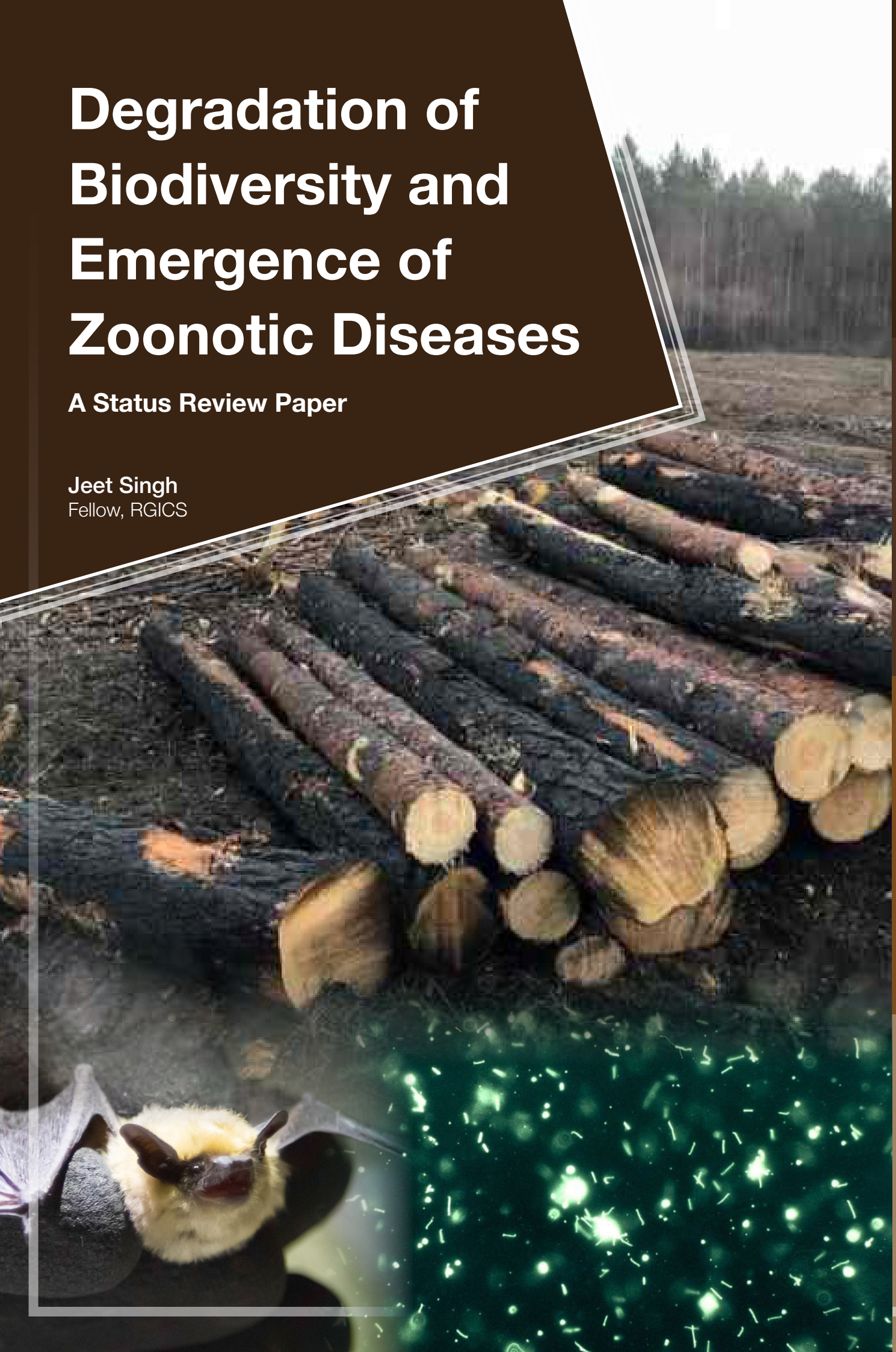
Degradation of Biodiversity and Emergence of Zoonotic Diseases

A Status Review Paper

Jeet Singh
Fellow, RGICS



RAJIV GANDHI
INSTITUTE FOR CONTEMPORARY STUDIES

Author

Jeet Singh, Fellow,
Rajiv Gandhi Institute for Contemporary Studies, New Delhi

Concept and Review

Mr Vijay Mahajan, Director
Rajiv Gandhi Institute for Contemporary Studies, New Delhi

Published by:
Rajiv Gandhi Institute for Contemporary Studies, New Delhi

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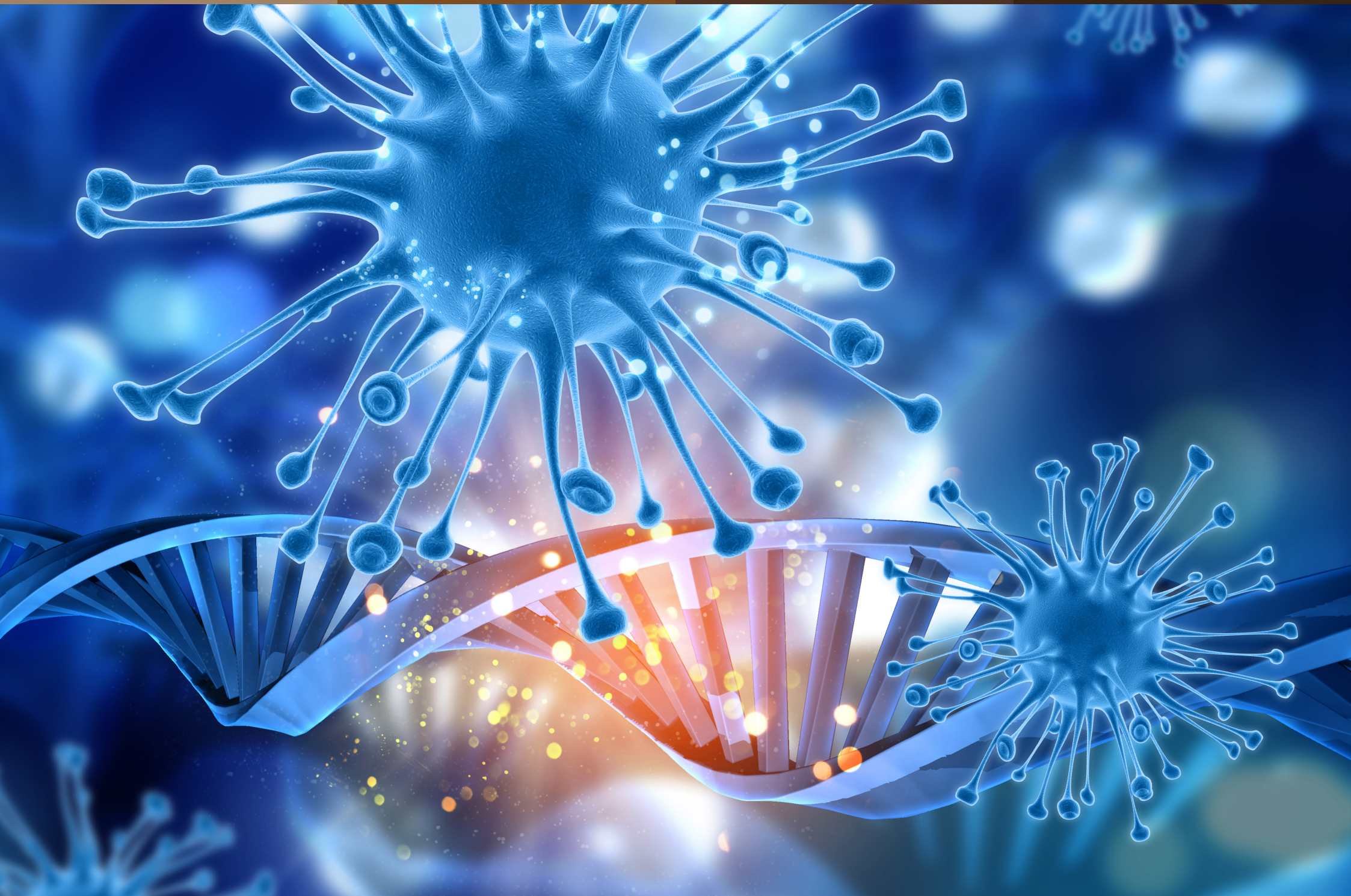


1 Introduction

Disease spill over from animals to humans and vice-versa has a long history. To an extent such transmission of diseases have also been documented worldwide. Various recent literature on animal originated diseases (zoonoses) reveal that incidents of identification and spill over of zoonotic pathogens have tremendously increased after 1960. A team of researchers led by Jones E. Kate analyzed 335 events of emergence of infectious disease from 1940 to 2004. In their analysis they found that these events increased over time, reaching to their maximum in 1980s. The study also found that the 71% of the total events of emergence of infectious diseases originated in wildlife (Jones, et al, 2008). According to the U.S. Centre for Disease Control and Prevention (CDC), 60% of infectious diseases are zoonosis and more than 75% newly emerging infectious diseases originate in animals (Vidal John, 2020). Scientists globally have discovered thousands of wildlife viruses, bacteria and fungi with high potential of spill-over. A 10 year project carried out by 'Eco-Health Alliance' funded by the USAID from 2009 to 2019 alone tested more than 1.45 lakh wildlife samples and discovered 931 novel virus species from almost all continents (Carlson, 2020).

The World Health Organization (WHO) in 1959 for the first time defined the term 'Zoonosis'. According to the WHO "Zoonoses are diseases and infections which are naturally transmitted between vertebrate animal and man" (NCDC, 2016). Zoonotic diseases can be transmitted through virus, bacteria, fungi and protozoa (Carrasco-Hernandez, 2017). To declare any diseases zoonosis, either a proof or strong circumstantial evidence for transmission between animal and man is required (NCDC, 2016). The world in the last one century has witnessed several zoonotic pandemic/epidemic. These include HIV, MERS, Hendra virus, Nipah virus, SARS Corona Virus, Ebola virus, H1N1 virus and Zika. There is a long list of such viruses, bacteria, fungi and protozoa, which have evolved as serious social, economic and health problem worldwide. There are various ways by which these zoonotic diseases transmitted from wildlife to human. However, a large range of literature on zoonoses reveals that the encroachment in the space of wildlife through hunting, deforestation, developmental projects and city expansion and others have opened the route of zoonotic diseases (Daszak, 2000, Joseph et al, 2016 and Ostfeld, 2009).

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS Cov-2) is newest corona virus that emerged from Wuhan city of Chinain 2019. The SARS Cov-2 also known as

COVID-19 is substantially different from SARS coronavirus discovered in 2004, so we do not have any medicine or vaccine to restrict its spread. Of the all other recent zoonotic diseases outbreaks, the COVID-19 has greater adverse impact on world economy. Declared and un-declared lockdowns in almost all countries in the world has been adopted as major response to contain the spread of the virus. The lockdown of economic activities, huge reverse migration of workers and continued fear of COVID-19 has devastated the world economy. The United Nations has recently stated that the world economy will go into recession due to COVID-19 pandemic. In response to unstoppable global recession, various governments have declared stimulus packages to revive their economies.

While it is important to revive economy, it is also import to revive it in the context of the current pandemic. We must not forget the causes of current and previous zoonotic outbreaks, which have affected us badly. We must also learn from our ongoing economic activities and their connection with zoonotic outbreaks from time to time. While it is really difficult time for human being across the globe, it can also be utilized as an opportunity to re-think the way we are using natural resources for economic gain. This paper is an attempt to highlight relationship of zoonotic outbreaks with degrading natural resources and suggest policy framework for post-Covid economy.

2 Zoonotic Diseases

According to a report published by Zoonosis Division of National Centre for Disease Control, more than 300 zoonotic diseases have been identified by veterinary scientists, biologist and ecologists all around the globe. However a group of scientists from University of Edinburgh surveyed as many as 1407 human pathogens which include viruses, bacteria, fungi, protozoa and helminths. The survey further revealed that 816 out of 1407 (58%) identified pathogens were zoonotic (Woohhouse et al, 2005). A project carried out by Ecohealth Alliance funded by USAID from 2009 to 2019 discovered more than 900 new virus reservoirs in different countries. While these numbers on zoonotic diseases and pathogens differs substantially in the available literature, all of them have pointed that the zoonotic pathogens are on rise and will intensify public health crisis in the future.

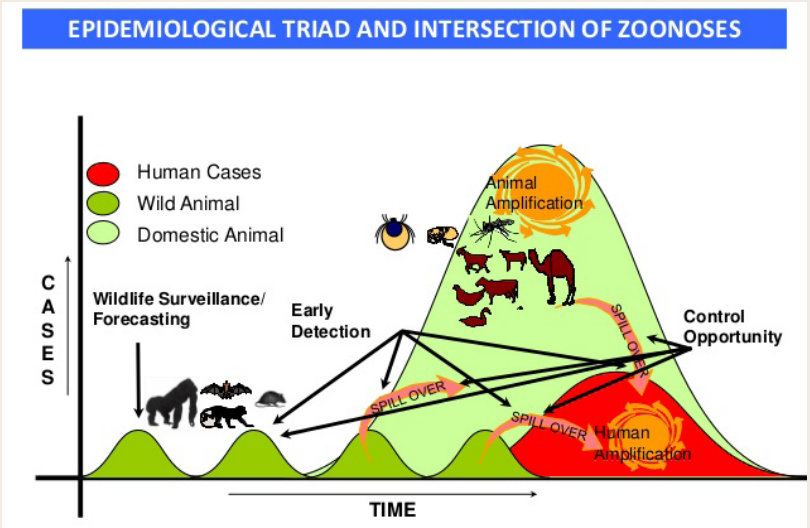
Some Emerging Zoonotic Diseases

Zoonosis	Primary Host	Locations of Emergence	Year of Emergence
Hendra Virus	Flying foxes	Australia	1994
NIpah Virus	Pigs	Malaysia, Singapore, India and Bangladesh	1998 2001
SARS Corona Virus	Bats	China	2002
MERS Corona virus	Egyptian Tomb Bats	Middle East, Europe and Africa	
Filoviruses	Bats	Africa	
West Nile Virus (WNV)	Birds	Uganda, North America	1937 1999
Chikungunya Virus	Bats and Aedes Mosquitoes	Sub-tropical region of Africa and Some part of Asia	1952
CCHFVCrimean-Congo Haemorrhagic Fever Virus	Ticks of the genus Hyalomma	Asia, Middle East, South-Eastern Europe and Africa	1944
SARS Cov-2 (COVID-19)		Originated from China	2019
Cryptosporidiosis	Wild Rodents	Europe, Asia	
Hantavirus pulmonary syndrome	Rodents	USA	
Canine distemper	Wide range of carnivores	USA, Africa	

https://www.oie.int/doc/ged/D14089.PDF

According to an estimate more than one billion cases of illness and millions of deaths across the world occur every year from zoonoses[1]. It is a public health threat in India too. A report published by the National Centre for Disease Control (NCDC), GoI in 2016 recognizes zoonoses as continued and future public health concern (NCDC, 2016). According to the report zoonosis like plague has killed nearly 120 lakh people since 1898 in India and more than 20,000 deaths occur due to rabies every year in the country. The report also highlights Leishmaniasis, Leptospirosis, Toxoplasmosis, Taeniasis, ArboviralInfenctions, Zika virus, CCHF and Ebola virus as serious threats to the public health in India.

Spill-over of diseases from animal to human is not a new phenomenon, it has been always there. **Many zoonotic diseases in the beginning have come from domestic animals these includes tuberculosis, plague, yellow fever and influenza (Wang et al. 2014). However, various studies have found that most of newly discovered zoonotic diseases are emerging from wildlife.** The WHO has recognized an increase in newly emerging zoonotic diseases. According to the WHO, an emerging zoonosis is diseases, which is "newly recognised or newly evolved or that has occurred previously but shown an increase in incidences or expansion"[2]. The WHO has also recognized that the incidents and fatality potential of the emerging zoonotic diseases is on rise. To address problems related to these newly emerging zoonoses, the WHO is collaborating with Food and Agriculture Organization of the United Nations (FAO) and World Organization for Animal Health (OIE). Thistripartite collaboration has created a Global Early Warning System (GLEWS) to inform prevention and control measures, through "the rapid detection and risk assessment of health threats and events[3]" of Zoonotic diseases. The WHO in one of its report in 2004 has admitted that in the Eastern Mediterranean Region (Middle East and eastern cost of Africa continent) of WHO have reported rise in zoonotic infection often with explosive outbreak and high fatalities[4].



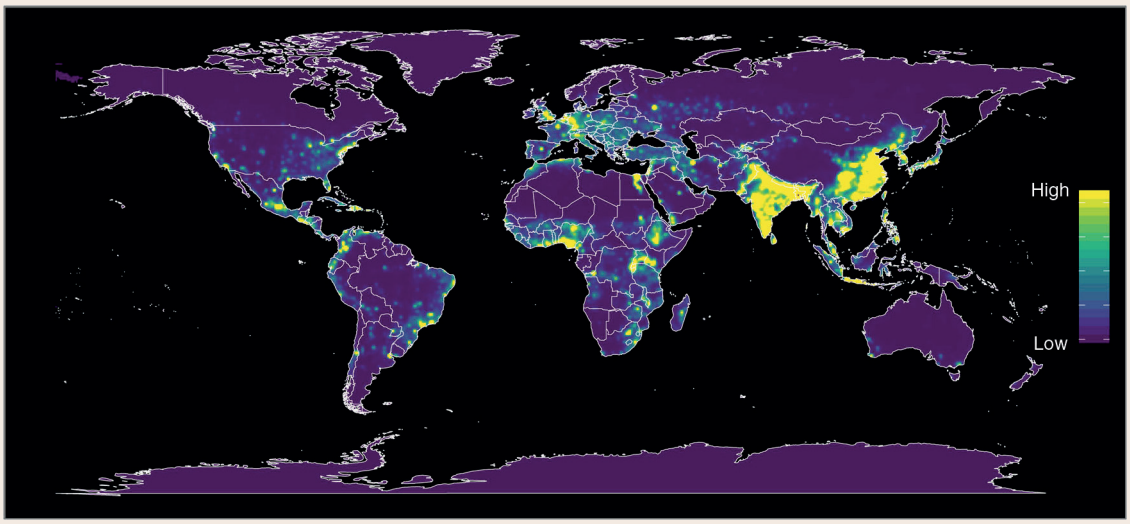
[1] World Health Organization: http://www.emro.who.int/pdf/about-who/rc61/zoonotic-diseases.pdf?ua=1, Accessed on 2.06, 2020
[2] World Health Organization: http://www.emro.who.int/pdf/about-who/rc61/zoonotic-diseases.pdf?ua=1
[3] Global Early Warning System (GLEWS): http://www.glews.net/?page_id=1041, Accessed on 1.06.2020
[4] World Health Organization: http://www.emro.who.int/pdf/about-who/rc61/zoonotic-diseases.pdf?ua=1

Woolhouse et al (2005) in their survey of human pathogens found 177 zoonotic pathogens which were emerging and re-emerging. In their study, they found that emerging and re-emerging zoonoses have range of natural hosts. Many pathogens have more than one natural host. Hosts of these pathogens include Ungulates, Carnivores, Rodents, Non mammals, Primates and Bats. However, the study clearly found that the "RNA viruses numericallydominate comprising 37% of all emerging and re-emerging pathogens".

3 Global Hotspots of Zoonoses

Many zoonotic pathogens such as HIV, Plague and now SARS-Cov 2 turned into pandemic resulting in huge loss to the global economy. The current COVID-19 pandemic is probably the worst zoonotic outbreak that the world has seen in last many decades. With the increased globalization of national economies, trade and human along with the unknown characteristics of the novel corona virus has made the current outbreak to spread quickly in almost all countries in the world. An expert suggests that prior knowledge of zoonotic pathogens and their geographical location can help to effectively respond such zoonotic outbreaks.

Heat maps of predicted relative risk distribution of zoonotic EID events



Source: Allen Toph, et al., 2017

To locate hotspots of zoonotic outbreaks across the world, a group of Scientists led by Kate E. Jones in 2008 published a paper in reputed journal 'Nature'. The authors of this paper analyzed 335 events of Emerging Infectious Diseases (EIDs) originated in different parts of the world from 1940 to 2004. More than 70% of these EIDs were zoonotic and they showed increasing trend from 1940 reaching to maximum in 1980s. As per the findings of the study in the following decades i-e 1990-2000 showed marginal decline in emergence of EID events, but the proportion of EID events originated from wildlife observed greater increases (Jones et al, 2008). The study further found that the emergence of zoonotic outbreaks were largely reported from areas which have rich wildlife and tropical region. It further concluded that the areas in lower latitude such as tropical Africa, Latin America and Asia are hotspots of zoonotic outbreaks.

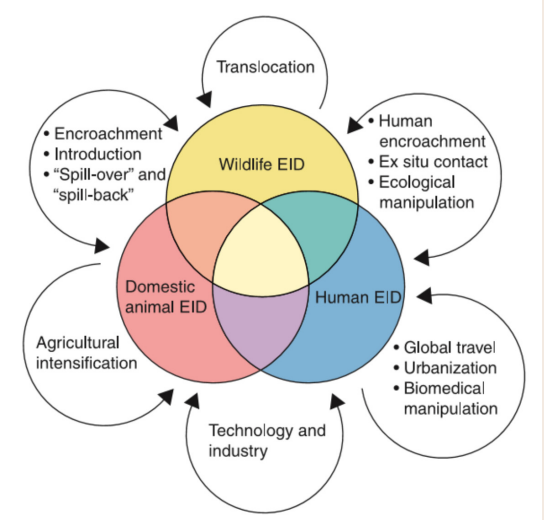
A separate group of scientists associated with Eco Health Alliance in 2017 updated the hotspot of zoonotic outbreaks identified by the scientists led by Kate E. Jones in 2008.

According to the new study **"no major land mass in the world is free from areas predicted to be suitable for EID events". It further found that high population areas "outside the tropics such as cities in Europe, the United States, Asia and Latin America remain among areas at the high end of the risk index."** Most importantly this study found strong correlation between EID events expansion of urban settlements. It found this factor as strongest predictor of zoonotic outbreaks in the world (Allen Toph, 2017).

4 Factors Associated with Zoonotic Outbreaks

In last more than one centaury hundreds of zoonotic diseases have jumped from wildlife reservoirs to human settlements. Many of these diseases have posed serious threat to life and livelihood of common people. For many zoonoses, we don't have clear evidences how they spilled over from wildlife reservoirs. But scientists across the globe have investigated sources of some of zoonoses and way by which they transmitted to human settlement. Ostfeld (2009) in one of his study about two zoonoses namely West Nile Virus (WNV) and Lyme Disease (LD) found strong correlation with destruction of natural habitat of various wild species and the spill over of these two diseases. The study found that the biodiversity loss resulted in habitat destruction and fragmentation, pollution, invasion of exotic species and direct human exploitation.

In many such studies scientists across the globe have found the increased anthropogenic activities have resulted in the loss of biodiversity. It further led to the destruction of natural habitat of wildlife. The struggle of wildlife to cope with destroyed habitat either created situations for increased in number of human-wildlife contact or resettlement of wildlife leading to inter-species transmission of pathogens. A working group of experts on Land Use Change and Disease Emergence in its report in 2004 found that anthropogenic land use changes worldwide drive a range of zoonotic outbreaks (Jonathan A. Petz et. al, 2004). Therefore, Ostfeld (2009) in his article based on study of MNV and LD diseases concluded that the richness of biodiversity work as a buffer against transmission of zoonotic diseases. There are number of examples worldwide to show that anthropogenic activities have instigated outbreaks of zoontic diseases. Nipah virus first crossed over from fruit bats to pigs and from pigs to human. Similarly, relocation of fruit bats due to destruction of forest in Australia infected horses and then infected horse transmitted it to veterinarian examining a sick horse (Robin A Weiss et al, 2004).



Source: Peter Daszak et al, 2000

Fig: Common Causes of Zoonotic Spillover and Spill-back

A team of scientists led by Peter Daszak surveyed major zoonotic outbreaks in the world to understand their emergence. They also tried to gather information about factors associated with emergence of zoonotic outbreaks. The study found that human activities such as extension of farming, translocation of infected species, dispersal of infected host, spill-back from domestic animal and translocation of naïve animal are few documented factors behind emergence of diseases like Avian malaria, Ebola, Cryptosporidiosis in Europe and Canine distemper in Africa (Daszak, 2000). An expert group led by Dr. Jonathan A Patz listed major drivers of infectious diseases (zoonotic) outbreaks to suggest actionable policies. The group found that anthropogenic **activities such as agriculture encroachment, deforestation, road construction, dam building, irrigation, wetland modification, mining, rapid urbanization and degradation of coastal zone causes a cascade of factors that exacerbate spillover and spill back of infectious diseases** (Jonathan et al, 2000).

Unlike early researches on hotspots of emerging infectious diseases, the latest and updated research by experts associated with Eco Health Alliance have warned that no area in the world is safe from emergence of new zoontic outbreaks (Allen et al 2017). The probability of emergence of new infectious diseases is also high in areas where anthropogenic activities are rampant. New zoonotic diseases in any area may occur "either from 'spillover' or crossspecies transmission or simply by extension of geographic range into new or changed habitat (Jonathan et al, 2000)."

Main Categories of Drivers Associated with Emergence and Re-emergence of Human Pathogens

Rank	Driver
1	Change in land use or agriculture practices
2	Changes in human demographics and society
3	Poor population health (e.g., HIV, malnutrition)
4	Hospitals and medical procedures
5	Pathogen evolution (e.g., antimicrobial drug resistance, increased virulence)
6	Contamination of food sources or water supplies
7	International travel
8	Failure of public health programs
9	International trade
10	Climate Change

Source: Woolhouse Mark E.J and Sonya Gowtage, 2005

Various studies have revealed that the land use change in many ways across the globe is main factor associated with the emergence and re-emergence of zoonotic pathogens. The joint conference of WHO, FAO and OIE in 2003 on the challenges of zoonoses recognized numerous social, technological, ecological and microbial factors associated with the emergence and spread of zoonotic pathogens. The conference further divided these factors into primary risk factors and amplifying risk factors. The conference recognized that the ecological factors such as change to an agricultural production, environment pollution, changing consumption patterns and increasing human-animal contact as primary risk factors (OIE, 2004). Woolhouse et al (2005) in their study categorized risk factors for zoonotic outbreaks into 10 categories and prioritized them based on their ability to instigate zoonotic outbreaks. They also found that the land use change is the most influential factor for emergence and re-emergence of zoonotic infections. Likewise a latest study by Eco Health Alliance also concluded that the "global disease emergence is linked directly to human-induced drivers like land-use change and interaction between humans and wildlife in highly bio diverse regions of the world[5]."

Emergence of zoonotic Diseases in Pacific and South- East Asia	
Key zoonotic diseases and zoonotic agents	**Main risk factors**
Avian influenza:	• Increased demand for animal protein resulting in expansion and intensification of farming – increase in mixed farming practices • Acceleration of international trade • "wet" markets (live animals and slaughter in public)
SARS:	• Human consumption of wildlife/exotic species as delicacies
Rabies:	• Lack of population control and vaccination of stray dogs • Inadequate vaccine coverage of pet dogs
Japanese encephalitis:	• Increased free-range pig farming in rice fields (high mosquito prevalence) – inadequate or lack of vaccine coverage in humans
Hanta virus:	• Close contact between humans and rodents
Echinococcosis:	• No proper slaughtering practices and poor hygiene • No meat inspection – lack of personal hygiene (e.g. hand-washing)

[5] Eco health Alliance: https://www.ecohealthalliance.org/2017/10/global-disease-hotspots-2-0, Accessed on: 1.6.2020

Cysticercosis:	• Environmental contamination with human faeces (poor sanitation) • Pig management practices (free-range farming) • Pork consumption habits (undercooked or raw pork) • Lack or absence of pork inspection and control
Leptospirosis:	• Increased exposure to rodent excreta and contaminated water
Nipah virus (henipaviruses):	• Anthropogenic introduction of large-scale pig farms into pteropid bat habitats • Fruit orchards or other food sources for megachiropteran bats in close proximity of farmed pigs • Increased interface between humans and pteropid bats and inadequate personal hygiene
Schistosomiasis:	• Uncontrolled irrigation – livestock management practices

Source: https://www.oie.int/doc/ged/D5681.PDF

5 Degradation of Biodiversity and Zoonotic Outbreaks

There is enough literature to suggest that the land use change especially in the form of expansion of agriculture, deforestation and increasing other anthropogenic activities in forest is the main factor associated with zoonotic outbreaks. However, leading global agencies including WHO, FAO and OIE have not yet focused on advocating for preservation and regeneration of natural resources. The attempt of the tripartite collaboration of WHO, FAO and OIE along with their national and regional partners have been responding zoonotic outbreaks by early detection, surveillance and increasing public health capacities at the local level[6]. However, these three organizations have also called for joint researches involving conservation organization, social scientist, anthropologist and medical professionals. A working group of global experts on the issue of land use change disease emergence in 2004 strongly suggested bringing land use change in public health policy. The group developed a conceptual framework to understand linkages between ecosystem services and human health (Patz, A. Jonathan et al, 2004). Major anthropogenic activities related to land use change leading to zoonotic spillover of spill back are briefly described as follows:

5.1 Deforestation

Deforestation is a global concern and it started growing from early 20thcentury. While the forest is home of almost all terrestrial wildlife, rapid deforestation has changed or destroyed their habitat substantially. As per an estimate around 420 million hectares of forest land have been converted for other uses since 1990s (FAO, 2016). According to the state of world forest report- 2016, 20,334 tree species had been included in the IUCN Red list of threatened species. The expansion of commercial agriculture has been identified as largest factors associated with deforestation of tropical forest.

Consequences of deforestation are highly harmful both to wildlife and human. While the deforestation for various purposes across the world has helped us to increase the industrial production, it also threatened life of tree and wildlife species.It further led to loss of life and/or livelihood of millions of people in many ways. Deforestation for number of anthropogenic activities such as construction of road, dam, mining and agriculture land modifies the environment by fragmenting habitat. It further leads to increase human interaction with pathogens, vectors and hosts, which is called 'edge effect' (PatzA Jonathan et al 2004). Dr. R.S. Ostfeld documented in detail the edge effect in USA leading to spread of two zoonotic diseases namely West Nile Virus (WNV) and

[6] https://www.who.int/foodsafety/zoonoses/final_concept_note_Hanoi.pdf?ua=1

Lyme Disease (LD) (Ostfeld, 2009). The edge effect has also played devastating role in the spread of malaria in different parts of the world (Eco Health Alliance, 2019). A study found strong association "between the biting rates of Anopheles darling and the extent of deforestation in the Amazon basin (Patz, 2008)."

In India, deforestation largely occurred during British period, which include time from 1880 to 1960. The rate of deforestation decreased from 1960-1980 in India. From 1980s onward various policies were introduced for the protection of forest and regeneration of deforested land through various schemes. A recent study reveals that the forest land in India reduced from 89.7 million hectare in 1880 to 63.4 million hectare in 2010. On the other hand the crop land increased from 92.6 million hectare to 140.1 million hectare during the same period (Tian H et al, 2014). The urbanization is also rapidly increasing in India. The share of urban population has increased from 18% in 1951 to more than 31% in 2011[7]. Correspondingly the built-up area has also increased tremendously in India. The built-up area of India has increased from 0.45 million hectare in 1880 to 2.04 million hectare in 2010 (Tian H. et al, 2014).

Not only the urbanization but the various industrial projects and encroachment have also led to deforestation in India. According to the official data of the Government of India, **from 1980 to till date 3.11 lakh forest land has been diverted for 27559 project required clearance under the Forest Conservation Act, 1980[8]. These projects include mining, quarry, irrigation, hydro power projects, defence and gas pipelines.** There are clear evidences to prove that the deforestation exposes human, livestock and wildlife to new pathogens (Patz, A Jonathan, 2004). Even in India, various zoonotic outbreaks were identified in areas where the probability of human-wildlife contact is high (Singh, B.B. et al, 2014).

5.2 Agriculture Expansion

The expansion of agriculture is one of the key reasons for massive land use change across the globe. The arable land suitable for the crop production has immensely increased in last seven decades despite revolutionary improvement in crop intensity and yield. According to the data compiled by the World Bank, the share of arable land has increased from 9.8% of the total world landmass in 1961 to 11.05% in 2016[9]. Despite this huge expansion of agricultural land by encroaching non-agricultural land, the population growth reduced the average per capita availability of the arable land. The per capita availability of the land has decreased from 0.36 hectare in 1961

[7] Ministry of Housing and Urban Affairs, GoI: http://mohua.gov.in/cms/urban-growth.php
[8] E Green Watch: http://egreenwatch.nic.in/FCAProjects/Public/Rpt_State_Wise_Count_FCA_projects.aspx
[9] World Bank Data: https://data.worldbank.org/indicator/AG.LND.ARBL.ZS

to 0.19 hectare in 2016[10]. The land use change for agriculture is dominant cause of deforestation of biodiversity rich tropical reason, which is natural habitat of many zoonotic pathogens (Patz A. Jonathan, 2004). According to the latest state of the World Forest report the expansion of agriculture is main driver of forest degradation and fragmentation. According to the report, the large scale commercial agriculture accounted for 40% of tropical deforestation from 2000 to 2010 (FAO, 2016). In India, as per the data compiled by the Government of India in last four decades as high as 1.33 lakh hectare forest land encroached by various stakeholdershas been converted into non-forest land[11].

The arable land is highly important to feed the human population, and the demand of food is expected to further increase, with increase in the world population. To feed the increased population, we will need more arable land. To meet this, more "forests will be cut, surface water andaquifers tapped, fertilizers applied and pesticides broadcasted-all of which threaten insects and other biodiversity either directly or indirectly[12]." Various studies have shown that the expansion of agriculture in different parts of the world led to zoonoses spill over. Woolhouse et al (2005) in their study found that the land use and agriculture are commonly cited drivers in various documentations of zoonotic outbreaks.

The outbreak of zoonoses associated with the expansion of agriculture is well documented. **There is evidence that the expansion directly threatens the wildlife and biodiversity and the use of pesticide and insecticide destroy the habitat. Both the direct and indirect impact of agricultural expansion have created favourable environment for zoonotic outbreaks.** The increased contact between human and wildlife due to expansion of agriculture led to sharing of *zoonoticLeptospiraspecies* between human and rodent (Singh, et al, 2014). Not only has the clearing of the forest for agriculture, but the introduction of invasive crop species also leaded to zoonotic outbreak. The emergence of Lyme Disease (LD) is attributed to the shift in agriculture from the eastern United States to the Midwest (Daszak, 2000). The food exported to other parts of the world also lead to disease outbreaks. For instance, strawberries imported by USA from Maxico and coconut milk from Thailand have caused disease outbreaks in USA (Patz, A Jonathan, et al, 2004).

5.3 Urbanization

Urbanization is another key factor associated with the land use change across the globe but especially in developing countries. According the data base of the United Nations,

[10] World Bank Data: https://data.worldbank.org/indicator/AG.LND.ARBL.HA.PC, Accessed on 1.6.2020
[11] E Green Watch: http://egreenwatch.nic.in/FCAProjects/Public/Rpt_State_Wise_Count_FCA_projects.aspx, Accessed on 2.6.2020
[12] Science Direct: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/arable-land

nearly 55% of the world's population live in urban areas. The rate of urbanization is exceptionally high in developing countries like India, China and Nigeria. According to the UN's estimate, the overall growth of world's population "could add another 2.5 billion people to urban areas by 2020 (UNO, 2018)". Of the total population of India nearly 31% lives in cities which was 27.8% in 1991[13]. The rate of urbanization has rapidly increased in the last few decades. The land used for the expansion of urban settlement in India is also huge. According to an estimate, **the built-up area of India has increased from 0.45 million hectare in 1880 to 2.04 million hectare in 2010** (Tian H. et al, 2014).

The rapid expansion of urban settlement in the world is also facing issues related to sustainability of urbanization. The growing urban population needs adequate and quality services such as housing, transportation, energy, water, sanitation, clean air, education, health etc. To meet these challenges countries needs to manage their resources sustainably to avoid ecological pollution and degradation. Any alteration to wildlife and ecosystem can lead to emergence of zoonotic diseases (Patz A. Jonathan, et al, 2004). The growth of cities especially in developing countries are changing agriculture conditions and leading to alternation of local biodiversity. China has witnessed increase in spill over of zoonotic pathogens as its cities grew in the past (Wo, Tong et al, 2015).

Other than land use change due to urbanization, cities are also amplifying factors in the spread of zoonotic diseases. The hotspot analysis of zoonotic disease by the Eco Health Alliance team found strong positive association of urban areas with emergence of zoonotic diseases (Allen, T. at al, 2017).Daszak Peter et al (2008) also found that the higher density of people in urban areas has driven the emergence of emerging infectious diseases. "Rabies is an example to zoonotic disease that has become habituated to urban environments" (Patz A. Jonathan et al, 2004). Studies have documented the amplifying characteristic of cities in the spread of zoonotic diseases. For example, Weiss et al., 2004 have found that cities in the different part of the world have boosted well established diseases such as pneumonia, diarrhea, tuberculosis, dengue and SARS.

5.4 Habitat Destruction

Destruction of habitat of wildlife is a serious concern. The sustainable development goal (SDG) number 15.5 calls for global action to "reduce the degradation of natural habitats, halting of the loss of biodiversity and preventing the extinction of threatened

[13] Ministry of Housing and Urban Affairs, GoI: http://mohua.gov.in/cms/urban-growth.php

species" (FAO, 2016). **Various anthropogenic activities have destructed habitat of millions of wild animal and insects that have resulted in spill over of zoonotic pathogens.** It has been observed that the destruction of habitat have increased contact between wild-life, human and domestic animal. The destruction of habitat changes the composition of host species in an environment and in many case it further leads to fundamental change of ecology. In any habitat, change in food chain can either affect top predators or prey and increase and decrease of one species can change everything (Patz, A Jonathan et al., 2004).

Ostfeld and Keesing (2000) demonstrated that the diversity of natural hosts of pathogens decreased the chances of Lyme disease outbreaks in Northern America. According to this study, the high density of white footed mice is highly efficient in transmission of Lyme disease. However, the adequate availability of other hosts of Lyme disease in same habitat such as other species of mice decreases the potential of white footed mice to infect human. In another case, habitat destruction resulted into spread of Hendra virus in Australia. In this case, the destruction of natural forest forced the natural host of Hendra virus – the fruit bat to relocate nearer human habitation. The Botanic garden in the heart of Sydney was one of large relocated colony of these fruit bats, which created environment for transmission of Hendra virus (Weiss Robin A. et al., 2004).

Habitat destruction some time also create environment for wildlife and domestic animal to share same piece of destroyed forest land. This facilitate the transfer of novel pathogens into naïve species either wild or domestic animal. Want et al. (2014) in their study found that the diseases which have come from domestic animals such as anthrax, tuberculosis, plague, yellow fever are now increasingly emerging form wildlife species due the change in environment.

5.5 Pathogen Pollution and Trade in Wild Meat

The introduction of invasive species, many time alter the ecosystem and threatens health of local wildlife, human and domestic animal. Such contamination in any ecosystem is called "Pathogen Pollution". According to Daszak et al. (2000), the human introduction of pathogens, hosts, or materials into new area is termed as 'pathogen pollution'. There are many ways by which pathogen pollution can occur in a particular area. These includes international exchange of agricultural materials, domesticated animals, food crops, timber and biologically contaminated wastes (Daszak et al 2008).

The wet market is another potential place for the transmission of zoonotic diseases. It is a place where food animals are sold either alive of as fresh meat. The handling of infected animal or through their excreta, new pathogen can jump from natural host to human. The wet markets in China have transmitted many infectious diseases including SARS (severe acute respiratory syndrome) and avian influenza (H5N1) (Woo et al, 2006). Wet market in South China is a huge business. The emergence of the current pandemic COVID-19 is still an issue of debate. While many believe that it was transmitted from a lab in Wuhan city, many other think that the wet market is responsible for its transmission. Apart from regularized trade of meat, the illegal trade of wild meat all across the world is also a great threat. The Pangolin found in the forest of Eastern Ghats of India is most trafficked animal for wild meat with high demand in China and South Asia. However, studies have proved that pangolin is natural host of many zoonotic pathogens (Nair, P, 2020).

While the consumption of wild meat is associated with cultural practices of many communities, the globalization of food has pose substantial threat to global biodiversity. Daszak et al. (2008) states that the pathogen pollution has potential to cause catastrophic depopulation of the new and naïve host population. Nair, P (2020) argues that the ban on international trade of food including meat won't work unless food and nutritional requirements of all are met adequately.

6 Zoonosis and Policy Responses in India

The updated module on 'Zoonotic Diseases and Public Health Importance' published by the NCDC in 2016 recognizes zoonotic diseases such as Plague, Japanese Encephalitis, Rabies, Leptospirosis, Degue fever etc as serious public health challenges in India. It also has cautioned about the other zoonotic disease emerging in other parts of the world such as Ebola, Zika and SARS (NCDC, 2016). The module also recognized that the degradation of biodiversity all across the globe is the main factor associated with the emergence of zoonotic diseases. While the module indicates about the prime causes of emergence of zoonotic disease, it does not suggest measures to prevent emergence of new zoonotic diseases.

The very rich diversity of forest including tropical forest, sub-tropical forest, Himalayan forest and Alpine enriches the biodiversity of the country. The latest state of the forest report 2019 published by the Forest Survey of India has categorized Indian forest in 18 different types. These forests in India is home for 3794 species of trees, 3111 shrubs and 2300 species of herbs (FSI, 2019). The rich biodiversity of India is also a huge reservoir of zoonotic pathogens. Many of these pathogens have spilled over in the past due to increased contact between wildlife, domestic animal and human in different parts of India. A literature survey by Singh and Gajdhar (2014) listed more than 50 zoonotic outbreaks reported from different states. These diseases includes Kyasanur Forest Disease (KFD) first recognized in 1957 from sick and dying monkeys in the Kyasanur forest of Karnataka and Avian Influenza (H5N1) reported in Assam in 2010. The health consequences of zoonotic diseases is very high, According to an estimate the animal biting cases in India is as high as 15 million people in a year and of those 25,000 to 30,000 people die every year. Similarly the morbidity and mortality due to diseases like Japanese Encephalitis, Avian Influenza, Leptospirosis, Plague, Zika and Ebola is also very high (Kumar et al, 2015 and NCDC, 2016).

Zoonotic Outbreaks in India from 2014-2918 Compiled by IDSP

Disease	2014			2015			2016			2017			2018			Total		
	Number of Outbreaks	Cases	Deaths	Number of Outbreaks	Cases	Deaths	Number of Outbreaks	Cases	Deaths	Number of Outbreaks	Cases	Deaths	Number of Outbreaks	Cases	Deaths	Number of Outbreaks	Cases	Deaths
Anthrax	6	55	1	11	177	12	32	205	3	23	135	9	6	52	0	78	624	25
Brucellosis	1	15	0	0	0	0	2	49	0	2	25	0	0	0	0	5	89	0
CCHF	6	6	4	15	18	8	12	13	6	5	5	3	0	0	0	38	42	21

Influenza A H1N1, H3N2 and Influenza B	0	0	0	2	213	0	2	102	0	3	196	1	8	269	1	15	780	2
KFD	4	101	0	4	326	9	4	219	0	1	20	1	2	10	2	15	676	12
Leptospiros	6	74	1	6	71	1	11	207	6	5	87	0	4	134	0	32	573	8
NipahVirus Encephalitis	0	0	0	0	0	0	0	0	0	0	0	0	1	19	17	1	19	17
Scrub Typhus	4	202	1	8	181	6	6	304	3	9	101	3	8	486	2	35	1274	15
Seasonal Influenza	0	0	0	0	0	0	0	0	0	0	0	0	1	75	0	1	75	0
Total	**27**	**453**	**7**	**46**	**986**	**36**	**69**	**1099**	**18**	**48**	**569**	**17**	**30**	**1045**	**22**	**220**	**4152**	**100**

Source: https://ncdc.gov.in/showfile.php?lid=421

6.1 Standing Committee on Zoonoses

In the view of increasing health risk the government of India constitute a permanent 'Standing Committee on Zoonoses' (SCZ) in 2006 subsequent the global pandemic of Avian Influenza (NCDC, June 2019)[14]. This was the first formal policy decision to monitor events of zoonotic outbreaks in India. The committee is headed by the Director General of Health Services of Government of India with number of other members from other national and state level ministries/institutions/departments. The objectives of the SCZ are as follows[15]:

1- To advise to various facets of the work on Zoonoses in the country and list zoonoses infection/disease according to priority.

2- To pursue the formation of zoonoses committee at the state level.

3- To formulate the terms of reference and modus operandi for developing the networking between various sectors.

4- To advise regarding the location and requirement of special laboratories at the national or regional level.

5- To formulate projects with detailed technical programme for effective and meaningful work on priority problems.

The Standing Committee on Zoonoses is expected to meet twice a year but in last 14 year it convened only nine meeting. The latest meeting of the committee was organized on May 02, 2019. Participants of this meeting expressed the need of expanding the membership of committee to include people from other sectors such as institutions related to biodiversity, wildlife, vaccine manufactures and civil society organizations. The meeting also felt need of strengthening coordination between Public Health, Forest, Wildlife, Animal Husbandry, Entomology and Environment[16] (NCDC, 2019).

[14] NCDC, minutes of ninth meeting of Standing Committee on Zoonoses, accessed from: https://ncdc.gov.in/showfile.php?lid=391, accessed on 2.6.2020
[15] Term of Reference of SCZ, Accessed from: https://ncdc.gov.in/showfile.php?lid=392, Accessed on 2.6.2020
[16] NCDC, minutes of ninth meeting of Standing Committee on Zoonoses, accessed from: https://ncdc.gov.in/showfile.php?lid=391, accessed on 2.6.2020

6.2 Inter-Sectoral coordination for Prevention and Control of Zoonotic Diseases

The Twelfth Five Year plan deliberated on the issues of zoonotic outbreaks and related public health challenges. The plan document provide for strengthening of integrated surveillance of transmission between wildlife, livestock and human to prevent spread of zoonotic diseases. Subsequently the Ministry of Health and Family Welfare, government of India approved the 'Inter-Sectoral Coordination for Prevention and Control of Zoonotic Diseases' as a national health program to be implemented during the twelfth five year plan period i-e 2012-13 to 2016-17[17]. After the end of the twelfth five year plan period, the program was extended for another three years i-e from 2017-18 to 2019-20. The major objectives of the program are as follows[18]:

1. Establish an inter-sectoral coordinating mechanism at National, State and District Level by utilizing the existing surveillance system (IDSP) to detect early warning signals of impending outbreaks for timely and effective public health actions.
2. Facilitate sharing of relevant information within stakeholders for taking appropriate actions.
3. Development of Laboratory capacity for diagnosis of Zoonotic diseases.
4. Capacity building and creating awareness among health and veterinary professionals about Zoonotic Diseases of Public Health Importance (ZPHI).
5. Activities such as Information, Education and Communication for spreading awareness among target population for all ZPHI.

The Inter-Sectoral Coordination for Prevention and Control of Zoonotic Diseases does not have any separate institutional mechanism. It uses existing resources and infrastructure of health, veterinary, wildlife and other sectors for the prevention of priority zoonoses. The total outlay for the extended term of the program was Rs. 8.68 crore[19]. According to the information related to the implementation of this program available on the website of NCDC, 14 states have constituted 'State Level Zoonoses Committee' (SLZC) for inter-sectoral coordination for prevention and control of zoonotic outbreaks. Under the program 11 regional coordinators (Medical, Veterinary college/institutions) have also been identified to work at the regional level[20].

[17] Twelfth Five Year Plan, Accessed from: https://niti.gov.in/planningcommission.gov.in/docs/plans/planrel/fiveyr/12th/pdf/12fyp_vol3.pdf
[18] Guidelines for regional coordinators of inter-sectoral coordination for prevention and control of zoonotic diseases program, accessed from: https://ncdc.gov.in/showfile.php?lid=421
[19] Guidelines for regional coordinators of inter-sectoral coordination for prevention and control of zoonotic diseases program, accessed from: https://ncdc.gov.in/showfile.php?lid=421
[20] National Centre for Disease Control, GoI, Accessed from: https://ncdc.gov.in/index1.php?lang=1&level=1&sublinkid=144&lid=152, accessed on 2.6.2020

6.3 One Health Approach and India

The wisdom related to health related interconnection of human and animal through their shared ecosystem is not new. The term zoonoses was first used more than a century ago. However, our modern health system largely focused on care giving and inventing new medicine to contain the spread of diseases especially infectious diseases. The World Health Organization and its global partners such as OIE and FAO pushed the idea of 'One Health' in the beginning of 21st century to address health issues of animal (domestic and wild) and human in comprehensive manner. According to the WHO, the 'One Health is an "approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes[21]."

The One Health program of the Centre for Disease Control and Prevention (CDC) of USA define the one health concept as a trans-disciplinary approach of work at local, regional and global level. Its work focuses on recognition of interconnection between people, animal, plants and their shared environment[22]. The WHO, FAO and OIE together with their national partners promotes multi-sectoral responses to food safety hazards, risks from zoonoses and provide guidance to reduce their risks.

In India the 'National Health Policy-2017' has a passing reference of zoonses. While it talks about concerted and coordinated action to address issues of zoonoses such a rabies, it does not give any policy and institutional mechanism to do so[23]. However, the national program on 'Inter-Sectoral coordination for Prevention and Control of Zoonotic Diseases' conceptualized in the 12th five year plan is an effort to realize the concept of 'One Health'. The program has imbibed the concept of 'one health'. A guideline prepared for the program recognizes that the zoonotic diseases are difficult to eradicate and control[24]. Therefore inter-sectoral coordinated approach is required for effective prevention. Programs like this across the world have recognized the loss of biodiversity has serious public health consequences. But the idea is not a mainstream approach to public health.

[21] World Health Organization: https://www.who.int/news-room/q-a-detail/one-health, Accessed on 2.6.2020
[22] Centre for Disease Control and Prevention (CDC), USA: https://www.cdc.gov/onehealth/index.html, accessed on 2.6.2020
[23] National Health Policy-2017, Government of India: https://www.nhp.gov.in/nhpfiles/national_health_policy_2017.pdf
[24] Guidelines for regional coordinators of inter-sectoral coordination for prevention and control of zoonotic diseases program, accessed from: https://ncdc.gov.in/showfile.php?lid=421

7 Conclusion and Lessons for the Post COVID-19 World

Most studies on zoonoses by scientists in the past have found strong link with increasing contact between human and wildlife. Of the many reasons of these increasing incidents of human-wildlife contact, the human induced destruction of biodiversity for economic gain is the dominant factor. Many experts suggest that the China being source of many incidents of zoonotic emergence has a lot to do with the way they industrialize their country. China has achieved rapid economic growth by discounting environment and labour. However, despite several incidents of zoonotic spill over in the past, our health policies globally remained silent on the issues of prevention from zoonoses by decreasing anthropogenic activities.

The WHO has recently clarified that the SARS Cov-2 (COVID-19) has zoonotic sources[25]. This zoonotic outbreak is exceptionally high in terms of its spread, fatality and its social and economic impacts. This pandemic is also important to set goals for new and sustainable futures. Many governments across the globe have talked about converting the current pandemic into an opportunity. Our Prime Minister Mr.NarendraModi has also in his address to the nation on May 12, 2020 stated that the country will turn this crisis into opportunity by shaping a self-reliant India[26]. Yes, it is right time to learn from zoonotic pandemics/epidemics and use it as an opportunity. All available knowledge on zoonoses suggests that we cannot continue with the destruction of biodiversity for materialistic gain. The only way to live healthy and prosperous is to respect nature. It is time to go back to our cultural ideas of सर्वेभवन्तुसुखिन: सर्वेसन्तुनिरामया: The scattered and half hearted efforts of 'One Health' across the globe can be further refined by the idea of सर्वेभवन्तुसुखिन: सर्वेसन्तुनिरामया: to bring harmony and peace.

However, it seems that the stimulus packages announced for the revival of the Indian economy has not learned from the current and previous zoonotic pandemics. The stimulus package is the continuation of current policies. In fact in some cases the package will further accelerate the degradation of natural resources such as the decision related to the opening of coal mining to all. Also the government is keen to change the rules related to the Environment Impact Assessment (EIA) by relaxing various norms in the favour of project proponent.

The address of Mr.Modi to the nation on 12th May 2020 rightly invoked the Indian culture and tradition to explain the idea of self-reliance, which is ingrained with the happiness, cooperation and peace of the world encapsulated as वसुधैवकुटुम्बकम.But the idea propagated

[25] https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200423-sitrep-94-covid-19.pdf?sfvrsn=b8304bf0_4
[26] https://www.moneycontrol.com/news/india/heres-the-full-text-of-pm-narendra-modis-may-12-speech-5258691.html

by the Prime Minister does not resemble with the subsequent series of stimulus packages announced by the Finance Minister. In the words of Mahatma Gandhi, this economic model for unlimited industrialization is 'Man's Mad Race'. He wanted to replace this by regional self-reliance (Gupta, 1994). The idea of 'Gram Swaraj' propagated by Mahatma Gandhi gives working framework for the regional self-reliance. Zoonotic outbreaks time and again have warned that self-reliance of any region/country is not possible without respecting the nature. Therefore, to turn the current crisis into opportunity, we must draw lessons from the past and the current pandemic.

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RAJIV GANDHI
INSTITUTE FOR CONTEMPORARY STUDIES

Rajiv Gandhi Institute for Contemporary Studies

Jawahar Bhawan, Dr Rajendra Prasad Road,
New Delhi 110 001 India

T 91 11 2331 2456, 2375 5117 / 118 | E info@rgics.org W www.rgics.org

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