model that facilitates the viable hosting atmosphere for vector-borne and zoonotic diseases is being revisited and reviewed in a wider aspect with respect to this pandemic. Therefore COVID-19 pandemic build up a vital platform for profound international responses with social, political, economic, and environmental implications that address social and economic development, climate change, and biodiversity issues together with public health. Under the One Health concept many international organizations work closely together with conservation experts and health professionals in research, capacity building and networking to reduce the likelihood of future pandemics. In this context scientists call for an integrated global action and rapid political response in ecosystem management with a multi-disciplinary approach for the future interventions by emphasizing the importance of environmental sustainability for controlling such outbreaks.

Keywords: COVID-19, zoonotic dieseses, emerging infectious disease (EID), biodiversity loss, ecosystem balance

1. Introduction

The World Health Organization (WHO) officially declared the outbreak of Corona virus disease 2019 (COVID-19), a Public Health Emergency of International Concern in January 2020 and a pandemic on 11 March 2020, followed by lockdowns and quarantine measures around the world (WHO, 2020). The causative organism of Covid-19, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified in Wuhan, Hubei Province, China, in December 2019 with a high rate of human to human tranmission spread worldwide and leading to an ongoing global health crisis (Chakraborty and Maity, 2020; Salian et al., 2021). According to Khan et al., (2020) the cost and disruption of human lives caused by rising number of critical cases reported with more deaths where due to the pandemic are undeniable and numbers are still rising with an unpredictable and uncontrollable rate producing severe environmental and economic impacts (Chakraborty and Maity, 2020). With reference to many hypotheses related to origin of Covid-19 pandemic WHO denied the lab-leak theory claimed by some skeptics and eventually confirmed the origin on the animal market (Maxmen, 2021).

As scientifically concluded that the Covid-19 is a zoonotic disease and currently becoming a significant threat to human health and many similarities have been identified between other SARS variants and therefore Covid-19 virus has been named as SARS-CoV-2 (Khan et al., 2020; Chakraborty and Maity, 2020; Dhama et al., 2020; Salian et al., 2021). Recent zoonotic disease outbreaks include Severe Acute Respiratory Syndrome or SARS (2002-2003), Avian Influenza or bird flu (2004), H1N1 or Swine Flu (2009), Middle East Respiratory Syndrome or MERS (2012), Ebola (2013–2015), Zika virus (2015–2016) and the West Nile virus (2019) (Chin et al., 2020; Schwartz, 2021). Cutler et al., (2010) estimate that 60% of emerging human pathogens are zoonotic of which >71% have wildlife origins and can switch hosts by acquiring new genetic combinations associated with the changes in behavior or socioeconomic, environmental, or ecologic characteristics of the hosts. Ostfeld (2009) alarms emerging zoonotic pathogen transmissions are triggered by current unprecedented habitat declines which should be prevented by preserving the intact ecosystems and their endemic biodiversity as generally reduce probability of future zoonotic emergence (Keesing et al., 2010; Smith and Guégan, 2010; Karesh et al., 2012; Nazir et al., 2021; Petrovan et al., 2021).

In 1992 the WHO Commission on Health and Environment published the report titled "Our planet, our health" which made a clear warning on the newly emerging infectious diseases as negative outcomes of degraded environment which is again highlighted in the report of the WHO/FAO/OIE joint consultation on emerging zoonotic diseases in 2004 (WHO, 2004). Another report "Ecosystems and human well-being: health synthesis" in 2005 alarmed on an upturn in the rate of emergence or re-emergence of infectious diseases caused by ecological malfunctions due to intensified human encroachments, reductions in biodiversity, particular livestock and poultry production methods and increased long-distance trade in wild animal species (WHO, 2005). The importance of a well-managed environment as clear as in human health is addressed in the report "Our Planet, Our Health, Our Future; Human health and the Rio Conventions: biological diversity, climate change and desertification" published by WHO in 2012, with a reference to emerging zoonotic diseases.

WHO and Secretariat of the Convention on Biological Diversity with UN Environment Programme (UNEP) published "Connecting Global Priorities: Biodiversity and Human Health" in 2015 with an in-depth review on biodiversity conservation and insights on the emergence of infectious diseases associated with wildlife borne pathogens. The UNEP's report titled "Preventing the Next Pandemic: Zoonotic diseases and how to break the chain of transmission" in 2016 and confirmed that 75 per cent of more frequently occurring outbreaks of new infectious diseases with a global concern are zoonotic and 80 per cent of pathogens infecting animals are "multi-host". The UNEP identified the issue of zoonotic diseases as a key emerging issue of global concern and amplification increases with the intensification of human activities surrounding and encroaching into natural habitats, enabling pathogens in wildlife reservoirs to spill over to livestock and humans. The report emphasizes the critical relationship between a healthy environment and healthy people, and how human activities often undermine the long-term health and ability of ecosystems to support human well-being.

Scientific American on the 07th March, 2020 published an opinion and analysis article titled "An Urgent Call for a New Relationship with Nature" to mark the World Wildlife Day (March 3, 2021) on the theme of "Forests and Livelihoods: Sustaining People and the Planet". In May 2020, the World Health Assembly in resolution WHA73.1 requested the Director-General of the World Health Organization (WHO) to continue to work closely with the World Organisation for Animal Health (OIE), the Food and Agriculture Organization (FAO) and countries, as a part of the One Health approach, to identify the zoonotic sources of the viruses and the route of introduction to the human population, mode of transmission and the possible role of intermediate hosts. In December 2020, the European Parliament issued a new report on the link between biodiversity loss and the increasing spread of zoonotic diseases and highlighted the importance of introducing policy options to reduce risks originating from wildlife trade. Also a public hearing on the "facing the sixth mass extinction and increasing risk of pandemics: what role for the EU Biodiversity Strategy for 2030" was held on the 14th January 2021.

According to the IPBES (2020) report currently an estimated 1.7 million undiscovered viruses to exist in mammal and avian hosts of which 540,000-850,000 could be transferred to humans and infect humans. Emerging vector-borne pathogen transmission following habitat conversions and landscape modifications driven by anthropogenic trade and travel enhanced enzootic cycles facilitated with ecological factors that support to mutate vector characteristics for evolutionary selective pressure to use of humans as transmission hosts (Kilpatrick and Randolph. 2012; Guo et al., 2019; Gibb et al., 2020). According to Karesh et al., (2004) causal factors influencing the dynamics associated with emergence or reemergence of zoonoses are very important connected with wildlife trade in the industrialized world. Many vector-borne diseases are arisen concurrently with the advent of agriculture and animal husbandry that create space for host populations and allow the maintenance of virulent pathogens by degrading natural buffers between humans and animals (Jessica, 2006; Ostfeld, 2009; Smith and Guégan, 2010; Hassell et al., 2017; Athni et al., 2021).

Dunk et al., (2019) describe the historical perspective of the impact of well-functioning natural ecosystems as an important factor for the human health when they have higher diversity of species and healthy space for symbiotic survival that do not host dangerous pathogens. From the beginning of this century the humans are increasingly being exposed to transmission of zoonotic diseases as the global wildlife trade and habitat destruction caused by human activities (Jowell and Barry, 2020). There are plenty of studies that suggest outbreaks of animal-borne illness become more frequent due to wildlife species threatened by exploitation or habitat loss caused by accelerated destruction of nature (Taylor et al., 2001; Weiss and McMichael, 2004; Karesh et al., 2004; Woolhouse and Gowtage-Sequeria, 2005; Keesing et al., 2006; Jones, et al., 2008; Ostfeld, 2009; Keesing et al., 2010; Smith and Guégan, 2010; Rhyan and Spraker, 2010; Morse et al., 2012; Salkeld et al., 2013; Murray and Daszak, 2013; Gottdenker et al., 2014; Pfäffle et al., 2015; Rubio et al., 2016; Ostfeld, 2017; Johnson et al., 2017; Alexander et al., 2017; Wilkinson et al., 2018; Schmeller et al., 2020; Kenyon, 2020; Gibb et al., 2020; Austin, 2021; Mishra et al., 2021).

2. Emerging Infectious Diseases and Zoonosis

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), a group of scientists from academia, governments, and nonprofits, hosted the science underlying through expert opinions to produce an assessment on connection between biodiversity loss and Emerging infectious diseases (EIDs) (Tollefson, 2020). In current global public health EIDs are a significant burden and having a negative impact on global economies. Therefore researchers are working together with a redoubled effort to understand nexus between habitat loss and EIDs to predict and prevent future outbreaks (Jowell and Barry, 2020; Khetan, 2020; Nature, 2020; Córdoba-Aguilar et al., 2021). According to Morand (2020) within last decade there is an increasing emergence of infectious disease outbreaks associated with biodiversity loss and livestock expansion due to growth of human population, transitions in diet, agricultural industrialization and the integration into the world trade (Schmeller, 2020; Keesing, 2021).

Keesing (2021) shows that zoonosis originated due to anthropogenic modification of nature represent a significant threat to global public health as well as economic growth and combatting EIDs has become a priority of health systems with a deliberate attention (Morse et al., 2012; Allen et al., 2017; Ellwanger et al., 2019; Gibb et al., 2020; Schmeller, 2020; Harrison et al., 2021). Athni et al., (2021) illustrate the socio-ecological mechanisms influence on vector-borne diseases throughout the history and the increasing number of EIDs all over the world is caused by pathogens originated in wildlife and transmitted through wild hosts and vectors or infected domestic animals (Rhyan and Spraker, 2010; Gottdenker et al., 2014; Pfäffle et al., 2015; Cunningham et al., 2017;). Actual transmission of the pathogen to humans from a zoonotic host is the first pattern of transmission while direct vector-mediated human transmission is the second as the usual source of human infection followed by human-to-human transmission that may persist for long period (Bengis et al., 2004; Keesing et al., 2010).

According to Mackenzie and Jeggo (2013) especially mammals and birds are reservoir hosts of enormous number of zoonotic viruses that are silent or asymptomatic in their natural hosts and cross-species transmission might lead to human infection (Woolhouse and Gowtage-Sequeria, 2005; White and Razgour, 2020). Keesing and Ostfeld (2021) suggest that increasing of possibility of spillover according to the hosts that determine patterns of pathogenic transmission and the process of transmission between susceptible species in human-dominated landscapes (Daniels et al., 2007; Ostfeld, 2009; Hassell et al., 2017). Alexander et al., (2017) highlight the eco-epidemiological aspect of spillover interface that depends on the diversity of pathogen life cycles and modes of transmission with broader geographic spread. Viruses transmitted at high-risk animal-human interfaces during practices that facilitate mixing of diverse animal species significantly amplify the spillover and viruses with greater host plasticity in animal reservoirs demonstrate more human-to-human transmissibility and therefore high pandemic potential (Kreuder et al., 2015; Plowright et al., 2017; Ellwanger et al., 2019; Jowell and Barry, 2020; Modonesi, 2020).

At the beginning of this millennia Taylor et al., (2001) identify through literature 1415 species of infectious organism known to be pathogenic to humans, out of which 868 (61%) are zoonotic, and 175 species are considered to be associated with 'emerging' disease conditions. According to Jowell and Barry (2020) in the current reviews on causative factors of EIDs suggest that they are produced by human-induced environmental change that causes direct and indirect loss of biodiversity largely responsible for public health emergencies (Daszak et al., 2001; Weiss and McMichael, 2004; Ostfeld, 2009; Salkeld et al., 2013; Alexander et al., 2017; Ostfeld, 2017; Ellwanger et al., 2019; Khetan, 2020; Keesing and Ostfeld, 2021). Therefore recognition of the eco-epidemiologic circumstances involved in public health emergencies caused by zoonotic spillover and the transmission, amplification and spread of such diseases is a crucial step for surveillance and predicting future emergence risk (Kreuder et al., 2015; Plowright et al., 2017; Ellwanger et al., 2019; Jowell and Barry, 2020).

Schwartz (2021) global emergence of novel viral infectious disease outbreaks are associated with higher forest fragmentation, concentrations of livestock, trending wet markets throughout many countries. Recent findings indicate that human-livestock-wildlife interactions in China may form hotspots with the potential to increase SARS-related coronavirus transmission from animals to humans. (Rulli et al., 2021). Nazir et al., (2021) show the impact of environmental factors such as air pollution for spreading the virus and potential role of pollutants in the mode of transmission (Al Huraimel et al., 2020; Mohan et al., 2020). The bidirectional approach suggests that thermal properties of air may affect the transmissibility and viability of the SARS-CoV-2 especially during lockdown interventions and environmental conditions are beneficial in transmitting the virus beyond geographical borders (Coccia, 2020; Rahimi et al., 2020).

Morand and Lajaunie (2021) explore that the rise of oil palm plantations at global scale play a key role in deforestation is a major cause of biodiversity loss may promote outbreaks of vector-borne and zoonotic diseases (VBZD) with a negative impact on human health (Tollefson, 2020). According to experts the EIDs are more likely to be driven by ecological factors on which no extensive study is conducted and therefore an explicit analysis is needed for describing linkages between global temporal and spatial patterns of EIDs or 'EID hotspots' (Jones, et al., 2008). Recording ecological outcomes responsible for the majority of outbreaks caused by zoonotic pathogens, their vector hosts and mode of transmission is very important activity in surveillance of global EID context (Smith and Guégan, 2010; Morse et al., 2012; Smith, et al., 2014; Pfäffle et al., 2015; Athni et al., 2021; Keesing and Ostfeld, 2021).

According to Schmeller et al., (2020) wild animals host a vast reservoir of pathogens that can cause EID outbreaks due to negative outcomes of natural habitats disturbed by anthropogenic interferences which have an impact on both the pathogens and the mode of transmission to humans (Allen et al., 2017; Wilkinson et al., 2018; White and Razgour, 2020; Córdoba-Aguilar et al., 2021). Existing data suggest that zoonotic spillover is linked to human-induced changes in ecosystems leading to habitat destruction and land conversion that increase the interspecies contacts and host (Faust et al., 2018; Redding, et al., 2019; Jowell and Barry, 2020; Khetan, 2020; Schwartz, 2021). Human-induced landscape modifications influence the natural habitats and increase the land-use pressures that leads to the EID prevalence (Brearley et al., 2013; Murray and Daszak, 2013; Gottdenker et al., 2014; Rubio et al., 2016; Harrison et al., 2021; Smith, 2021).

3. Anthropocene and Covid-19

The new era began with an irreparable damage produced by human activities on the nature ic referred as Anthropocene where the symbiotic relationship between humans and environment is totally ruined and caused great biodiversity loss (Lewis and Maslin, 2015). The global biodiversity crisis due to degradation of ecosystems is emerged due to the loss of historical synergism between human populations and nature (Johnson et al., 2017). O'Callaghan-Gordo and Antó (2020) claim Covid-19 as a side-effect of Anthropocene and the best example of spillover event that eventually transformed into a pandemic. Aronsson and Holm (2020) suggest that adopting a multispecies perspective on novel pathogens cause EIDs that are associated with anthropogenic environmental changes at global scale. The great acceleration of human involvements in natural habitats and ecosystems was the major pathway of EID outbreaks in anthropocene (Chin et al., 2020).

There is a global need to establish strategies focused on the reduction of the frequency of zoonotic spillover as a fundamental cause EIDs and minimize facilitating factors of the transmission of pathogens (Ellwanger and Chies, 2021). Carlson et al., (2021) call for multilateral and multidisciplinary cooperation at international level to achieve pandemic preparedness in the Anthropocene policy updates for paving the way for stronger and sustainable global health governance, health systems, and scientific research. There is an urgent need to build an internationally agreed framework to ensure the preservation of natural habitats and the ecosystem services based on the positive link between global deforestation and outbreaks of VBZD that contribute to epidemics of infectious diseases (Morand and Lajaunie, 2021).

Barbier (2021) anthropogenic influence on ecosystems triggers EIDs such as COVID-19 resulted due to zoonotic disease spillover and the best example of a potential outbreak directly related inter-species pathogen spillover (Chin et al., 2020; Gibb et al., 2020; Kenyon, 2020; White and Razgour, 2020; Austin, 2021; Delahay et al., 2021). Borremans et al., (2019) suggest that ecosystem boundary areas are spatial hotspots where complex interactions between multiple species and higher rates of zoonotic disease spillover occur. Since the spillovers are caused by habitat destructions land conversions increase the pressure on ecosystems and affect directly on public health burdens through zoonotic pathogen transmissions, potential sustainable ecological mechanisms must be explored (da Silva et al., 2021).

Wu (2021) highlights ecosystem conversion, meat consumption, urbanization, and connectivity among cities and countries as the four basic environmental drivers of pandemics intensified in recent decades. This helps to explain the dynamics of the COVID-19 pandemic and other recent EIDs that emerged from illegal wildlife trade and bush-meat market in line with deforestation (Brancalion et al., 2020; Kenyon, 2020; Tollefson, 2020; Austin, 2021). The recent outbreaks of EIDs were evidently linked with virus evolved from wildlife reservoirs linked to environmental disruption and their spread was triggered by economic globalization (McNeely, 2021). Barouki et al., (2020) argue that the emergence and spread of SARS-CoV-2 appears to have a connection to urbanization, habitat destruction, live animal trade, intensive livestock farming and global travel. According to Banerjee et al., (2021) the COVID-19 is originated naturally, probably from bats with several theories about the 'patient zero' that revealed the connection between intensive food systems and zoonotic diseases. Few of the studies have confirmed zoonotic links in the origin of SARS-CoV-2 and spillover events, transmission to humans and rapid spread of virus (Dhama et al., 2020; Banerjee et al., 2021; da Silva et al., 2021; Salian et al., 2021).

Emergence of outbreaks of VBZDs is becoming global public health concern with increasing frequency and consequences and having potentially long-lasting effects on human health with inevitable negative impacts on ecosystems. In this context it is evidently shown that the human-driven biological degradation as the main underlying reason that increases the anthropogenic impact on nature that exacerbates pandemic threats like COVID-19 crisis (Gibb et al., 2020; Kenyon, 2020; Schmeller et al., 2020; White and Razgour, 2020; Austin, 2021). Human activities driving biodiversity degradation cycle are tightly linked with the socio-ecological factors based on contemporary livelihood and market patterns that contribute to reductions in the natural regulating capacities of ecosystem services to limit pathogen transfer (Everard et al., 2020; Smith, 2021).

Gibb et al., (2020) argues that the negative impact of human dominated ecosystems influenced with increasing population and anthropogenic activities as habitat fragmentation, deforestation, biodiversity loss, intensive agriculture and livestock farming, uncontrolled urbanization, pollution, climate change and bush-meat hunting and trading on the environment causes the emergence of pandemics (Hassell et al., 2017; Wilkinson et al., 2018; Morand 2020; Tollefson, 2020; White and Razgour, 2020). Zoonotic pathogens are leading to sustained human-to-human or vector-borne are currently becoming the greatest threats to human health as a result of anthropocentric ecosystems degradation, climate change, pollution and biodiversity loss (Pfäffle et al., 2015; Cunningham et al., 2017; Ostfeld, 2017; Wilkinson et al., 2018; Gibb et al., 2020; Jowell and Barry, 2020; Rahman et al., 2020; Keesing and Ostfeld, 2021; Nazir et al., 2021; Smith, 2021).

4. Eco-epidemiological Model and One Health initiative

McMahon et al., (2018) highlight importance of understanding the nexus between the VBZDs and environmental factors influencing the pathogen spillover and transmission within different ecological and cultural contexts for planning for One Health to assess and manage to the emergence and impact of zoonosis in the Anthropocene. In such strategy Force of infection (FOI) is a measure of the ease with which a pathogen reaches the human population and the disease ecology alters it within ecosystem categories such as domestic, peridomestic and sylvatic. Jones et al., (2017) demonstrate the complexity and connectedness of epidemiological and eco-social processes with emergence, transmission and spread of VBZDs that must be addressed by an increasing mode of research efforts with a multidisciplinary approach within the One Health context (Cunningham et al., 2017; Zinsstag et al., 2020; Cooke et al., 2021). All the mechanisms linked with pathogen characteristics and pathogen population and molecular evolutionary dynamics in different host species, and host response to infection are strongly influenced by eco-social processes, such as globalization and urbanization (Athni et al., 2021; Petrovan et al., 2021).

Ecosystem-based studies have suggested the link between the climate change and the incidence of VBZDs is well understood from the beginning of this millennium and mechanisms that facilitate the pathogen transmission are aggravated by anthropogenic influences (Weiss and McMichael, 2004; Mills et al., 2010; Jowell and Barry, 2020; Athni et al., 2021). Landscape epidemiology attributes related to landscape attributes, spatial patterns and habitat connectivity drive the pathways of pathogen transmission and influence spatial variations in VBZD risk or incidence. Instead of the static view of the pathogenecity of landscapes more dynamic view emphasizing the spatial and temporal interactions between these agents at multiple scales are suggested as appropriate and susceptible for understanding of interactions between changes in ecosystems and human health (Lambin et al., 2010; Murray and Daszak, 2013; Gottdenker et al., 2014; Rubio et al., 2016; Hassell et al., 2017; Guo et al., 2019; Nazir et al., 2021; Petrovan et al., 2021).

Roche et al., (2012) emphasize the timely need of a theoretical framework that takes into account realistic community assemblages that can be used to study the interaction between wildlife diversity and directly transmitted pathogen dynamics within a multi-host species epidemiological model. In this aspect integration of community perspective to study zoonotic prevalence and circulation of pathogens for understanding ecological interactions among host species and predicting inter-species transmission rates and emergence events of VBZDs are very important. Kock (2013) highlight the global socio-ecological changes driven by sophisticated technology and global political economy that influence natural resource consumption rates in an unsustainable manner with negative impacts on the biosphere as the cause of imbalance balance between hosts and pathogens (Woolhouse and Gowtage-Sequeria, 2005; Gottdenker et al., 2014). For shifting this paradigm global political, social and economic systems need to be reassessed and epidemiology of VBZD must be readdressed in terms of demographics, agroecology, biodiversity with a precautionary approach to establish the health of natural ecosystems (Córdoba-Aguilar et al., 2021; De Garine-Wichatitsky et al., 2021; Snedden et al., 2021).

Dirzo et al., (2014) names current global wave of anthropogenically driven biodiversity loss causes the major driver of global ecological change as "Anthropocene defaunation" which leads to the sixth mass extinction. Anthropogenic sixth mass extinction is accelerated by rapidly growing human pressures on the biosphere and having severe implications that increase the degradation of ecosystem services and decrease the public health security (Ceballos, 2020). Dunk et al., (2019) highlight report of 2015 Lancet Commission that alarmed enfeebled condition of the earth's natural systems assigning the term "planetary health and concluded to receive the ongoing collaboration with experts and a range of stakeholders with existing monitoring processes for "the greatest global health opportunity of the 21st century" due to the climate change (Watts et al., 2017). Abiha et al., (2021) evidently highlight the positive effect of strategies like lockdowns on the natural habitats and wildlife which is referred as a the period of "Great Pause" or sometimes named as "Anthropuase" has helped to recover environmental damage of caused by human activities (Arora et al., 2020; Buxton et al., 2020; Rutz et al., 2020; Zuluaga et al., 2021).

Zoonotic spillover requires several factors to align, including the ecological, epidemiological and behavioural determinants of pathogen exposure, and to prevent an occurrence of spillover of a pathogen there can be effective, affordable, durable and scalable solutions to set up a hierarchical series of barriers (Alexander et al., 2017; Plowright et al., 2017; Sokolow et al., 2019). The destruction of natural habitats causing critical state of biodiversity is an important driver of emerging transmission of zoonotic pathogens that is more likely to occur in phylogenetically related hosts (Modonesi, 2020; Abiha et al., 2021). Grange et al., (2021) developed SpillOver, a risk ranking framework and interactive web tool for estimating a risk score for wildlife-origin viruses and assessed 509,721 samples from 74,635 animals and ranked the spillover potential of 887 wildlife viruses in which SARS-CoV-2 was in the top 12 viruses.

According to Vandersmissen, and Welburn (2014) zoonoses are included into One Health movement, depends on forging strong links between human and animal health services, for implementing policies at the human-animal-environment interface. One Health is an Interdisciplinary approach integrating professionals from multiple disciplines that prescribes measures at local, regional, and national levels for mitigating emerging outbreaks of zoonotic infectious disease (Konda et al., 2020; Zinsstag et al., 2020; Dykstra et al., 2021; Snedden et al., 2021). Sánchez et al., (2021) call for transdisciplinary approaches to provide a more holistic understanding of zoonotic spillover phenomena and subsequent emergence of VBZDs that casue public health burden affects on long-lasting impacts on our social, economic, environmental and political systems. 'One Health' disciplines including Veterinary Science and Animal Health, Public Health and Medicine, Ecology and Evolution, Environmental Science, with broad conceptual scope can be used for identifying priority areas for further research interventions into zoonotic and filling the gaps in academic disciplines (Dykstra et al., 2021).

VBZD risks are ultimately interlinked with biodiversity crisis, climate change and water insecurity that need to be changed with rapid political responses and systemic policy changes at global level (Everard et al., 2020; Smith, 2021). Rahman et al., (2020) highlights COVID-19 pandemic as a newly emerging zoonotic disease burden and recommend implementing One Health measures for effective prevention and control of possible zoonosis in future (Cooke et al., 2021; Córdoba-Aguilar et al., 2021; Delahay et al., 2021). De Garine-Wichatitsky et al., (2021) suggest to adopt a social-ecological system framework (SESF) based on a transdisciplinary definition of Socio-Ecological System Health (SESH) to prevent and cope up with emerging health and environmental risks One Health integrated approaches.

Plowright et al., (2021) recommend interdisciplinary collaborations and mechanistic focus on land use implications for zoonotic EIDs and to urgently formulate an integrated science-based policy and management measures for addressing human-induced habitat loss that is known to be the major driver of zoonotic pathogen spillover (Snedden et al., 2021). The scientific underpinnings for effectively overcoming primary technical challenges, and advance policy and management issues to be implemented for reducing the risk of pathogen spillover from reservoir hosts and land use pressure-induced zoonotic pathogen infect-shed-spill-spread cascade must be a priority in research sector (Rubio et al., 2016; Guo et al., 2019; Harrison et al., 2021; Snedden et al., 2021).

Marselle et al., (2021) introduce four domains for better mechanistic understanding biodiversity as a cornerstone of human health and well-being as reducing harm, restoring capacities, building capacities and causing harm. With an understanding of range of pathways through which biodiversity influence human health, a policy framework based on evidences from across the natural, social and health sciences for fostering biodiversity-focused public health actions and reinforcing biodiversity conservation (De Garine-Wichatitsky et al., 2021; Harrison et al., 2021; Petrovan et al., 2021). Cooke et al., (2021) highlights conservation physiology driven sustainable development interventions leading to win-win solutions based on integration of biodiversity conservation and public health are now becoming the timely needs of strategic planning of health systems. Negative biodiversity changes influence and are mechanistically linked to the zoonotic pathogen spillover process and then global efforts can be initiated for effectively reframing the discussion to integrate the related goals of biodiversity conservation and spillover prevention (Zinsstag et al., 2020; Abiha et al., 2021; Glidden et al., 2021; Petrovan et al., 2021; Snedden et al., 2021).

Clark (2020) emphasizes the linkage between the Covid-19 pandemic and ecological connectivity as an international criminal of ecocide from transitional justice point of view. Therefore pandemic brought profound international responses with social, political, economic, and environmental implications that address social and economic development, climate change, and biodiversity issues together with public health (McNeely, 2021). Under the One Health concept conservation physiologists work closely together with conservation experts and health professionals in research, capacity building and networking to reduce the likelihood of future pandemics (Cooke et al., 2021). Everard et al., (2020) suggest an integrated global action and rapid political response in ecosystem management in mitigating and managing the public health emergencies ultimately interlinked with biodiversity crises. Current COVID-19 pandemic provides learning for the future for policy-makers, organizations, and governments, in particular the importance of environmental sustainability for controlling such outbreaks (De Garine-Wichatitsky et al., 2021; Mishra et al., 2021; Petrovan et al., 2021).

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