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Review Article

THE IMPACT OF GLOBAL CLIMATE CHANGE ON BIODIVERSITY AND PUBLIC HEALTH: A REVIEW

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ABSTRACT
Previously, pressures on the climate system are influential on the earth's surface. These are not limited to only increased superficial temperatures but also more frequent floods and droughts, including variations in normal environments such as early flowering of plants and fluctuations in the spreading of many species. The health of humans and the biodiversity of other creatures are significantly impacted by these changes. The change in climate affects both biodiversity and human health directly and indirectly through physical effects of climatic extremes (directly) and impacts on the stages of air contamination, agricultural, marine, and freshwater classifications which make available food and water, and vectors and pathogens which result in transmittable disease species. The concentration of energy-trapping gases in the atmosphere, raised by anthropogenic climate change is progressively viewed as a drive for biodiversity loss besides being a threat to the sustainability of the ecosystem and human health. Drought, fire, floods, and outbreaks of certain pests and illnesses that impact both wildlife and humans have occurred recently and are projected to grow more common in the next decades. This mini-review summarizes the connections between biodiversity (ecosystem health), human/public health, and climate change, and provides insight into recent events that have shaped the world consequent on global change in climate. It similarly discusses ways to protect the most vulnerable, as climate change is now an important and emerging danger to both public health and the ecosystem.

Keywords: Climate change; Biodiversity; Public health; Global.

INTRODUCTION

The globe's environment, living diversity, and life support system, upon which all humans rely, are frequently overlooked in a fast-growing globe with a metropolitan populace. The continuous loss of biodiversity and global ecosystem deterioration resulting from global climatic change endangers human health (Shivanna, 2022). Today, climate change is one of the most pressing issues and it is generally known that a link exists between the change in climate and the loss of biodiversity which is gradually inclined by social activities (CDB 2003, 2009); Campbell *et al.,* 2009; Rockstrom *et al*., 2009; Pereira *et al*., 2010; Beaumont *et al*., 2011; Parmesan *et al*., 2011; Bellard *et al.,* 2012; IPCC 2014). For now, the focus is more on nature and the timing of action to reduce the pace of global climate change. It is generally accepted that humans influence the global climate. Consideration has been paid to the stability of the potential impacts of climate change and the increase in economic and technological costs and societal adjustments needed to mitigate the damage.
Interchangeably, the terminologies weather and climate are often utilized which in a real sense mean something else on the same spectrum. The nature (state) of the atmosphere at a specific period and place is called weather whose conditions differ significantly on yearly bases and from one particular area to another. Temperature and precipitation, clouds and wind which humans are constantly exposed to throughout the day are the well-known features of weather (US EPA, 2022). The climate is understood to mean the average conditions of weather which last for several years or several decades longer (US EPA, 2022). While the weather can change in minutes or hours, detecting an alteration in the weather takes time and required observations spanning centuries and even more. Climate change covers temperature rises and falls including
changes in precipitation, varying risks of some kinds of harsh weather and variations in added characteristics of the climatic system.
The World Health Organization recognized the links between ecosystem health, human health and climate change (as shown in Figure 1) and concluded that "climatic change instils a substantial and emergent danger to public health." Therefore, those at risk and our surrounding population need to be protected as they bear the brunt of ecosystem changes and the influences of climatic change.

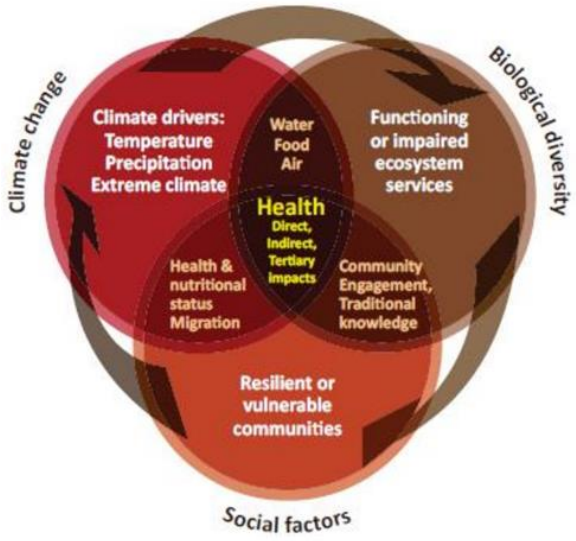

Figure 1: Interactions between climate, biodiversity and social factors
Source: Romanelli *et al*., 2015

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One of the greater sets of disrupting large-scale ecological variations which are presently in progress is the world climatic change and individually showing the growing anthropological strength of the ecosphere (Watson, *et al*., 1998; IPCC, 2001). These comprise key worldwide deviations that include stratospheric depletion of ozone, loss of biodiversity, global land deprivation, freshwater reduction, and others (the disturbance of the essential nitrogen and sulfur cycles, and the worldwide distribution of tenacious biological contaminants). These all possess excessive significance to withstand the ecological systems such as the manufacturing of food, commercial activities of people and human population health (McMichael, 2001).

Climate Change and Public Health

The longstanding good health of populations rests on the constant constancy and viability of the biosphere's physical and ecological systems which are called 'life support systems. There is a growing awareness that sustainable population health needs to be at the Centre of the public debate on how human societies can move towards sustainability (McMichael, 2002).

Therefore, the general policymakers, together with additional scientists are increasingly interested in the views of population health researchers, who are turning to an opinion of population health serving as an ecological unit which is an indicator of accomplishment in the lasting management of social health and also of the environment (McMichael, 2002). In fact, this recognition will help change social and commercial practices and the importance to prevent or curtail the incidence of worldwide changes in the environment and their negative influences.

Human health can be influenced by climate change in two main ways (US EPA, 2023):

i. By altering the regularity of health issues that have been influenced by climatic or meteorological features.
ii. By causing unique or unexpected health issues in areas without any record of performance.

The influence of weather and climate on the health of man is important and diverse. These include clear threats from extreme temperatures and strong thunderstorm calls which could have a bleak appearance on the survival, circulation and behaviour of mosquitoes, ticks and rodents as carriers of sicknesses such as the West Nile virus or Lyme disease. They can as well be impactful on the value of water and food in certain parts disturbing the health of humans. Over and beyond, the effect of world climate change on psychological health and happiness is an integral portion of the programme on the global effects of climate on the health of man. A beneficial method to understanding how the change in climate disturbs health is to reflect the exact pathways that expose and can lead to human disease. The idea of the pathways for exposure is modified after its usage in chemical hazard evaluation, also in this setting defines the core ways by which climate change affects the health of humans (Figure 2). The pathways for exposure change with time and also in diverse positions, and climate change-related exposures can disturb diverse people and communities at varying degrees. Though frequently evaluated independently, contact with multiple climate change pressures can happen concurrently.

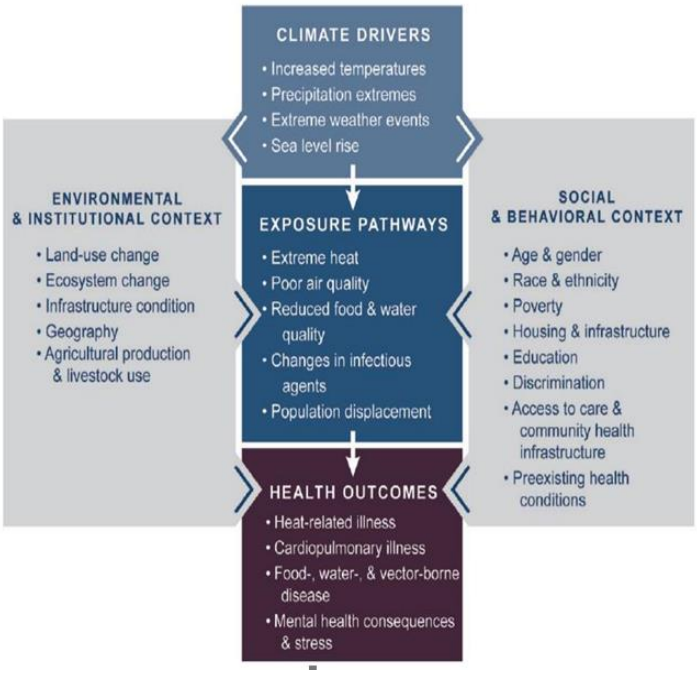

Figure 2: Theoretical illustration of the exposure pathways through which climate change affects human health
Source: Balbus *et al.*, 2016

The aim of the research on the effects of climate unpredictability and change on health is to gain a better knowledge of the possible threats and to detect measures to adapt which requires the expansion of experimental understanding in 3 ways:

i. The use of an ancient analogy for the evaluation, of definite populaces, the dangers of climate-sensitive illnesses (with knowledge of the mode of the outcome) and prediction of the probable health consequences of similar experiences in diverse geographical regions or in the future.
ii. Studies in search of initial indication of deviations, in either the pointers of health hazard or position, that happens in retort to real climate change.
iii. The Use of current information and philosophy to grow an empirical-statistical or biophysical model of impending health consequences involving definite climate circumstances of the change.

Currently, the issues of climatic change and health are of broad public health concern and occupy an increasingly important place in universal scientific works. More consideration from the scientific world is supported by a risin g awareness of problems within the scientific community society in general and the civic world. The expectation of a universal awakening by the public to the health hazards of climate change will hasten the emerging "sustainability change" that is required to safeguard the existence of development (McMichael *et al*., 2000), even outside that of equal alertness in other areas. The countless consequences of health on climate change can be classified into three wide classes; the direct, the indirect and the tertiary (Butler, 2014a).

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The Direct Impact

The impacts on health are directly attributed to climate variability, such as cardiovascular risks related to waves of heat or accident risks related to stronger and increasingly recurrent storms. Recently, it was found out that the IPCC has reported with great confidence that the current impacts of extreme weather events, including heat waves, droughts, floods, hurricanes and wildfires, which have previously subsided, leaving some ecosystems and various human systems vulnerable to currents and climate variability. These dangerous weather measures have the greatest influence on susceptible groups which include the indigent and the aged, although adverse human health impacts can be mitigated to some level through technical and societal intermediaries (enhanced municipal strategy and raising values) (Santamouris, 2013; Birkman *et al*., 2010). Despite the technical controversy that the observed increases in the waves of heat, wildfires, etc., the negative harvests in Eurasia in 2010 were unintentional or exacerbated. The subsequent increase in world grain prices also had indirect impacts on the health of humans and the security of food for susceptible people globally (Johnstone and Mazo, 2011). For example, the impacts of climate change on water, the security of food and life-threatening weather measures have a direct impact on global public health (Costello *et al*., 2009).

The Indirect Impact

Climate change and fluctuations have indirect effects on health. The aetiology of these impacts is extensive and variable, such as changes in the distribution of infectious disease vectors and the pollution of air combined with the waves of heat. Leaf (1989) addressed the varying ecology of disease vectors although the health impact of climatic change on vector-borne diseases was questioned by some environmentalists and disease professionals (Lafferty, 2009; Randolph, 2009; Gething *et al*., 2010). The dispute is finally displaying some signs of abating the most dominant vector-borne diseases, in addition to malaria. An agreement is evolving that these risks are increased by climate change (Siraj *et al*., 2014), although technological developments, control and treatment together can lessen the disease burden such as malaria (Feachem *et al*., 2010).

Climate change contributes directly to the infrastructural destruction of human shelters and causes human death and disease, including the psychological health and well-being of those who survive (IPCC, 2014d). At all phases of growth, these effects are coupled with unpreparedness for climate change in some segments; the most significant appearances will affect the underprivileged and most exposed inhabitants (IPCC, 2014d).

The Tertiary Impact

In diverse ways, the most vital health hazard related to climate change is the tertiary impact (Butler, 2014b). They comprise the health effects of widespread starvation, compulsory migration and human conflict triggered by the geophysical and ecological penalties of climate change, such as disruptions to ecosystems, rising sea levels and lasting interruptions to the production of food and water. Unexpectedly, this category of impact has received little or no attention over the past few decades, even in the most recent IPCC assessments from 2014. The variety, creation, allergenicity, supply, and timing of airborne allergens can be changed as a result of climate change and these changes add to the harshness and frequency of allergic diseases in humans, higher CO_2 levels and temperatures changes (Ziska *et al*., 2019). For instance, a current study on climate change in America discovered that the increasing temperatures, changing precipitation outlines, etc. should increase the levels of CO_2 in the atmosphere and thus increase the levels of some substances in the air. They compared allergens and the related increase in asthma and other allergic diseases in a climate-free future. Some previous studies which employ municipal zones as an indicator of advanced temperatures and CO_2 have also discovered previous flowering of pollen species, which can result in an overall extended pollen season (Neil and Wu, 2006; George *et al*., 2007).

Our Fluctuating Health

Valuations of the health effects of climate change are essential to build on the knowledge of the present state and practical drifts across an extensive range of health environments, this is necessary in understanding the nature at which climate change causes health problems. Furthermore, valuations of climate change health effects should be based on predicted changes in these features since pre-existing health circumstances, socioeconomic status, and lifetime phase add to susceptibility to climate- and weather-associated health impacts. In situations where the health of people or socioeconomic standing is deteriorating, climate change might exacerbate the burden of health linked through these deteriorating inclinations.

On the other hand, if socioeconomic status or the health of individuals improves, climate change may limit development. Where the nature of the scientific knowledge permits, the integration of predicted health trends and socioeconomic conditions into copies of climate change effects on health can offer beneficial perceptions of the connections between non-climatic issues and climate impacts.

A complex set of risk factors determines if one is unprotected from a health danger or suffers an illness or additional hostile health consequences due to such exposure. Susceptibility is the tendency to be affected by climate-associated health effects and includes three components: exposure, vulnerability or susceptibility to damage, and the ability to acclimatize. Because many fields make use of these terminologies in different ways and there are many descriptions in the literature, the differences among them are not constantly clear (Gallopin, 2006). These three elements are subject to change with time and are site and system-specific (Smit and Wandel, 2006).

A person's contact with one or additional biological, psychosocial, chemical, or physical stressors, including stressors influenced by climate change is defined as exposure. The interaction may arise one or more times with time and may happen in a solitary place or in a greater geographic location.

The extent to which climate variability or change affects people or communities both negatively and positively is referred to as sensitivity. Adaptability is the capability of people to adapt to possible threats, seize opportunities, or retort to values. A correlated terminology, flexibility, is the capability to effectively make, design, absorb, recuperate from, and adjust to hostile measures.

Factors that function at many points, from the distinct and public to the national level that affect all people to some degree is

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susceptibility (Smit & Wandel, 2006). For a person, these factors comprise human behavioural choices and the extent to which that individual is exposed depending on their level of exposure, vulnerability, and adaptability. Susceptibility is likewise influenced by social factors of health, including those that affect an individual's ability to adapt, such as social capital that drives overlapping or sequential health outcomes.

The pressures of climate change can also collect with time and lead to lasting changes in flexibility and health. Worldwide climate change would affect human health in different complex, large and immediate ways and at diffe rent times. Likewise, impacts would vary geographically depending on the environment, topography and exposure to local populations. The effects would be equally positive and negative (even though scientific experience suggests that is likely to be mostly negative). This is not surprising given that climate change would interrupt or else modify many natural ecological and physical systems essential to sustaining life on Earth and humans are helping to alter the circumstances of life on Earth. The key pathways and types of climate change impacts on health are shown in Figure 3.

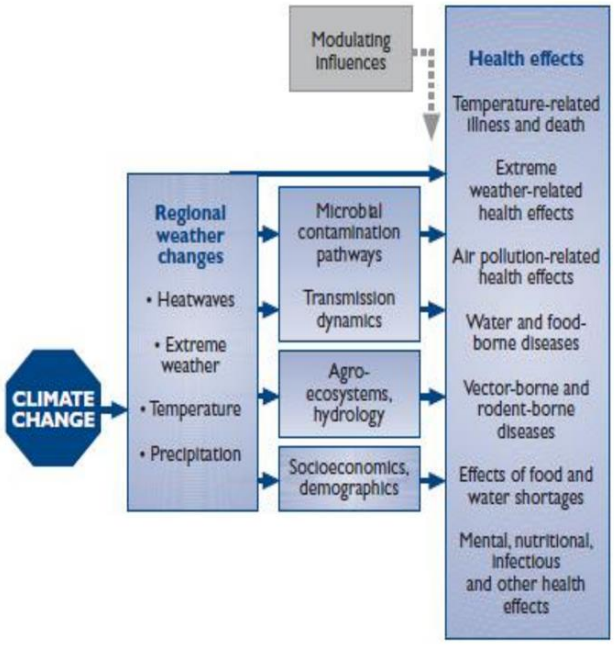

Figure 3: Pathways through which climate change affects human health
Source: Patz *et al.,* 2000

Climate Change and Biodiversity

Climate change has arisen for a longer period, in a far less tarnished and uneven landscape compared to nowadays and with much fewer or no burden from human activities up until the onset of industrial development. The disintegration of the habitation has limited several species to moderately minor zones of their former range, consequential in abridged genetic inconsistency (Parmesan and Mathews, 2006) and further structural and compositional changes (CBD, 2009). Warming outside the Pleistocene maximum temperatures will remain to pressurize biodiversity and ecosystems more than climate change has in the ancient evolution (Templeton *et al*., 1990; Parmesan, 2006). The effects of climate change on biodiversity occur at diverse scales (such as microbial, individual, population, species, community, ecosystem and biome levels) with dissimilar responses at each scale (Bellard *et al*., 2012; Parmesan and Martens, 2009. For instance, an increase in temperature associated with a reduction in the supply of rainfall can lower freshwater heights in lakes and rivers (Campbell *et al*., 2009). Fish stocks redistribute poleward and the tropical oceans become relatively less diverse with warmer temperatures (CBD, 2010). Drought could lead to the disappearance of some tree species, which in turn will have significant impacts on the building of vegetation and species structure (February *et al*., 2007).

Association between Biodiversity and Health Links

The health of humans is subject to ecosystems aimed at elements that are vital to the health of humans and well-being (fresh water and food). The environmental roles and procedures which result in the ecosystems provided benefits, as well as sanitizing water and air, control of pests and illnesses, pollination, fertility of soil and flexibility to climatic change are all supported by biodiversity. In addition, different foods, important nutrients and medicines are supplied by numerous species and genotypes of organisms. When not properly managed, biodiversity can occasionally be a basis for disease-causing organisms and can worsen adverse health consequences. Hence, the health, source of revenue, and sustainability of public health interferences can be strongly influenced by the associations between people and biodiversity.

Health and biodiversity can be affected both separately and combined by drivers of change. Land use change, loss of habitation, overutilization, contamination, the advent of invasive species, and climate change are all direct drivers of biodiversity loss, which distress the health of humans directly and through their influences on biodiversity. For illustration, biodiversity loss depends on air and water which also have direct toxic effects on health.

Conclusions

The universal depletion of the lower and middle atmospheric natural systems (such as the fertility of the soil, aquifers, ocean fisheries and overall biodiversity) comes across unaccustomed human-imposed changes that affect the world's population. There remained little consciousness that such significant ecological alteration would wane the support for a strong life notwithstanding early acknowledgement that such variations would affect commercial events, infrastructure and achieved ecosystems. Human civilizations have degraded local ecosystems and altered local climates over the years. The collective human impact has reached a worldwide measure without a model that reproduces the current speedy upsurge in population size and energy-intensive, high-throughput, mass consumption.

Variations in the health danger caused by universal climate change can be equally positive and sensitive and can happen at the population, community and individual levels. An inadequate chance to transfer an initial appraisal of adaptation choices will be available to represent a climate change global experiment which necessitates a sturdy circumstance for carefulness, together in justifying climate change and in acclimatizing to its effects. Additional scientific study on the relations between biodiversity and health in order to seal scientific breaches, create further unified data, monitoring and pointers, and for wider distribution of these

results necessitates a vital need.

There is adequate knowledge to support several "no regrets" measures yet further research is imperative such as investment in nature-dependent results, (the incorporation of biodiverse green spaces in municipal growth, refining accessibility of and availability to various foods, constriction regulators and explaining the usage of antimicrobic therapies, pesticides and other biocides; exploiting the health profits of experience to biodiverse environments; and better monitoring of environmental change in line with the "One Health" method).

Once biodiversity and health associations are mainstreamed into general policies and programmes, new opportunities for nature-based results for consolidating flexibility and facing key social tasks which disturb the health of humans, such as the insecurity of food and water, climate change, tragedy hazard, and societal and commercial inequality will be made available. Certainly, if attention is given to worldwide climatic-environmental hazards to human population health, it will produce an essential part in the sustainability conversion dispute. In addition, the comprehensible and effective application of the 2030 program for sustainable growth and its accomplishment will depend on the links between health and biodiversity.

REFERENCES

Balbus, J., Crimmins, A., Gamble, J., Easterling, D., Kunkel, K., Saha, S. and Sarofim, M.(2016). Introduction: Climate Change and Human Health. In book: The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (pp.25–42). Publisher: U.S. Global Change Research Program.

Beaumont, L. J., Pitman, A., Perkins, S., Zimmermann, N. E., Yoccoz, N. G. and Huiller, W. (2011). Impacts of climate change on the world's most exceptional ecoregions. *Proceedings of the National Academy of Sciences, 108*(6):2306–2311.

Butler, C.D. (2014a). Climate change and global health: a new conceptual framework-Mini Review. *CAB Reviews,* 9:027.

Butler, C.D. (ed.) (2014b). *Climate Change and Global Health*, Wallingford UK, Boston, US: CABI.

Birkmann, J., Garschagen, M., Kraas, F. and Quang, N. (2010). Adaptive urban governance:New challenges for the second generation of urban adaptation strategies to climate change. *Sustainability Science,* 5(2):185–206.

Bellard, C., Bertelsmeier, C., Leadley, P., huiller, W., & Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecology letters*, *15*(4):365–377.

Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., Friel, S., Groce, N., Johnson, A., Kett, M., Lee, M., Levy., C., Maslin, M., McCoy, D., McGuire, B., Montgomery, H., Napier, D., Pagel, C., Patel, J., Puppim de Oliveira, J.A., Redclift, N., Rees, H., Rogger, D., Scott, J., Stephenson, J., Twigg, J., Wolff, J. and Patterson, C. (2009). Managing the health effects of climate change: lancet and University College London Institute for Global Health Commission. The *Lancet,* 373(9676):1693–1733.

Convention on Biological Diversity (CBD) (2010). *Global Biodiversity Outlook 3.* Secretariat Of the Convention on Biological Diversity, Montreal.

Convention on Biological Diversity(CBD) (2009). Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Montreal, Technical Series 41:26 pages.

Convention on Biological Diversity (CBD) (2003). Interlinkages between biological diversity and climate change. *Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto protocol.* Montreal, SCBD, 154 pp. (CBD Technical Series no. 10).

Campbell, A., Kapos, V., Scharlemann, J. P.W., Bubb, P., Chenery, A., Coad, L., Dickson, B., Doswald, N., Khan, M. S.I., Kershaw, F. and Rashid, M. (2009). *Review of the Literature on the Links between Biodiversity and Climate Change: Impacts, Adaptation and Mitigation.* Secretariat of the Convention on Biological Diversity, Montreal. Technical Series 42:124 pages.

Feachem, R., Phillips, A.A., Hwang, J., Cotter, C., Wielgosz, B., Greenwood, B.M., Sabot, O., Rodriguez, M., Abeyasinghe, R., Ghebreyesus, T. and Snow, R. (2010). Shrinking the malaria map: progress and prospects. The *Lancet,* 376:1566–1578.

Gallopin, G.C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change,* 16**:**293-303.

Gething, P.W., Smith, D.L., Patil, A.P., Tatem, A.J., Snow, R.W and Hay, S.I. (2010). Climate change and the global malaria recession. *Nature,* 465:342–346.

George, D.G., Hurley, M.A. and Hewitt, D.P. (2007) The impact of climate change on the physical characteristics of the larger lakes in the English Lake District, *Freshwater Biology,* 52:1647–1666.

Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2001: Third Assessment Report (Volume I).* Cambridge, UK Cambridge University Press, 2001.

Intergovernmental Panel on Climate Change (IPCC) (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., and White, L.L. (Eds.), 1132 pp. Cambridge University Press, Cambridge, UK and New York, NY.

Intergovernmental Panel on Climate Change (IPCC). (2014d). Summary for policymakers. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability.* Part A: Global and Sectoral Aspects. Contribution of *Working Group II* to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J.Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy,S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1–32.

Johnstone, S. and Mazo, J. (2011). Global Warming and the Arab Spring. *Survival,* 53:11–17.

Lafferty, K.D. (2009). The ecology of climate change and infectious diseases. *Ecology,* 90:888–900.

Leaf, A. (1989). Potential health effects of global climatic and environmental changes. The *New England Journal of*

DOI: https://dx.doi.org/10.4314/swj.v18i2.18

Medicine, 321:1577–1583.

McMichael, A.J. (2001) *Human frontiers, environments and disease.* Cambridge, UK, Cambridge University Press, 2001.

McMichael, A.J. (2002). Population, environment, disease, and survival: past patterns, uncertain futures. *Lancet,* 359:1145–1148.

Neil, K. and Wu, J. (2006). Effects of urbanization on plant flowering phenology: A review. *Urban Ecosystems*, 9:243–257

Parmesan, C., Duarte, C., Poloczanska, E., Richardson, A.J. and Singer, M.C. (2011). Overstretching attribution. *Nature Climate Change,* 1:2–4.

Patz, J.A., Graczyk, T.K., Geller, N. and Vittor, A.Y. (2000). Effects of environmental change on emerging parasitic diseases. *International Journal of Parasitology,* 30(12–13):1395–1405.

Parmesan, C. and Matthews, J. (2006). *Biological impacts of climate change. Principles of Conservation Biology*. Sinauer Associates, Inc. Sunderland, Massachusetts 333–374.

Parmesan, C. (2006). Ecological and evolutionary responses to recent climate change. *Annual Review of Ecology, Evolution, and Systematics,* 637–669.

Parmesan, C. and Martens, P. (2009). Climate change, wildlife, and human health. In SCOPE/DIVERSITAS Assessment: Biodiversity Change and Human Health: From Ecosystem Services to Spread of Disease, Island Press.

Pereira, H. M., Leadley, P. W., Proença, V., Alkemade, R., Scharlemann, J. P., Fernandez-Manjarrés, J. F., Araújo, M., Balvanera, P., Biggs, R., Cheung, W., W., L., Chini, L., Cooper, H., D., Gilman, E., L., Guénette, S., Hurtt,G., Huntington, H., Mace, G., Oberdorff, T., Revenga, C., Rodrigues, P., Scholes, R., Sumaila, U. & Walpole, M. (2010). Scenarios for global biodiversity in the 21st century. *Science,* 330(601):1496–1501.

Randolph, S.E. (2009). Perspectives on climate change impacts on infectious diseases. *Ecology,* 90:927–931.

Rockström, J., Steffen, W., Noone, K., Persson, Å., F. Stuart Chapin, I., Lambin, E.F., Lenton, T., Scheffer, M., Folke1, C., Schellnhuber, H., J., Nykvist, B., de Wit, C., Hughes, T., vander Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R., Fabry, V., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen P. and Foley, J. (2009). A safe operating space for humanity. *Nature,* 461:472–475.

Romanelli, C., Cooper, H.D., Campbell-Lendrum, D., Majero, M., Karesh, W.B., Hunter, D. and Golden, C. (2015). Connecting Global Priorities: Biodiversity and Human Health, a State of Knowledge Review. World Health Organization and Secretariat for the Convention on Biological Diversity. Editor: Inís Communication. ISBN: 978 92 4 150853 7.

Shivanna, K.R. (2022). Climate change and its impact on biodiversity and human welfare. *Proceedings of the Indian National Science Academy,* 88(2): 160–171.

Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change,* 16**:**282- 292. http://dx.doi.org/10.1016/j.gloenvcha.2006.03.008

Santamouris, M. (Ed.). (2013). Energy and climate in the urban built environment. Routledge. Schiedek, D., Sundelin, B., Readman, J. W., & Macdonald, R. W. (2007). Interactions between climate change and contaminants. Marine Pollution Bulletin 54(12):1845–1856.

Templeton, A. R., Shaw, K., Routman, E. and Davis, S. K. (1990). The genetic consequences of habitat fragmentation. *Annals of the Missouri Botanical Garden,* 13–27.

United States Environmental Protection Agency (US EPA), (2022). Climate Change Indicators: Weather and Climate**.** https://www.epa.gov/climate-indicators/weather-climate. Accessed on 18th June, 2023.

United States Environmental Protection Agency (US EPA), (2023). Climate Change and Human Health. https://www.epa.gov/climateimpacts/climate-change-and-human-health. Accessed on 18th June, 2023.

Watson, R.T., Dixon, J.A., Hamburg, S.P., Janetos, A.C., *et al* (1998). *Protecting our planet, securing our future. Linkages among environmental issues and human needs*. UNEP, NASA, World Bank, 1998.

Ziska, L.H., Blumenthal, D.M. and Franks, S.J. (2019). Understanding the nexus of rising CO_2, climate change, and evolution in weed biology. *Invasive Plant Science and management,* 12:2