Environmental Science and Pollution Research (2021) 28:24872–24888
https://doi.org/10.1007/s11356-021-13139-7

REVIEW ARTICLE

Multidimensional analysis of global climate change: a review

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Received: 2 April 2020 / Accepted: 21 February 2021 / Published online: 24 March 2021

Abstract
Even though climate change involves much more than warming, it is the name given to a set of physical phenomena. It is a long-term change in weather patterns that characterises different regions of the world. The warming effect in the earth's atmosphere has dramatically increased through the influence of some heat-taping gases emitted by various human activities, especially fossil fuel burning. The more the input of such gases, the more will be the warming effect in the coming times. Global climate change is already visible in various parts of the larger ecosystems like forests, fisheries, biodiversity, and agriculture; however, it is now also influencing the supply of freshwater, human health, and well-being. This paper reviews climate change drivers, its global scenario, major global events, and assessing climate change impacts. The most daunting problem of economic and ecological risks, along with the threats to humanity, is also discussed. The paper further reviews the species' vulnerability to climate change and the heat waves and human migration vis-à-vis climate change. Climate change politics and coverage of climate change episodes in mass media is the special focus of this review that concludes with a few mitigation measures.

Keywords Climate change · Global warming · Drivers · Effects · Mass media coverage · Mitigation measures

Understanding of climate change

Although climate change includes much more than warming, it is the name given to a set of physical phenomena and a public policy issue, often called global warming (Weber and Stern 2011). Scientists have been guided by physical evidence in the atmosphere and space to recognise that many reasons lead to the earth's long-term climate change (Britt n.d.). The examples include solar radiations, the earth's solar orbit, volcanic activity, ocean currents, and even the tectonic flats (Leiserowitz 2007). A process of collective learning based on the accumulation of observational information; the creation of hypotheses, theories, and patterns of synthesis of knowledge; and their subjective empirical tests (National Research Council 2010) has developed the scientific understanding of climate change over more than 150 years. Although, a deeper public understanding has emerged on some critical aspects of climate change since the late 1990s. A survey conducted by Leiserowitz et al. (2011) showed that American climate change concerns were still at a moderate level, distinguished by the perception that potential changes were more global but not inherently local. This finding was reinforced by a different question that asked Americans to rank the local or global impact areas explicitly. In the study, 68% of respondents showed more significant concern for human and non-human nature throughout the world. In contrast, their concern for themselves, their families, and their local communities was intense for 13% of respondents (Seymour 2008). It indicated that the concept of global warming had been embraced as a contemporary issue of concern by many Americans, and many people are less sure about it. Some of Leiserowitz's most exciting data further elaborated that, while 71% of Americans believe global warming is happening, only 48% believe there to be a scientific consensus on why it is happening with a substantial discord on the matter (Leiserowitz 2007) in 40% people.

Regarding the state of scientific work in climate change, every six to seven years, a review (Cook 2019) is released by the Intergovernmental Panel on Climate Change (IPCC n.d.).

Responsible Editor: Philippe Garrigues

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Over the last few decades, their statements on the human contribution to recent global warming have grown significantly from a discernible human influence on the worldwide climate change in the Second Review Report (Houghton et al. 1996) to the dominant cause of the observed warming since the mid 20th century in the fifth review report. Additionally, the number of other experiments attempted to measure the level of agreement between climate scientists on human-induced global warming, alongside the strengthening of IPCC's scientific consensus report. Cook and Lewandowsky (2016) found that 90-100% of scientific research conducted so far indicates that humans are the primary causes of global warming, with multiple studies coming together at a consensus of 97%.

Drivers of climate change

Human activity, including their consumption culture, peer effect, lifestyles, and inequitable sharing of resources, has led to a higher temperature increase than it has since the dawn of civilisation (IPCC 2007; Gifford et al. 2011). These factors have been the main driving forces behind human-induced climate change (Fiske et al. 2018). These human activities, alongside the others, are responsible for producing core GHGs including methane, carbon dioxide, perfluorocarbons, hydrofluorocarbons, and sulfurhexafluoride, the main culprits of climate change. Burning of fossil fuels, coal mining, and the 1900s deforestation of Amazonian rainforests, which contain significant amounts (120 ± 30 pg C) of biomass (Malhi et al. 2006, 2008), resulted in a substantial impact on the local and world environment, which further warmed up the global climate (Ramankutty et al., 2007; Mgbemene et al. 2016) (Table 1). Similarly, industrial processes like portland cement production have been found to emit 5-8% of all the human-made GHG's (Aïtcin 2000). For example, nitrous oxide, which has a global greenhouse potential of approximately 300 times (Mgbemene et al. 2016) that of carbon dioxide (IPCC 2001a; Cantarel et al. 2011), is produced through industrial processes. Likewise, SF_6, the most potent industrial GHG, is made through gaseous electrical insulation products, formed initially to save space (Rabie and Franck 2017). Because of its capacity to interact with other aerosols, black carbon from biomass and fossil fuel burning is the 2nd largest contributor to global warming after CO_2 (Ramanathan and Carmichael 2008). Furthermore, transportation, which accounts for about 26% of the worldwide carbon dioxide emissions, is still increasing (Chapmann 2007). Livestock generates 18% of GHGs, higher than all transport emissions (FAO 2006; Ilea 2009). It is estimated that by 2050, global livestock emissions are expected to double, mostly in developing countries (Ilea 2009). Almost half of the soy for livestock is

Table 1 Global warming potential (GWP) for a 100-year horizon of selected gases

S. No.	Compound	Sources	Application	100-year GWP
1.	Carbon dioxide (CO_2)	Stationary and mobile emissions from fossil fuel combustion and processes	Human respiration	1
2.	Methane (CH_4)	Combustion of fossil fuels, waste treatment, landfills, livestock	Bacterial activity	23
3.	Hydrofluorocarbons (HFC's)	Refrigeration and cooling systems, foams, propellants for aerosols		
	HFC-23		Refrigerant, fire suppressor	9400
	HFC-32		Refrigerant	550
	HFC 125		Refrigerant, fire suppressor	3 400
	HFC-134a		Refrigerant	1 300
	HFC143a		Refrigerant, propellant	4 300
4.	Perfluorocarbons (PFC's)	Semiconductor manufacturing, aluminium production		
	CF_4		Refrigerant, Electronics microfabrication	5700
	C_2F_6		Etchant in semiconductors	11900
5.	Sulfur hexafluoride (SFC's)	High voltage applications, semiconductor manufacturing, magnesium production	Enchant in the manufacture of semiconductors	
6.	Nitrous oxide (N_2O)	Agriculture, stationary, and mobile emissions from fossil fuel combustion	Fertilisers wastes	296

produced in the Brazilian cerrado region, the second major biome in Brazil (Klink and Machado 2005; World Wildlife Fund (WWF) n.d.; Ilea 2009). Agriculture is yet another driver of climate change, as among the food crops, rice has the highest GHG potential due to its potential contribution (11%) to the global methane ($CH_{4)}$ emissions (Linquist et al. 2012; IPCC 2013; Carlson et al. 2017; Jiang et al. 2019). Wetlands, the natural source of methane ($CH_{4)}$, produce 150-180 Tg CH_4 per year. They dominate all other types of emission sources (Bousquet et al. 2006; Bergamaschi et al. 2007; Montzka et al. 2011) as the wetlands are expected to generate 20-25% of the world's current methane emissions (Whalen 2005; Bergamaschi et al. 2007; Bloom et al. 2010). Further, the tropical and subtropical wetlands show more significant emissions than temperate ones (Bloom et al. 2010; Mitsch et al. 2013). Change in land use and land cover is another vital driver of climate change. It is also observed that, although the shift from gasoline to corn-based ethanol does reduce the immediate emission of GHGs, over the years, ethanol consumption will be emitting the same amount of carbon production as before (Searchinger et al. 2008; Fargione et al. 2008).

Global outlook of climate change

Global climate changes progressively with unforeseen consequences (Houghton et al. 2001). Each aspect of the ecosystem reacts closely to climatic constraints and is expected to result in distributive change and declines in biodiversity (Johnston and Schmitz 1997). Although extinction and drastic reductions in the range of species are estimated to be relatively few, it is expected that species turnover will exceed 40%, suggesting the purported occurrence of severe environmental disturbances due to climate change. The IPCC and UNFCCC use scenarios for identifying and addressing future climate threats and reactions. In the words of Mike Hulme, "the present climatic fear will van in the end or shall be reconfigured as a function of cultural change." According to Karen O'Brien, the transformational thinking needed for climate change includes cultural change and changes in attitudes and practices: transition strategies and decision making. This goes further than the status quo and often challenges conventional ways to think, do and plan for the future (O'Brien 2017). This broader area needs new approaches for strategic improvements to understand and adapt to the organisation and the relationships with the human environment.

The new IPCC approach to pollution scenarios aims to open up the foreseeable plans and encourage people to shape their future instead of selecting a collection of predetermined ends (Girod et al. 2009).

Climate change and some significant events throughout the Globe

Human-induced climate change aggravates the built environment and the naturally occurring phenomena such as storms, wildfires, floods, and heatwaves. During Hurricane Harvey of August 2017, the Gulf of Mexico's oceanic heat content got transferred to the atmosphere as moisture, which later became the reason for record-breaking rainfall. Thus, the human-induced warming, on the one hand, sustained the severity of the hurricane and, on the other hand, intensified the rains (Trenberth et al. 2018). It was found that although both global warming and Elniño-southern oscillation had an impact on the hurricane Harvey, yet the effect of global warming was seen to increase the precipitation by a factor of 3.5 (Risser and Wehner 2017). In 2010, many extreme events occurred throughout the globe that started with the most extended summertime warming of the Northern hemisphere (Trenberth and Fasullo 2012; Hansen et al., 2012; Panda et al. 2017). It was followed by extreme rainfall events in India, Pakistan and the mega heat waves in Russia (Lau and Kim 2011; Trenberth and Fasullo 2012; Panda et al. 2017). Although wildfires are a prevalent phenomenon in California (Keeley and Fotheringham 2001; Moritz 2003; Nauslar et al. 2018), the 2017 fires in Southern California and North Bay are in many ways novel. The North Bay fire of October coincidently occurred with the downslope winds, leading to significant destruction in the first 12 h of burning. While the South Californian fire of December that caused the largest wildfire in California's history broke during the longest Santa Ana wind occurrence and was followed by a four-year drought period (Nauslar et al. 2018). Moreover, climate change shows its consistent influence on the temperature, precipitation, snow cover, and glacial melt of the European Alps alongside the summer heatwave of 2003 and the flood events of 2005. The summer heatwave in 2003 reported the highest temperature in Central Europe for the last 500 years (Luterbacher et al. 2004; Keiler et al. 2010) and the warmest summer in the European Alps for 1250 years (Keiler et al. 2010). This led to the glacial retreat of the Alps, which occurred primarily because of the low snow cover followed by the exposure of underneath fern to the atmospheric warming that had developed a soft albedo effect owing to the dust buildup in the dry summer (Paul et al. 2005; Haeberli et al. 2007; Koboltschnig et al. 2009; Keiler et al. 2010). Showing a doubling of impacts, high-temperature impacts of heatwaves, accompanied by drought, increased death levels from 35,000 (Fischer et al. 2007; Keiler et al. 2010) to 70,000 (Keiler et al. 2010). Another significant event was the August 2005 floods of Central Europe, which affected the Alpine region (Table 2). The floods were marked by loss of life, communication, agriculture, and infrastructure (Beniston 2006; Frei et al. 2006; Keiler et al. 2010). A high precipitation rate of 10 mm/h,

Table 2 Climate change and some major events throughout the globe

S. No.	Event	Year	Countries impacted	Reference
1.	Hurricane Harvey	2017	Gulf of Mexico	Trenberth et al. 2018
2.	Wildfires	2017	North Bay and Southern California	Nauslar et al. 2018
3.	Floods	2016	Louisiana in the United States	Domonoske 2016
4.	Heavy floods	2010	Pakistan, India, China, Columbia, and Australia	Kundzewicz et al. 2014
5.	Longest summertime warming	2010	Northern hemisphere	Hansen et al. 2012; Trenberth and Fasullo 2012; Panda et al. 2017
6.	Extreme rainfall events	2010	India, Pakistan	Lau and Kim 2011; Trenberth and Fasullo 2012; Panda et al. 2017
7.	Mega heat wave	2010	Russia	Lau and Kim 2011; Trenberth and Fasullo 2012; Panda et al. 2017
8.	Kosi floods	2008	Nepal and Bihar, India	Ghimire and Chautari 2010
9.	Floods	2005	Central Europe (Alpine region)	Beniston 2006; Frei et al. 2006; Keiler et al. 2010

which was never seen before in the last 100 years' time period (Keiler et al. 2010), was a major factor behind these floods.

Impacts of climate change

On urbanisation

Due to impervious surfaces such as concrete and dense populations, the heat absorption and retention in urban centres appear to be higher than the surrounding suburbs and rural areas, resulting in an "urban heat island effect". The gap in the rural and urban energy balance clearly shows a relation between land cover land use and the regional and local climate (Arnfeild 2003). This additional warming from the urban heat island's effect makes cities more vulnerable to climate change (Rosenzweig et al. 2011a). It leaves the urban population more exposed to its effects than rural people (Luber and McGeehin 2008; Hajat et al. 2010). According to the Urban Climate Change Research Network, the average temperature in urban areas is expected to rise by 4 °C by 2050 (Rosenzweig et al. 2011b). Although the impact of urban heat islands has averaged around 2 °C (Taha 1997; Chen et al. 2006), this can vary up to 10 °C depending on local location and weather conditions. They are related to the extreme temperatures and health risks intensified by climate change in urban areas (Luber and McGeehin 2008; IPCC 2014). The blocking of outgoing radiation at night in urban areas is affected by their geometry, reducing the nocturnal cooling (Bonan 2008; Unger 2009). The use of remote sensors that track ambient radiation in cities typically tests the urban heat island effect in local zones (Dempsey 2011).

On agriculture

The productivity of wheat, soybean, mustard, groundnut, and potato may decrease 3-7%, as temperatures increase by 1 °C (Aggarwal 2000). Severe calamities such as droughts, floods, heatwaves, and cyclones have affected India's agriculture industry (Goswami et al. 2006), resulting in lower food grain production, exacerbating the vulnerability of marginalised and small farmers, causing food insecurity and poverty (Brithal et al. 2014). Estimating the effect of these natural disasters, Bhandari et al. (2007) found that household income in India's eastern regions was down significantly by 24–58% in the year of drought. The increase in atmospheric carbon dioxide concentration and subsequent change of climate is likely to affect the future global agricultural production because of global warming by shifts in plant growth rate (Cure and Acock 1986; Rotter and Van de Geijn 1999) and rate of transpiration (Morison 1987; Jacobs and De Bruin 1992). The moderate climate change situation (2 °C rises in average temperature and a 7% increase in precipitation) in major developing countries showed significant adverse effects, which would result in 10% loss of agricultural income. This unfavourable impact on the agriculture of climate change is subsequent. Recent estimates from developing countries indicate that 1% of agricultural GDP growth increases consumption by 4-6% of the lowest three deciles (Ligon and Sadoulet 2007).

On forests

Forests that are highly affected by the climate face many threats, such as droughts, fires, landslides, invasions of invasive animals, pests, insects, and storms that influence the morphology, structure, and function of forests (Dale et al. 2001).

Climate change can directly affect nutrient cycling by impacting temperature and precipitation or indirectly affecting forest composition, the length of growing seasons, and the water cycle. On the other side, droughts will decrease forests' productivity and increase their vulnerability to insects and diseases, affecting biodiversity, wood supplies, and other economic resources. The damage caused by extreme events such as severe droughts may further be exacerbated by the damage caused by wildfires (Kauppi et al. 2006; Fleming et al. 2002). For example, Europe's 2003 heatwave led to a season of intense forest fires, where forest fires destroyed 0.4 million ha in Portugal (5.6% of the country's total woodland area). Wildfires, insect outbreaks, wind, and other catastrophic events result in significant economic harm to the wild sector, such as the 2003 forest fires in the United States resulted in a substantial loss of 337 million dollars. Other adverse effects include a decline in biodiversity and non-timber forest products and adverse effects on hydrology, and loss of esthetic and leisure interests (FAO 2006). Higher direct and indirect threats from more frequent extreme events impact timber supplies, market prices, and insurance costs in changing climate (DeWalle et al. 2003), although the effects are highly uncertain.

For forests and forest managers, climatic changes pose a significant potential threat (Keenan 2015). Forest losses are often recorded in low-income countries, primarily in the tropics, compared to earlier losses in higher income and forestry expansions (Kauppi et al. 2006). Changes in the composition and operation of natural habitats and forestry also have a detrimental effect on the beneficial function of forest ecosystems that, on the other hand, have an impact on local economies (FAO 2005).

On fisheries

As the oceans' heat capacity is about a thousand times greater than that of the atmosphere, they play a significant role in controlling the global climate (Barange and Perry 2009). Globally, the sea level has risen by 10-20 cm during the 20th century, primarily because of thermal expansion. This sea-level rise could alter estuarine salinity, flood wetlands, and reduce or eliminate the abundance of overflowing vegetation in coastal areas. This shift in oceanic dynamics could result in changes in fish migration patterns and could potentially minimise landing in coastal fisheries in particular (African Action 2007). The difference in the environment that can increase or decrease the water's salinity is also affected by the organism's level of tolerance and its ecosystem. As the salinity of some freshwater ecosystems raises due to climate changes (IPCC 2001b), the population of planktons and more prominent prey species gets affected negatively by this physical change due to the reduction in the organism's osmoregulatory capacity (Schallenberg et al. 2003).

According to FAO, climate change has the following impacts on fisheries:

- Shift in seasons of development and increased biological process rates
- Less availability of oxygen
- Coastal infrastructure relocation
- Impairment of fish migration and their reproduction
- Introduction of exotic and undesired species
- Effect on production and maintenance of seasons
- Aquaculture device alteration

On human health

Once seen as a far-off future issue, climate change has slowly and steadily crept into our present. We see inevitable present time implications of climate change in the form of extreme weather conditions, skewed social infrastructure, and a range of direct and indirect health impacts (Pachauri, IPCC 2007; Luber et al. 2014).

The United States environment and health assessment have recognised the following major health impact categories as a result of climate change:

- Increased temperature morbidity and mortality
- Increased vectors and water-borne diseases
- Decreased food safety, food supply, and distribution
- Mental health, such as anxiety and depression

Some people like pregnant women, children, aged people, people with disabilities, and chronic diseases are at greater risk due to climate change (Luber, Knowlton et al., and Frumkin et al. 2017). According to the 4th assessment report of IPCC, the negative impacts are more on the population health of low-income areas with heat-related mortality, flood-related health risks, and emerging infectious diseases as the most common (Alcamo et al. 2007).

Threats to humanity from climate change

Human life has evolved within a specific range of temperature, humidity, and solar radiation that have not changed over the years. It implies that we have to get ready for many drastic changes (McMichael et al. 2006; Berry et al. 2010). Climate change poses a varied degree of threat to human life. It either enhances the geographical distribution of a disease vector or increases its population or both as many vector species or individuals are even capable of surviving the winter (Burmagina et al. 2014; Mesheryakova et al. 2014; Parham et al. 2015; Bruce et al. 2016; Yastrebov et al. 2016; Waits et al. 2018). Many diseases, like Rift valley fever (RVF), frequent in Africa and the Middle East, are associated with climatic changes (heavy rainfall) (Chevalier et al. 2010). Dengue fever cases that have increased 30-times since the 1960s are expected to expand from the South to North and from low latitude to high latitude areas in China (Añez et al. 2017; Jing-Chun and Qi-Yong 2019). Because of global warming, several Vibriosis cases have been reported from the Arctic (Waits et al. 2018). Due to its cyclical and seasonal nature, Ebola is believed to have originated due to changes in climatic variables (Ng et al. 2014; Mgbemene et al. 2016). In South and South-east Asia, the highest monthly temperature of 33.5 °C and the most increased precipitation of 650 mm were associated with mosquito-borne diseases (Servadio et al. 2018). Cases of post-traumatic stress disorder (PTSD) and long-term depression, and even suicide rates are found to increase in children in association with the floods (Ahern et al. 2005). Climate change is expected to raise the burden of diseases in the next century as it will impact the world's food security (Myers et al. 2017). With a rise in local temperature of 2 °C, rice, wheat, and maise yields are also expected to decrease (Challinor et al. 2014). The meteorological data from 1951-2016 has shown the increase in temperature, outbalancing the precipitation increase, hence causing more severe and frequent droughts (Spinoni et al. 2019). The decline in resources due to climate change fuels intergroup conflicts either by direct consumption of resources or by forced migration of communities (Costello et al. 2009; Reuveny 2008). Water shortage (Gleick 2010) is expected to increase the tensions between the nations (Cooley et al. 2009; Gleick 2010) as the Intergovernmental Panel on Climate Change (2007) has assessed that by 2030, almost 42% of world's population will have insufficient water for their agricultural, domestic and industrial purposes. There are already severe year-round water shortages to half a billion people globally. Hydrological and hydraulic models predicted the upcoming floods in the Yang river (Thailand) with a return period of a hundred years (Shrestha and Lohpaisankrit 2017). In the Carpathian region (Europe), Models (RCP 4.5) have shown an increase of the 30-year flood level from 4.5-62% in the Tisza and 11-22% in the Prut region (Didovets et al. 2019). In 2010, heavy floods occurred in Pakistan, India, and China in summer, Columbia from October to December, and Australia during the Austral summer (November) (Kundzewicz et al. 2014). Similarly, a record-breaking flood was witnessed in the valley of Kashmir during September 2014.

Economic risks of climate change

Climate change poses a wide range of impacts on things that people enjoy and grow, which can be detrimental or beneficial, based on the area, location, and time. These impacts can be helpful or harmful. Developing countries are highly vulnerable to climate change impacts because they are more exposed to weather conditions and are more dependent on agriculture and water resources in their economy. Poorer countries are usually limited in capability (Adger 2006) depending on several factors such as infrastructure availability and willingness to pay for this. They often lack access to advanced technologies and institutions that shield them from extreme weather events. Climate change had reduced the crop yield in Africa by up to 50%. Sustainability yields are often only a tenth of the total in model farms with the same soil and environment (Mueller et al. 2012).

Climate change increases the spread of diseases (Martens et al. 1997; Van Lieshout et al. 2004), which account for a considerable amount spent on bed nets, insecticides, and vaccines to combat the diseases and to ensure a malaria-free environment regardless of climate change (Seder et al. 2013). Climate change affects labour force size and output, and capital stock affects investment and influences future production.

Climate change and interconnected risks to sustainable development

Probably coined in the 1980s (Wall 1994), the term sustainable development may be described as a balanced framework of three closely related elements, including the economic, social, and environmental aspects of development. As outlined in the Brundtland Report, sustainable development calls for carefully controlled changes to enhance environmental conditions, economic conditions, and life quality. Since the beginning, the idea of sustainability has been closely connected to incorporating socio-economic issues into the environmental agenda (Robinson and Herbert 2001). As climate change impacts sustainable development (Cohen et al. 1998), it is one of the most critical unsustainability symptoms. The convergence of sustainable development with climate change offers an opportunity to discuss rational societal responses with a long-term global environmental change (Bizikova et al. 2011). There have been numerous reports on climate change-sustainable development relations (Eriksen and Brown 2011), wherein it has been shown that climate change influences the developmental process in a region. Changing land use, increasing pollution, and declining biodiversity resulting from climate change remain behind sustainable development risks (Cramer et al. 2018). Although researchers' attention on climate change - sustainable development linkage has increased, there is still a dearth of case studies that could provide models of mutually supporting policies (Swart et al. 2003; Wilbanks 2005; IPCC 2007).

Climate change associated events like droughts, hurricanes, and floods have already grabbed the public and policy-makers attention to the impacts of climate change and the need for adaptation and mitigation measures. However, this new emphasis seems to have placed issues of sustainable development in the background. Climate change is inseparable and circularly interacts with sustainable development problems (Downing 2003: Yamin et al. 2006). It is expected to cause loss of biodiversity, pollution, and natural resource degradation (Perrings and Opschoor 1994; Munasinghe and Shearer 1995) by changing the abundance and distribution of coral reefs, marine animals, and fisheries (McLean et al. 2002). Over a billion people worldwide lack sufficient food and are malnourished. There is no safe drinking water for 1,4 billion, while about 2 billion people do not have adequate sanitation or electricity access (Munasinghe 2001). The globe's mean temperature is increasing, which has risen by 0.7 °C in the 20th century, and it continues to increase. The threat of heatwaves and extreme events has levied a retreat of glaciers (Banuri and Opschoor 2007).

Ecological responses to climate change

Climate change is causing ecological transformations in ecosystems that have not been encountered for millions of years (Hoegh-Guldberg and Bruno 2010). Many species have shown a dramatic decrease in their body size due to climate change, and many others are likely to face the same fate as a result of ecological and metabolic rules. But, the problem with the variability in size is expected to upset the ecological balance (Sheridan and Bickford 2011) for instance; Polar bears have started to decrease in their size because of the reduction in the sea-ice extent (Regehr et al. 2006; Rode et al. 2010; Sheridan and Bickford 2011). This decrease in body size is likely to occur due to the reduction in the Net Primary Productivity (NPP) of ecosystems, thus creating food scarcity across the trophic levels (Sheridan and Bickford 2011). The temperature increase beyond the optimum values is likely to cause increased mortality and decreased population (Hochachka and Somero 2002; Hoegh-Guldberg and Bruno 2010). In marine ecosystems, climate change has been seen to have a massive impact on the habitat shaping species like seagrasses, corals, oysters, and mangroves (Hoegh-Guldberg et al. 2007; Hoegh-Guldberg and Bruno 2010) and significant impact on phytoplanktons (Polovina et al. 2008; Hoegh-Guldberg and Bruno 2010). Climate change is expected to cause species extinction, and in fact, one in every six species is predicted to go extinct (Urban 2015). Risks are found higher in the regions with no analogue climate (Williams et al. 2007; Urban 2015) and smaller landmasses (Williams et al. 2003; Urban 2015). Climate change has already shown its effect on many species' phenology besides their timing of interaction with other species (Parmesan 2006; Yang and Rudolff 2010). Other phenological responses to climate change include mistiming some migratory bird species' breeding and feeding, such as *Ficedul ahypoleuca* (Pied flycatcher). It has begun to display decreases in its population in areas where food supply was assured in the earlier season (Both et al. 2006). In addition to its effect on the animal kingdom, climate change is found to have massive implications on vegetation (Peteet 2000; Nemani et al. 2003; Pearson et al. 2013; Peng et al. 2013; Wu et al. 2015) as vegetation gives varied reactions to the climatic conditions. Temperature is found as the primary driver of such changes at the global level (45.09%), followed by radiation (20.72%) and precipitation (15.72%) (Wu et al. 2015). There are also some positive effects of climate change on vegetation. For instance, an insect outbreak of the noctuid moth, Euroisocculta in Greenland, increased primary productivity the following year due to larval faeces and carcasses (Karlsen et al. 2013; Lund et al. 2017). The effect of changing climate on the bio-geographical boundaries shows that both the core and boundary regions are being eroded due to the biodiversity loss and homogenisation, i.e. the abundance of generalists over specialists (Pálinkás 2018). In the Arctic region, change from glacial-melt to snow-melt streams could also lead to shifts in the longitudinal organisation of macroinvertebrate communities and the dominant species because of the high channel stability of snow-melt streams (Docherty et al. 2018).

Species vulnerability and climate change

Many species worldwide are predicted to become vulnerable to 21st-century Climate Change (Thomas et al. 2004; Thuiller et al. 2005, 2011). With the increase in heatwaves and subsequent droughts, world forests are projected to get changed (IPCC 2014; Breshears et al. 2005; Allen et al. 2010 and 2015; Cailleret et al. 2016; Buras et al. 2018; Zscheischler et al. 2018; Buras and Menzel 2019). In the Forests of Costa Rica, shifts in composition, driven by the mortality factor, have been seen towards the upward or poleward areas suggesting the migration of the tropical species to higher latitudes if there is an availability of the land surface (Feeley et al. 2013). Moreover, the use of simulation models has helped us in understanding the forest dynamics through individual tree phenology (Bugmann 2001; Pretzsch et al. 2008; Cailleret et al. 2014) with one such model predicting significant dieback in the Bavarian Forest Park (Cailleret et al. 2014) of the dominated plants, *Picea abies* (Norway spruce) and *Abies alba* (Silver fir) due to the increase in spring and winter drought and their simultaneous replacement by the *Fagus sylvatica* (European beech). Another model, Landis-II, predicted a significant impact of drought on the species composition of Forests of Oconto County in Wisconsin (USA)

(Gustafson and Sturtevant 2013). Analysis of the NFI's (National Forest Inventory) data and climate analogues showed that tree species' composition for twenty-six significant European trees is likely to change from 2061 to 2090 (Buras and Menzel 2019). Due to changes in temperature conditions, the species composition of both native and invasive species has changed in the sub-tidal community of Newcastle (NH) (Dijkstra et al. 2010). Climate change is known to have a profound effect on the forests of the Alpine areas (Chen et al. 2013; Piao et al. 2012; Liu et al. 2018) like the Tibetan plateau, which is almost 60% Alpine (Zhang et al. 2007; Liu et al. 2018). The region's annual temperature has doubled the global average over the past 50 years (Dong et al. 2012; Hansen et al. 2010; Liu et al. 2018), and the impact of this drastic warming has been observed in the change in species composition of plants from Sedges to Grasses in the Alpine grassland ecosystem of the Tibetan plateau (Liu et al. 2018). A shift in climate is expected to result in 'Cul-de-sac' effect, that is, the movement of organisms to high altitudes in response to Climate change (Tingsley et al. 2009; Ben RaisLasram et al. 2010; Albouy et al. 2012). This effect is expected to bring some significant changes in species composition in the Aegean and Adriatic seas, where the species richness at first will increase due to the migration of species from the Gulf of Gabes that would experience a net loss of species. However, the Lion Gulf and both the Adriatic and the Sea of the Aegean will inevitably be subjected to a net loss of biodiversity resources due to niche loss for the indigenous species (Albouy et al. 2012). Therefore, throughout the 21st century, the Mediterranean coastal fish mix's makeup would change considerably (Ben RaisLasram et al. 2009; Albouy et al. 2012). Climate change can also be found to affect primate composition either through changes in the vegetation cover or through the availability of resources (Kamilar and Beaudrot 2018; De Lima et al. 2019) or thorough their physiological response to climate change (Mandl et al. 2018; De Lima et al. 2019).

Heatwaves and climate change

In recent years, several parts of the world have experienced an increase in the number of heatwaves (Sun et al. 2014; Christidis et al. 2015), including the world's major urban areas, with the largest human populations (Mishra et al. 2015; Matthews et al. 2017). The global growth of heatwaves since the early 21st century is one of the most severe climatic threats for humanity (Panda et al. 2017). According to the World Meteorology Organization (WMO 2013), the number of deaths caused by heatwaves during the last decade (2001–2010) has significantly increased (2300%), compared to 6000 deaths in the previous decade (1991–2000). Anthropogenic emissions have most likely increased (Schär et al. 2004; Meehl and Tebaldi 2004; Wehner et al. 2016). The likelihood of existing heat waves and the predicted potential warming of the atmosphere is proving to increase the incidence of extreme heatwaves (Hayhoe et al. 2010; Jones et al. 2015; Schär 2016). It has made the intense heat waves and is projected to make heat waves even hotter and more frequent in the future (Vose et al. 2017; Diffenbaugh and Scherer 2013). Prolonged exposure to very high temperatures can lead to thermal diseases, encompassing heat cramps, heat exhaustion, and heat stroke (CDC 2017; Choudhary and Vaidyanathan 2014). It has shown to increase heart attacks (Braga et al. 2002), respiratory mortality (Mastrangelo et al. 2007), and cardiovascular mortalities (Medina-Ramon et al. 2006; Curriero et al. 2002). Furthermore, hot weather has a significant worldwide effect on socio-economic setups, water uses, forest resources, and crop losses (Valor et al. 2001).

Many extreme heatwaves have had significant social impacts in the early years of the 21st century, including 2003 in Europe, 2010 in Russia, 2015 in South Asia, and the Middle East, and 2016 in South East Asia. The estimated result of these events is some 100,000 excess fatalities (García-Herrera et al. 2010; Shaposhnikov et al. 2014; Robine et al. 2008) and several other human and ecosystem effects such as wildfires, crop failures (Wegren 2013), and disruption and damage of infrastructure (García-Herrera et al. 2010). These effects are also estimated to be associated with a range of human and environmental impacts. In India, heat waves almost annually cover certain parts of the country during the pre-Monsoon seasons (March-May) and result in a high mortality rate in large populations. Heatwaves of 1998 and 2015 experienced by parts of India resulted in more than two thousand deaths each (Patz et al. 2005; Dunne et al. 2013; Pai et al. 2013) and are ranked among the deadliest events globally. Extreme heat events have become a primary public concern, receiving increasing attention in the literature (Lu and Chen 2016). These heat waves would be more intense, frequent, and prolonged in the future warming climate with a rising mean temperature (Cubasch et al. 2001; Karl and Trenberth 2003).

Human migration and climate change

Ravenstein (1885), one of the founders of migration studies, described migration as 'life and progress' while others in the field described it as a change-adjustment process. Climate change is expected to bring a significant shift in migration patterns in the developing world. The chronic environmental risks and sudden onset of disasters are expected to change populations and countries' traditional migration patterns. Since 2008, an average of 26.4 million people, equivalent to one person every second (UCB 2019), has been displaced per year from their homes by natural disasters. The environmental changes and the consequences thereof (natural and human-made disasters) have compelled millions of people to flee their homes (Myers 1997). However, subsequent studies argued that environmental degradation, particularly climate change, is about to become a significant driver for the displacement of populations (Brown 2008). Climate shifts affect ecosystems, including the supplies of water, food, energy, livelihoods, economics, cultures, and societies (Cozzetto et al. 2013). It was widely reported in the mid-1990s that a range of severe environmental pressures such as pollution, land degradation, droughts, and natural disasters had forced as many as 25 million persons out of their homes and land. Migration has been gradually seen since the late 2000s as a potential response to climate change adaptation (Webber and Barnett 2010; Black et al. 2011). However, many people try to stay in place during and after various environmental stressors, including climate-related challenges, to retain social networks and livelihoods and escape inexpensive transport. (Cubie 2017; Adger et al. 2007). Populations in fragile areas, such as mountains (Afifi et al. 2014; Milan and Ho 2014; Milan et al. 2015) or islands (Barnett 2001; Mortreux and Barnett 2009; IPCC 2007, 2014), have been highly manipulated. Similarly, there are increased threats in the low-lying coastal regions with rising seas, as many major urban areas are situated near significant flooding bodies (Barroca et al. 2006). Today, over half of the world's population living in urban areas (UNDESA 2016) is located just ten meters above sea level and thus exposed to the threats of coastal flooding, erosion, and submergence. Stern (2006) indicated that 200 million people would face climate change-induced migration by 2050, while others predicted between 25 million and 30 million 'climatic migrants' per year (Myers 1997; El Hinnawi 1985). A recent report from the Foundation for Environmental Justice (EJF 2017) indicated that a rise in sea level would cause hundreds of millions of people to be displaced by 2100. For instance, 2016 flooding in Louisiana, USA, in which some households were displaced for months because of damage to their homes and properties and government relief weaknesses (Domonoske 2016). Similarly, in the 2008 Kosi flooding in Nepal and India, many displaced people were forced to live on embankments even up to a year after the flood due to slow recovery and rehabilitation measures (Ghimir).

Climate change and politics

Climate change itself is politics now, not only in the developed world but also in the developing world, although the political response to these changes varies from country to country. Political parties in Latin America have been showing a lukewarm reaction to climate change by framing it as a social concern and thereby de-politicising the matter (Ryan 2017). COMPON (comparing climate change policy networks), a research project found that although there is a similar political system in Sweden and Finland, the emissions of Sweden are not even half of Finland due to Sweden's government's neutral policies (Yl -Anttila et al. 2018). Another comparison between the USA and Germany revealed that the USA favours fossil fuel lobbies. At the same time, Germany's decision to curbing greenhouse gas emissions of the 1990s and its steadfastness on the same itself explains its climatic policy (Grundmann 2007).

On the other hand, although a leading producer of crude oil and natural gas, Russia has not yet openly disclosed its policy over climate change (Sabintsev 2017). In many countries like North Africa and the Middle East, where there are increased water-related vulnerabilities, adaptive governance remains a low priority. It thus increases their chances of vulnerabilities in socio-political and economic sectors (Sowers et al. 2011). Therefore, climate change is a "multiplier of threats" (Evans 2008a; Evans 2008b; UNDP 2007/2008; Sowers et al. 2011). Even a case study of Nepal showed the use of the adaptive policy measures being exploited for claiming the authority by political parties despite the provision of funds and technical support by the United Nations Framework Convention on Climate Change (UNFCCC 2015) (Nightingale 2017). In association with the climate change policies, the carbon trading market policy of China is growing. Still, the carbon market is likely to be affected by potential risks like uncertain policy mechanism designs and uncertain policy expectations (Mao-Zhi and Wen-xiu 2019). The 2015 Paris Agreement was the first global climate agreement to give a green signal to low carbon emissions (Dimitrov 2016; Yong-Xiang et al. 2017) and the transnational cooperation on climate change, therefore, entered a new era (Zheng et al. 2016; UNEP and Bloomberg 2017; Yong-Xiang et al. 2017). This was indeed the European Union's culmination, India, China, the USA, and the Icelandic states' four-year diplomatic process. This agreement contains the policy agreement for all the countries involving top-down and bottom-up approaches (Bodansky 2011; Dimitrov 2016). Thus, this climatic regime combined science, international politics, economics, and stakeholders (Richard 2017; Yong-Xiang et al. 2017). The deal entered into effect within a year in November 2016; however, US ex-president Donald Trump's statement on climate change being a "Hoax" and "fabricated by China" to weaken America's industrial power presented a significant threat to the agreement. Although he said that he would reinstate the deal to make things equal to the USA, his comment also undermines the agreement and is likely to impact US funding for climate-related research. Overall, the objective of the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement was to set up proper global governance and to develop clean energy (Du 2014; Zou et al. 2015; Yong-Xiang et al., 2017) mechanism. The agreement focused on long-term economic targets, policy sustainability, climate change, and policy trends over time (Rajamani 2015; Dimitrov 2016).

Climate change and mass media

Mass media is a critical factor in recognising and understanding climate change (Spector and Kitsuse 1977; Schoenfeld et al. 1979) and other related environmental issues. Climate change has significantly differed between countries regarding its reporting and context (Anderson 2009; Boykoff and Smith 2010). More recently, several research initiatives in emerging and developing economies have begun to explore its media coverage, such as China (Yang 2010), Bangladesh (Miah et al. 2011), India (Jogesh 2012), and Mexico, Peru (Takahashi and Meisner 2013). Mass media campaigns are one of the main policy instruments used to influence public opinion on specific topics (Sampei and Aoyagi-Usui 2009). There has been a reasonably short-lived impact on the public opinion in mass media as media coverage moves from topic to topic, even daily (Driedger 2007). Climate change in the USA has recently become a mainstream topic like climate change. Its impact is a significant challenge for the 21st century, which concerns both people and governments and constitutes a significant political concern (Carvalho and Peterson 2009). Therefore, the media has proven to be the principal source of climate change information (Synovate 2010), from which the public draws most of its knowledge. Most UK and US studies on media coverage on climate change are credited to Boykoff (2018) and Sampei and Aoyagi-Usuiu in Japan (2009). Specific qualitative and quantitative analyses have been carried out on the mass media reporting of climate change issues. Some have described the rise and decline in media attention (Major and Atwood 2004; Carvalho and Burgess 2005), and others concentrated on factors behind media attention's cyclicality (Brossard et al. 2004; O'Brien 2006). Extreme weather events, like the Katrina hurricane of 2005, the Haiyan typhoon of 2013, and the severity of heatwaves, led to increased media coverage of climate change (Antilla 2005).

Furthermore, scientific activities such as the releases of the 2007 and 2013/14 intergovernmental panel on climate change (IPCC) reports have become international media events (Boykoff 2010; Holt and Barkemeyer 2012) at the United Nations Climate Change Conferences (UNCC). Therefore, the media has a significant effect on shaping public perception and opinion on such issues (Carvalho and Burgess 2005). Although environmental scientists and social movements have been concerned with climate change since the 1980s, mass media reporting has turned it into one of the most complex and influential environmental issues in the global political circles (Anderson 2009; Boykoff 2011). Mazur and Lee (1993) suggested that the level of public concern regarding environmental issues is often influenced by the substantive content of news reports and the amount of media attention it receives.

Mitigation approaches

Mitigation tackles the risk of climate change deterioration and has the ultimate objective of sustainable human society growth. It addresses a reduction in greenhouse gas levels by reducing greenhouse gases emissions and taking carbon sinks to reduce climate change pace and the rate of extreme events (Lu 2013). Developed countries focus on mitigation actions, while in countries of the south, there is a high vulnerability of climate change and less scope to reduce the greenhouse gas emissions. Therefore, adaptation actions are particularly urgent in this region (Ayers and Huq 2009; Wilbanks et al. 2007). The primary mechanisms thus far developed to mitigate climate change are the following:

- Mechanisms of access and distribution
- Mechanisms of consistency
- Mechanisms based on prices

According to Liu et al. (2013), two important ways to reduce the emission of greenhouse gas are the following:

- Increasing the carbon storage and capture
- Increasing the carbon sinks

Conclusions

Climate change that has developed over 150 years through a collective learning process depends on accumulating observational data, hypotheses, theories, models, and empirical testing. Deforestation, transportation, industrialisation, livestock, and fossil fuel burning are the main drivers of climate change, which has specific, irreversible impacts on human societies' different sectors, including human health and well-being. Climate change has been responsible for some historical losses to human civilisations regarding certain natural events like droughts, hurricanes, floods, and heatwaves. It further drives and determines the political systems of many nations around the world. Furthermore, the coverage of climate change episodes and events in the mass media helps the common man and policymakers re-strategise climate change mitigation plans.

Author contribution Suhaib A. Bandh and Sana Shafi conceived, designed, and prepared the final draft of this review, while Shahid A. Wani and Rubiya Dar screened the literature needed for the preparation of the final draft. Mohazeb Peerzada, Tanzeela Rehman and Shahnaz Bashir helped in screening the relevant literature besides preparing the first draft of four sections each of the paper. All authors together at the end gave final shape to the manuscript.

Data availability The authors confirm that the data supporting the review are available within the article.

Declarations

Ethics approval This article does not contain any studies involving animals or humans performed by any of the authors.

Consent to participate Not applicable.

Consent for publication We ensure that all the authors mentioned in the manuscript have agreed for authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.

Competing interests The authors declare no competing interests.

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