



Climate Change and Biodiversity: A Review on Understanding the Global and Local Impacts of Warming on The Ecosystems

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Abstract: *Some living organisms have been eliminated in some ecosystems, while some diseases have recently been caused due to extreme climate changes nowadays which have been affected by greenhouse gases which disturb the ecosystems. To an extent, the temperature of Earth's planet has increased markedly over the last 100.000 years. This increment can strongly affect the normal existence of a large number of living beings such as animals, plants, and microorganisms. Human life span has been decreased due to the harsh conditions in ecosystems and as one of the consequences of global warming; besides the pathogens, like bacteria, viruses and parasites, have become more resistant to disinfectants and to novel antimicrobial agents much more than before. The production and cultivation of some crops and numerous plant species become harder as a result of high salinity and decreases rainfall. Since 2007, forestation and drought have been the most obvious manifestations in many countries, especially in Iraqi lands leading to the migration of people and some animals like birds away from them. Cattle and some animals like deer and fish have been in a limited number tending to extinction in some Iraqi areas. This review has been prepared to document the global and local impacts of climate change on biodiversity.*

Keywords: *biodiversity, global warming, climate change, ecosystems, Iraq.*

1.Introduction

As the earth's crust changes, the moderating effect of the living-nonliving balance is interrupted, which influences species extinction, even though it is considered a natural phenomenon [1]. However, some organisms have a definite life span, especially

when they face harsh climate conditions and fail in adaptation, resulting in accelerated extinction within a few years rather than longer [2] Some human beings' life span in earlier periods were between 60-80 years in natural ecosystems [3]. However, in the last few years, it has decreased because of interference from new environmental situations [4]. Habitat loss is also a serious problem that causes the threat

of species to be extinct, either by human activities or destruction by nature. Deforestation can satisfy human needs but decreases the population of some animal and plant species, which cannot further adapt to the new living habitats [5].

The main objectives of this review are to conserve biodiversity, encourage the survival of various species, maintain the overall ecological balance by supporting undesirable ecological processes, utilize sustainable resources to promote a peaceful interaction between living and non-living elements and prevent the extinction of plant and animal species. By achieving these goals, we can ensure the preservation of our natural environment and promote a sustainable future.

Biodiversity:

Biodiversity refers to the variety of living organisms such as microorganisms, plants and animals within a specific given area. Biodiversity is divided into biological diversity, which deals with living things and non-biological diversity, which means a variety of ecosystems. The genes of living organisms in specific ecosystems can also be considered because these organisms form a part of these areas [6]. Biodiversity has three levels of diversities: genetic, species, and ecosystem diversities [7]. Genetic diversity refers to the forms of living things that the ecosystem contains, the breeds, varieties, or races of the same species; for example, the different colors of butterflies to adapt to the environment [4].

The second level is species diversity which refers to the number of species represented in each community. It also refers to the number of species per unit of the area, which is called species richness and can be related to the species biodiversity [8], in addition to the species abundance, which deals with the number of individuals per species in a community. In another term, "Relative Abundance," of species refers to how common or rare species are relative to other defined species in a certain community [9]. The third level of diversity is the ecosystem which refers

to the north or south areas. As an example, regardless of the species types they both contain, dealing with the temperature and rainfall or other climate conditions [10].

Biodiversity is important as it affects creatures' distribution in the following areas: tropical rainy forests, deserts, boreal forests, and grasslands as a form of ecosystem diversity. Species diversity is related to organisms (such as algae, bacteria, fungi, etc....) according to their features to adapt to the given area and interact with it [3]. As a result, genetic diversity will be related to the races of these living organisms to distinct populations from the species to the detailed characteristics within the species giving the external and internal evolutionary level of individuals, which can be tightly linked to the outer changes in the ecosystem [5].

Measurements of Biodiversity:

Biodiversity can be measured in three terms: alpha, beta and gamma. Alpha biodiversity can be applied within the area to measure the number of abundant species, while beta biodiversity compares two distinct ecosystems as several species. Meanwhile, Gamma biodiversity measures the overall diversity within a large region on a geographical scale [8].

The measurement of biodiversity in alpha, beta, and gamma forms can result in the following values [11]:

- 1) Ecosystem-ecological values include nutrients, energy, pollution breakdown, and stability.
- 2) Biological values, such as food, medicinal plants, pharmaceutical drugs, breeding stocks, and genomics of species.
- 3) Social values include research, education, tourism, and cultural values.

Biodiversity loss:

Recently, biodiversity has been lost due to many factors. Those factors can be categorized into two main causes: natural factors and man-made factors [6]. Natural factors include floods, earthquakes, landslides, pollination lakes, and diseases. Meanwhile, man-made

causes include anthropological habits, invasive species, over-exploitation species, human overpopulation, genetic pollution, global warming, and climate change [12].

Climate change:

Climate change is one of humanity's most serious threats, putting the functioning of natural systems that sustain human health at risk [1]. In the Anthropogenic environment, human activities have significantly altered the Earth through global warming, habitat loss, and changes in the atmosphere. Based on a moderate emissions scenario that reflects little change from today's development patterns, the average global temperature will rise by 2.1–3.5 °C from preindustrial levels, which is above the 1.5–2 °C threshold set by the 2015 Paris Agreement [13] (Figure 1). Although many countries are committed to reducing carbon emissions and waste at the 26th United Nations Climate Change Conference and still aim at net-zero emissions, these commitments are insufficient to reach the target of keeping global warming within 1.5 °C above preindustrial levels [5]. Despite the scientific evidence, the gap between what we know and what we do in practice and political inaction continues to prevail. The co-occurrence and synergistic interaction of climate change, loss of biodiversity, and effects on food production have an exponential multiplier effect on human health compared with when these conditions are experienced separately. For example, food production and processing, retail, distribution, consumption, and food waste contribute to climate change through the emission of greenhouse gases [2].

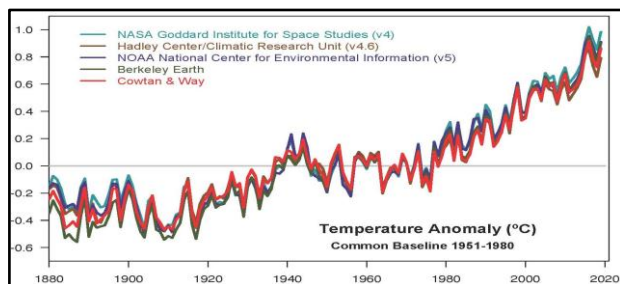


Fig. (1) Average temperature changes of the Earth's planet [14].

Climate change has had a big impact on the landscape, dramatically increasing over the last few decades. It is a serious global challenge that the entire world is concerned about the impact of warmer temperatures and higher rainfall with severe floods [1]. Heat waves have become more frequent and severe. Climate change causes biodiversity to move towards its minimum limits of life and be in the wrong place for crops relying on producing fewer yields [15]. Experts concluded that the extinction of animals becomes more life-threatening in the changing climate and pollution crisis [16]. One million animal species are at risk of becoming extinct. Food and drinks are also limited to these creatures as they relate to ecosystem changes. Recent documents have referred those human actions degraded 97% of global biodiversity. These costs more, need more effort to maintain biodiversity [2].

Via conferences and communiqués, global communities are working together to alarm about the serious issue of losing biodiversity and food insecurity. After all, crops and some plants are no longer protected. Scientists also predicted that humans can interact with some wild pathogens at faster, interact with some wild pathogens faster, which can harm health and socioeconomic status [17].

Causes of climate change

The climate is constantly in change through geological time perspectives and has been in many cycles since the ice ages, affecting the species of our planet. Simultaneously, climate change is a natural process that leads to the extinction of some creatures like what happened to the dinosaurs [11]. However, scientists have focused on a concise period, just after the industrial era, which is the time when human activity started the cause of a lot of impact on the environment and the climate [4].

One of the examples of the impacts of climate change in the preindustrial age, about 300 years ago, was the vast tracks of forests.

Lots of amazing bio diversities occurred simultaneously with human activity related to energy [10]. Resources were everywhere and humans were able to reach these resources. There were only small urban populations that had huge wild areas in which carnivores were still present rampantly in terms of agriculture was mainly subsistent agriculture, so people planted their own needs [5].

Later on, in the industrial age, challenges for providing human things and amenities at the same time lots of diseases appeared. Many machines were suddenly invented to help humans by using energy fossil energy that was stored on the Earth, such as petrol, which was extracted and used in such machines and factories, leading to pollution and emotion to the atmosphere [9], in addition to the need for fertilizers and pesticides for modern agricultural strategies of crops for growing populations [16]. Then, the need for more and more land encroached on the natural habitats of wild animals and plants via intensified agriculture and transportation. Diagrammatically, the postindustrial age represented large-scale industries with large urban populations and limited areas of wildness [15] in as Figure(2).

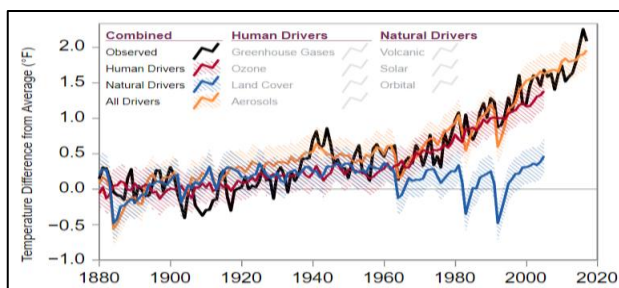


Fig. (2) Human and natural influences on global temperature (U.S.). [18]

Impact of climate change

Apart from resource depletion and degradation of natural spaces of creatures, the emitted greenhouse gases into the atmosphere, such as carbon dioxide methane which are generated from agricultural activities and nitrous oxide from the fertilizers of crops, are the main three greenhouse gases as in Figure 3. Gradually these gases were admitted to the

atmosphere in huge amounts even though they are necessary to trap the sun's energy to keep some heat so we can live and thrive on the earth's planet [19].

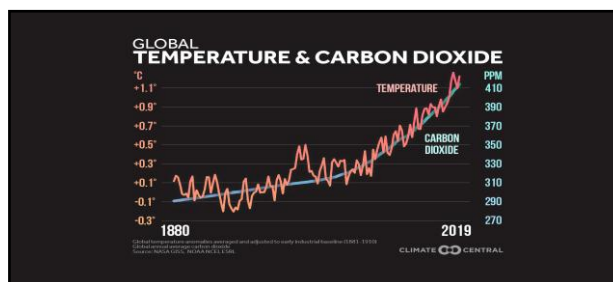


Fig. (3): Global temperature and carbon dioxide levels during the previous periods [20].

However, the balance of atmospheric gases was tipped because the mentioned three gases were released more than accepted limits; so, the heat has been more trapped since the 1980s, until the warmest decades in the recorded data the 1990s and dramatic 2000s [19].

In this millennium, the same pattern showed evidence that the Earth's average temperature is rising (20). This raised temperature leads to elevated humidity and air temperature near the surface with high temperatures of the oceans, sea surface water, and over lands, resulting in the melting of glaciers and sea ice and an increase in seawater amount as in Figure (4). [12].

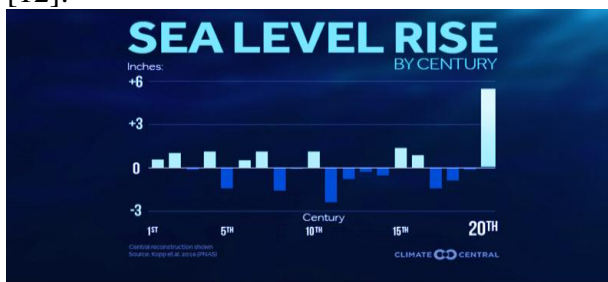


Fig. (4): Sea level rise for one century [21].

Pollution can also negatively affect the biodiversity of many organisms as a big threat to the life of wild plants and big animals. Surviving organisms are unlikely to be alive if the causal factors of climate change continue. Removing or disturbing any part of the ecosystem can strongly affect the functions of

these resources, such as those in the food chain or animal shelters [9].

Climate change impacts biodiversity

Biological diversity plays an important role in forming soil and nutrition or moisture. Therefore, the loss of diversity in animals or bacteria through cleaning these areas can reduce productivity, either by human anthropological habits or climate disorders [3]. Some organisms can be conserved through biodiversity by examining the importance of variation to prevent species extinction. It seems essential to maintain the global food chain and conservation of animals or plants on Earth [22].

Some surrounding factors like pesticides, chemicals, people's behaviours, climate, and environmental factors directly impact the limited species of animals and plants, in addition to microorganisms [4]. Contribution to the climate and vegetation influence can be obtained by rainfall and recycling vapor at a steady rate to maintain water in the atmosphere; therefore, vegetation depends on the climate and some organisms for the sustainability of breeding plants [10]. Ecosystem relationships with animals and plants refer to a web of connections among non-living and living organisms because surviving organisms can maintain the balance of atmospheric gases and soil moisture in addition to complex relationships with microorganisms in each environment [19].

Biodiversity is responsible for 1,5 million organisms on Earth, which is very important to living organisms. Biodiversity refers to the huge variation of life on Earth, which gives life forms in extremely cold regions, hot deserts, tropical forests, tropical forests, and ocean organisms.

For example, in food-producing animals, only two out of nine species can be domesticated nowadays; people can consume cattle and chickens on a large scale [22]. Fish are less to be domesticated even if they have been grown on farms by modern agricultural techniques. Plants, on the other hand, are consumed by a very small proportion of

people; therefore, fewer species, such as wheat and rice, form two-thirds of the food supply compared to other plants [13].

Turtles that come to beaches to nest are critically endangered due to human activities and fishing activities, so these turtles either die or their eggs are poached, threatening the survival of their species [6]. Climate change affects them during the nesting season and turtles that are born at beaches on high-temperature lands make the sex ratio affected as the turtles lay on their legs depending on the coast temperature, which is not preferable and threatens their viability [23]. In addition, the ability of new turtles to swim into the open seas is impeded due to hotter temperatures, so these species can fall prey to big fish around easily and their survival becomes threatened [22].

Other examples of climate change impacts on biodiversity are the species number which has been reduced to a critical level and the natural habitats have drastically minimized. Some examples of these animals are Cheetahs, Sloth bears, Elephants, Indian wild ass, Chinkara, and Lion-tailed macaques. Plants that are under extinction are carrots, chilies, turnips, and some crops [1, 22] (Figure 5).

Orangutan mammals are also affected by climate change, which already compounds the existing activities imposed upon them with the fragmentation of their habitats, which would be changed to agriculture or used lands [7]. The raised temperature allows forest fires to become greater and affects fruiting periods, which these orangutans rely on. Climate change is also causing extreme weather and rainfall patterns, which dramatically change to more rainfall at certain times of the year, and less rainfall at other times of the year causing almost dry spells that were not found in the past [3]. The annual rainfall does not remain the same but drastically changes, affecting the fruiting and flowering periods and eventually the food source that animals depend on [12].

These kinds of impacts and habitats and food loss will also threaten other animal species. Aquatic habitats, which corals various corals

occupy, usually represent biodiversity coral reefs, which would be stressors due to the pollutants resulting from human evolutionary patterns that affect their viability [22]. Besides the negative impact of high temperatures on oceans as they are the natural carbon sink the high amounts of carbon put into seas and oceans are being absorbed by its water started causing acidification in these oceans, lowering the pH levels. When this happens, it would be difficult for calcification to occur, which promotes coral growth and becomes stunted [23].

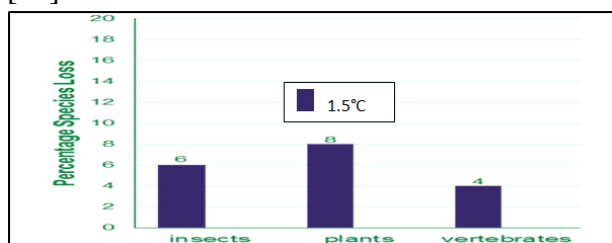


Fig. (5): Loss of different living organisms due to global warming [24].

Another effect of global warming is the sea, temperatures are elevated as well beyond certain optimal ranges resulting in coral leaching because the algae that is in the coral reefs, which provide colours and nutrients for the growth of the corals, get expelled out [23]. Fish that use the coral reefs as their spawning ground will lose the area of breeding and nursery as in Figure 6. [17].

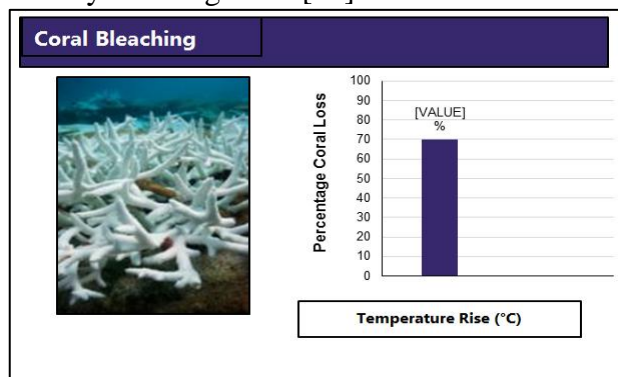


Fig. (6) Coral bleaching due to high sea temperatures [25].

Forest fires can minimize terrestrial animals' habitats in forests with increasing temperatures. The shifting ranges and distributions can be seen in mountain areas where migrated animals are located with no other areas. likewise, in

conditions of sea levels rise encroaching upon the high lands with not enough space for biodiversity to move as they finally lose their original habitats and ability to live [7, 12]. Another thing, diseases can result from changing climate, bringing about various types of pathogens in a complex manner [13].

An example of tree diseases from the United States is the dramatic loss of the pine tree (pine nuts) which results from warmer winters, severe drought, incidences, heat waves and frequent fires making the pine tree produce fewer saps which are considered defense mechanism against pests which are themselves have less winter mortality because the winter nowadays is warmer and have two life cycles instead of a single one [1]. So, the population of pests, like beetles, becomes higher and can attack the pine trees easily. At the same time, attacked and dead trees with elevated greenhouse gases can increase the risk of forest fires, releasing more carbon into the atmosphere [5]. Another example from the United States is the moose with warmer and shorter winters, as more ticks (more than 15,000 new types of ticks) can stick to moose skin, leading to the loss of blood, making the moose anemic and starting to lose hair from scratching areas of the skin [26] with the start of losing its body heat-declining moose population, especially during rainy times, compounding with many other threats that moose species are already facing [17].

In microbiology, many pandemics have occurred recently in the world, potentially related to climate change consequences such as viral assembly, host interactions, and the function of new active viruses like Covid-19 [27], which in turn contribute to climate impact on virus behaviours, particularly those linked to biogeochemical cycles and biological products, which is a relationship between viral or microbial actions and global phenomena [16].

Local impacts of global warming on Iraq's agriculture and animal breeding: An overview:

The relationship between climate change and agriculture is very close as the most influential activity in Iraq and many other countries. The crop species are identified and their resistance is determined by heat, humidity, dust storms and water availability. Areas that can be cultivated with specific plants, including crops, were studied by [28] who mentioned that the climate elements and the atmosphere manifestations (like, wind, solar radiation, moisture and dust) can affect Iraq's rice and wheat production and cultivation. The study relied on eight climate stations of the productivity yield for the study years (2012-2022).

According to [29], more than 100000 acres have been lost as good areas for agriculture, in addition to that fishing boats decreased from 4000 to only 400 as a result of the high salinity of Shat Al-Arab. Temperature is strongly related to other climatic elements (like pressure, wind, humidity, evaporation and precipitation) as these elements significantly affect agriculture and animal breeding directly or indirectly; especially the temperature and rainfall [30].

According to [31], the absence of the ideal environment for some birds; like those living in Iraqi marshes besides drought, decreased water inflow and dust storms led to the migration of such birds. The extended areas of sand dunes make some cattle and water buffaloes and some kinds of fish decrease drastically due to high salinity and dried wetlands [32]. In Al-Salman protected area, only 61 deer are still alive out of the tens due to high temperatures and shortage of water in Iraq recently. Figure (7) illustrated the changed annual temperatures from 1901 to 2021, which results in drought with associated agricultural and environmental issues [33].

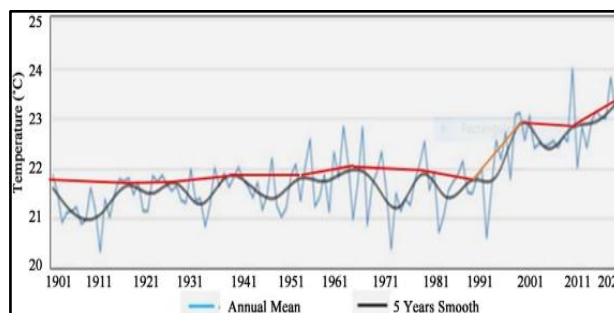


Figure (7): Mean annual temperature changes in Iraq for the period (1901-2021) [33].

Another harsh impact of climate changes on cultivated areas is changing these lands to residential sites or for charcoal production as people are forced to do this illegally due to water shortages for irrigation and domestic uses [34]. In short, climate change has very severe consequences in Iraq, mainly in rural areas. The decreased water inflow of Iraqi rivers, decreased rainfall, elevated temperature levels, immigration of some animals, and migration of some people towards cities and forestation are all these factors resulting in the ecosystem biodiversity of crops and animals and retrogression.

Conclusions:

Even though the industrial age has brought significant improvements for humanity, such as access to clean water, comfortable housing, reliable energy supply, better healthcare, medication, and public health measures; we are now facing serious challenges that endanger our survival. Climate change has started manifesting in various ways, including food insecurity, reduced crop yields due to unpredictable rainfall patterns, deteriorating air and water quality, and the insecurity of habitats for living beings. These climate changes can greatly impact the existence of all life forms and may even lead to a significant decline in their populations.

References

1. CSIR, (2012). Climate Change and Agriculture by National Botanical Research Institute, Lucknow. *Plants and Pollution*. 8 (2).

2. Farooq, M., Uzair, M. *et al.* (2022). Uncovering the Research Gaps to Alleviate the Negative Impacts of Climate Change on Food Security: A Review. *Frontiers in plant science*. doi: [10.3389/fpls.2022.927535](https://doi.org/10.3389/fpls.2022.927535)
3. Muluneh, M. (2021). Impact of climate change on biodiversity and food security: a global perspective a review article. *Agric & Food Secur.*10:36.
4. Tosun, J. (2022). Addressing climate change through climate action. *Climate Action*. 1:1.
5. Hartley, A. and Tandon, A. (2022). The impacts of climate change. *Earth and its resources*. doi: [10.3389/frym.2022.716479](https://doi.org/10.3389/frym.2022.716479)
6. Gienapp, P., Reed, T. and Visser, M. (2014). Why climate change will invariably alter selection pressures on phenology. *Proc. R. Soc.* 281: 20141611.
7. Ali, J., Rauf, M. *et al.* (2020). Mosquitoes and viruses are dual threats to Pakistan in the era of climate change. *Int. J. Biosci.* 16 (3): 375-383.
8. Kurup, R. (2021). Human Origin of Climate Change, Species Change, Pandemics and Human Extinction - Climate Change and Climate Change Diseases. A book. <https://www.researchgate.net/publication/350020660>
9. Adhikari, M., Longman, R. *et al.* (2022). Climate change impacts shifting landscape of the dairy industry in Hawai'i. *Translational Animal Science*. 6, 1–11.
10. Kemp, L., Xu, C. *et al.* (2022). Climate Endgame: Exploring catastrophic climate change scenarios. *PNAS*, 119: 34.
11. Petersen-Rockney, M. (2022). Farmers adapt to climate change irrespective of stated belief in climate change: a California case study. *Climatic Change*. 173:23. <https://doi.org/10.1007/s10584-022-03417-9>
12. Santos, M., Smith, A., Dekker, S., *et al.* (2021). The role of land use and land cover change in climate change vulnerability assessments of biodiversity: a systematic review. *Landscape Ecol.* 36:3367–3382.
13. Mauder, S. (2022). Climate Change & Heat. *Planetary health*. 23:2-9. <https://www.researchgate.net/publication/362280023>
14. Potter, S., Cabbage, M. and McCarthy, L. (2017). "[NASA, NOAA Data Show 2017 Warmest Year on Record Globally](https://www.nasa.gov/data/show/2017-warmest-year-on-record-globally)". (Press released).
15. Pimpalkhute, P. (2022). Is it the change in climate change or the change in approach of our interaction with climate causing impact? - The Global Stock take on climate change on adaptation and mitigation. A Review. <https://www.researchgate.net/publication/361207009>
16. Singh, D. (2022). Subtle Differences - Climate Change. <https://www.researchgate.net/publication/361431909>
17. Aguilar, C., Abdulhameed, S. *et al.* (2023). *Microbial Biodiversity, Biotechnology and Ecosystem Sustainability*. A Book. ©Springer Singapore, 1st edition.
18. -U.S. Global Change Research Program (2017). Fourth National Climate Assessment, Chapter 2: Our Changing Climate.
19. Mora, C., McKenzie, T., Gaw, I. *et al.* (2022). Over half of known human pathogenic diseases can be aggravated by climate change. *Analysis*. <https://doi.org/10.1038/s41558-022-01426-1>
20. NASA (2020). Received on 20 January 2023. (Press released).
21. Coastal flood days (2016). Scientific conference <https://www.climatecentral.org/outreach/alertarchive/2016CoastalFloodDays.php?market=NYC>
22. Kumar, C. (2022). Biodiversity, ecosystem services and climate change. <https://www.researchgate.net/publication/361924130>
23. Klerks, P., Athrey, G. and Leberg, P. (2019). Response to Selection for Increased Heat Tolerance in a Small Fish Species, With the Response Decreased by a Population Bottleneck. *Frontiers in Ecology and Evolution*. 7: 270.
24. Jennersten, O. (2023). Untitled by © Ola Jennersten/ WWF-Sweden licensed under CCBY.
25. Scoones, P. (2021). Bleached coral, Maldives by © naturepl.com / Peter Scoones / WWF licensed under CCBY.
26. Estrada-Peña, A. and Hubálek, Z. (2014). Tick-transmitted viruses and climate change. <https://www.researchgate.net/publication/312760941>
27. Weinbauer, M. and Peduzzi, P. (2020). *Aquatic Viruses and Climate Change*. A book. Chapter 7. © Caister Academic Press. 2nd Edition.
28. Al-Jashami, S. H., and Khudair, Z. H. (2022). Continental climate and its relationship to dusty

- phenomena and health effects in Iraq. *International Journal of Health Sciences*, 6(S4), 11608–11621. <https://doi.org/10.53730/ijhs.v6nS4.11677>
29. Merza , F. and Abul-Doanej , H. (2020). Some Classes of Phytoplankton in Iraqi waters. *Al-Kufa University Journal for Biology*, 12(2), 39–55. <https://doi.org/10.36320/ajb/v12.i2.11784>
 30. Yehia, M., Al-Taai, O. and Ibrahim, M. (2023). Spatiotemporal Distribution of Mean Temperature and Total Precipitation over Iraq for a Period (1980-2017). Fifth International Conference for Agricultural and Environment Sciences. *IOP Conf. Series: Earth and Environmental Science*. 1158 (2023) 032004 IOP Publishing. [doi:10.1088/1755-1315/1158/3/032004](https://doi.org/10.1088/1755-1315/1158/3/032004)
 31. Al-Jebory, Z., Al-Saadi, R., and Hussein, M. (2023). Drugs as corrosion inhibitors for the environment . *Al-Kufa University Journal for Biology*, 14(1), 48–54. <https://doi.org/10.36320/ajb/v14.i1.11747>.
 32. Jabar S., and Hussain, N. (2021). Review of Some Classes of epipelagic in Iraqi waters. *Al-Kufa University Journal for Biology*, 13(2), 17–27. <https://doi.org/10.36320/ajb/v13.i2.8221>
 33. Sissakian, V., Adamo, N. and Al-Ansari. N. (2023). The severe consequences of climate changes in Iraq: A case study. *Engineering*. 25:154019.
 34. Serih, K., and Abd Alkadhim M. (2022). Determination of Tetraethyl Lead in Gasoline fuel. *Al-Kufa University Journal for Biology*, 14(1), 38–47. <https://doi.org/10.36320/ajb/v14.i1.11743>