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REVIEW

Consequences of Global Climate Change on Biodiversity and Food Security: A Mini Review

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ABSTRACT

A thriving eco-system and abundant species diversity are crucial for all forms of life on Earth. Whether or not the climate remains stable has a direct impact on biodiversity and the ecosystem services that are provided by that diversity. There is a strong correlation between biodiversity and food security, and this is influencing how the impact of biodiversity on climate change is felt. Changes in the duration of the growth season for plants, the distribution of arable lands, and the availability of high-quality water are all ways in which climate change impacts agriculture. There will be numerous positive effects on the food production system as a result of biodiversity's effect on food security. Productivity increases and improved well-being are two examples. Therefore, agricultural biodiversity has an immediate impact on economic growth and quality of life.

Keywords: Adaptation, Agriculture, Biodiversity, Climate change, Crops, Eco-agriculture

1. Introduction

A healthy ecosystem and high biodiversity are essential elements of life on the earth planet. The ecosystems require a wide variety of plant and animal organisms ranging from soil microbes to predators, where any change, whether the removal of one or more species affects the ecosystem and damages it [1, 2]. As well as the introduction of alien species in the habitat, leads to change is possible that these species compete with the original species for food or housing, and thus change occurs one of the most influential causes of biodiversity is climate. Any change in climate, mostly due to human activity, leads to a change in biodiversity, such as increased temperatures that damage biodiversity [3].

Biodiversity and biodiversity-based ecosystem services are intrinsically dependent on the climate [4]. Climate has a significant impact on the habitats of many species that must protect themselves by adapting or migrating to other areas that are more suitable for them, even minor changes in temperature rates can have a significant impact on ecosystems, this means that there is a great correlation between ecosystems and biodiversity Any change or loss of species has a significant impact on ecosystem functions [5, 6]. The world is heated due to the increased concentration of greenhouse gases such as carbon

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dioxide in the atmosphere. This has kept the climate system with more energy since the beginning of the 20th century, and the Earth's surface temperature has risen about 0.7°C, according to (IPCC) the Intergovernmental Panel on Climate Change, temperatures could rise by 1.6–4.3°C by 2100, compared with 1850–1900 [7]. This dramatic rise in temperature has a direct impact on biodiversity and, unfortunately, this effect is often negative. The high temperature affects the climates in different ways for example, the regions of Southeast Asia show the effect of increasing monsoon rains and rising sea levels, it affects South Africa and Southeast America, causing droughts and crop failures. The rising of temperature also affects the amount of ice and shrinking amounts on the mountains and thus lead to a decrease in the flow of rivers and lakes as well as decreasing the amount of water available for irrigation and drinking for example, in the Himalayas, two billion people depend on the flow of glaciers [8].

Other impacts of climate on biodiversity include the loss of Arctic Sea ice, leading to a significant change in biodiversity in and around this region. As well as high acidity in the seas resulting from the high amount of CO_2. Climate change and rising temperatures are driving global crop production down corn, rice, and wheat yields are expected to decline by 3% and 10% for each higher temperature as shown in Fig. 1(A) [9, 10]. It also affects fishing yields, with a decrease of 5–10% in marine ecosystems in the tropics by 2050. This is due to changes in the distribution of plankton and the transformation of appropriate habitats due to high temperatures and changes in wind, ice thickness and pH as shown in Fig. 1(B) [11].

The vulnerability of ecosystems to current climate changes has already been demonstrated and is relatively small compared to expected changes in the future, in addition to rising temperatures, other climate changes are affecting the ecosystem, such as changing patterns of rainfall and drought all these factors significantly affect biodiversity [12, 13]. The impact of biodiversity on climate change is also affecting food security as there is a significant relationship between biodiversity and food security [8]. Where climate change affects agriculture, this is through the availability of good water quality as well as the distribution of habitats and species and the length of the growing season for plants and the distribution of arable areas. The impact of biodiversity on food security is to add many benefits to the food production system. These benefits are productivity and human well-being. Agricultural biodiversity thus contributes directly to production and human well-being [14].

2. Impact of climate change on biodiversity

There are significant impacts of climate change on biodiversity loss. Loss of biodiversity means the extinction of species, the extinction of stocks, a change in species abundance and changes in the distribution of these species [15]. There are many reasons why plants and animals may be less adaptable in the current phase of global warming. One of these is the speed of changes in the climate many species will not be able to adapt quickly enough to cope with new conditions and the inability to move to new areas is more appropriate [16]. At the same time, the great changes caused by humans have also reduced the chances of life for many species, these impact not only on living things on Earth but also livelihoods

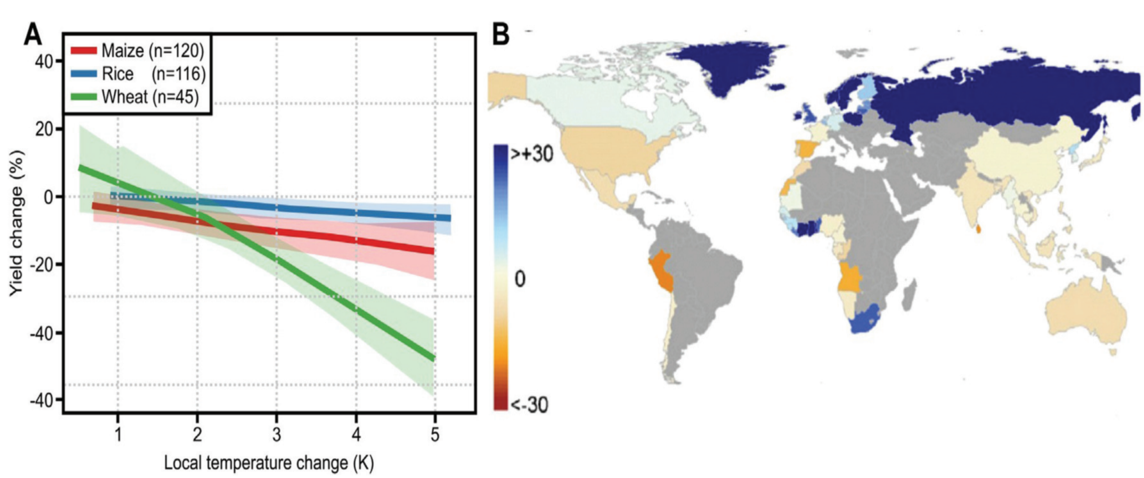

Fig. 1. (A) Impacts of climate change on the productivity of tropical cereal crops. (B) Percentage change in fisheries production aggregated to the country level for select countries by 2050 [11].

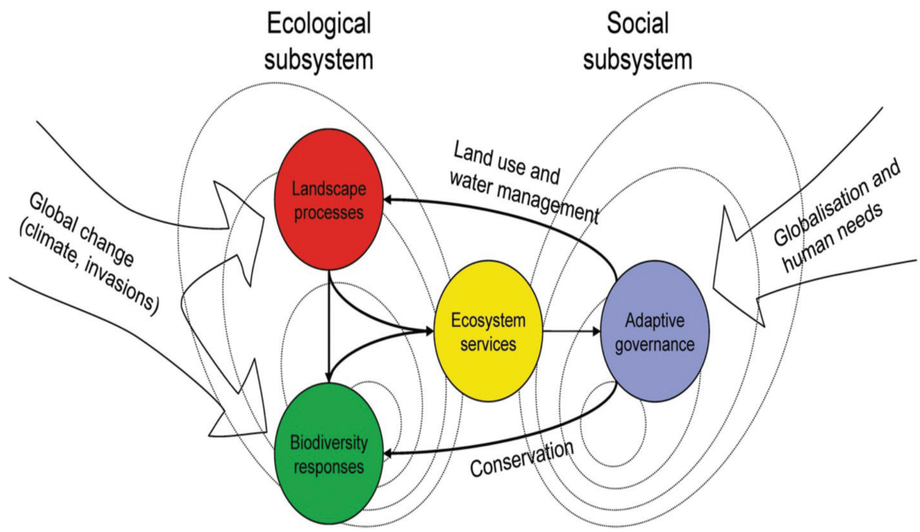

Fig. 2. Form to illustrate the factors affecting biodiversity according to the concept of the Ecoclim Research Program [63].

around the world [17]. Any degradation of the ecosystem leads to the loss of basic ecosystem services and therefore affects people, especially poor people. Biodiversity can be defined as a variety of living things on Earth that, through their interaction with each other, provide the ecosystem with the goods and services that sustain our lives. Human pressures cause significant impacts on ecosystems due to changes and the loss of many species at very high rates. In addition to these pressures, climate change is also putting great pressure on ecosystems [18].

According to the Millennium Ecosystem Assessment, a comprehensive assessment of the links between ecosystem health and human well-being climate change will become the main factor for the loss of many species by the end of the previous century in addition to changing the correct use of land as well as the introduction of alien species. All of these factors will limit species' ability to migrate and lead to rapid loss of species [19]. How biodiversity is affected by climate change can be illustrated by four closely related factors: landscape processes, biodiversity response, ecosystem services, and adaptation governance. By clarifying the relationship of these factors with each other, it is possible to understand how they impact biodiversity is obtained the diagram the Ekoklim program below Fig. 2 shows how climate change and how land-use changes and how it affects ecosystems and social systems [8]. As well as the impact of society and its interaction with these factors and effects and mitigating the effects of changes as well as require research cooperation between scientists from different disciplines to identify these effects [20].

In a bio-ecosystem, species can accept changes in climate, either through evolution or adaptation to new conditions, or follow the appropriate environment through camouflage or dispersion. As a result, organisms that follow the method of camouflage or dispersion are more likely to lose and lead to the loss of other species associated with their existence through the change of species interactions [21]. The relationship between climate change and its impact on biodiversity can be illustrated in Fig. 3 which shows the impact of climate on species and communities and thus on the ecosystem and biodiversity within this ecosystem. Fig. 3 shows that any increase in temperature, precipitation, carbon dioxide, and other greenhouse gas emissions leads to an increase in the rates of photosynthesis and respiration of species in turn leads to increased life cycle processes. At the same time increasing temperatures lead to lower Arctic species that are trying to adapt. These adaptation attempts change interactions between species with each other as well as a difference in competition for food. This results in either the widespread spread of certain species or extinction of others. All these factors lead to reduced biodiversity, an abundance of organisms at the expense of other organisms, and loss of ecosystem resilience [22].

3. Biodiversity effect on food security

Food security refers to the availability and access to food the World Bank always defines food security as the access of all people to sufficient food for a healthy and active life [23]. However, these definitions infer that access to enough food is an adequate criterion to achieve food security at the household, national or global scales [24]. The provision

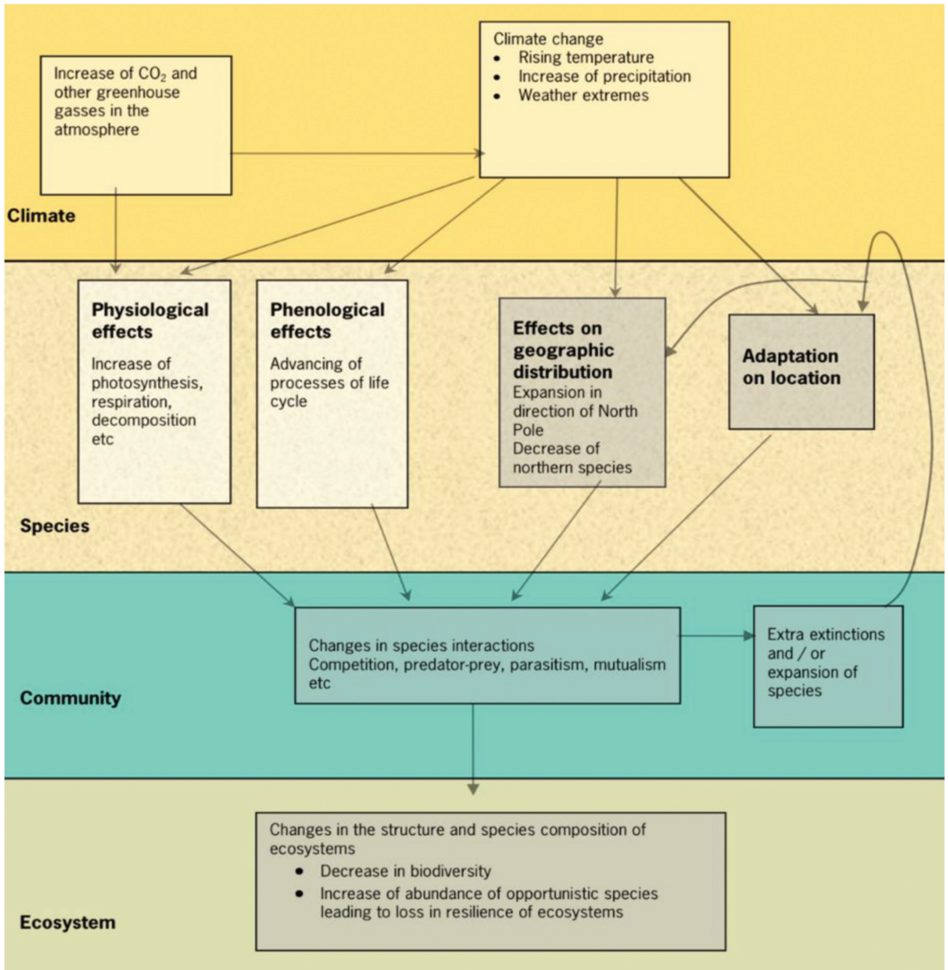

Fig. 3. Impact of climate change on biodiversity [22].

of food should be safe in the long term and for later generations the availability of food and the requirements of life today can only be considered safe unless consumption is done in a way that conserves resources for future generations [25]. Some studies suggest even if the availability of food is satisfactory human well-being is achieved through access to environmental health, such as clean water, good sanitation, and various diverse ecosystems. This makes it difficult to tie food security with safe nutrition [26]. Food security depends heavily on the biological diversity of the ecosystem, as the availability of good biodiversity preserves food security and prevents cross-infection and disease [27]. Biodiversity, whether it is in the ecosystem, in species, or in genetic material within species, is very beneficial for modern agriculture as well as providing the basics of living for millions of people [28]. Agricultural biodiversity provides several benefits within production systems. These include benefits associated with production and productivity, agroecosystem function, and human well-being, as shown in Table 1 (FAO 2008) [29, 30]. Thus, agricultural biodiversity contributes directly to production and productivity, ecosystem function and human well-being. The World Health Organisation estimates that in many developing countries up to 80% of the population relies on biodiversity for primary health care. The loss of biodiversity causes many diseases and transmits infectious diseases that have adverse effects on human health [31].

Many studies point to the importance of biodiversity and the importance of wild flora and fauna to the economy of the poor, especially in rural areas [32]. For example, forests in India are an important and major source for some 6 million people who depend on forests as their main source of livelihood [33]. Many rural areas are totally dependent on wildlife, these areas lack the infrastructure and have difficult access to markets. Harvesting and selling land resources is the only way to get cash [34]. Agriculture began around 12,000 years ago and approximately

Table 1. Adapted from UNEP, 2007 [29].

Provisioning	Regulating	Supporting	Cultural
• Food and nutrients • Fuel • Animal feed • Medicines • Fibres and cloth • Materials for industry • Genetic material for improved varieties and yields • Pest resistance	• Pest regulation • Erosion control • Climate regulation • Natural hazard regulation (droughts, floods and fire) • Pollination	• Soil formation • Soil protection • Nutrient cycling • Water cycling	• Sacred groves as food and water sources • Agricultural lifestyle varieties • Genetic material reservoirs • Pollinator sanctuaries

7,000 plant species and several thousand animal species have been used historically for human nutrition and health requirements, in 1900 work began to simplify the world food system. Today, the World Food System relies on 12 crops of plants and 14 animal species that provide 98% of wheat, rice, and maize, which alone account for 50% of global energy consumption. Uniformity of production and wider biodiversity destruction has led to the loss of many wild relatives of crop plants and livestock [35]. There are many studies to rely on other plants that grow in forests to improve the economy of some rural areas in Nigeria, as the impact of climate change on agriculture and crops opened the door to studying the economic aspects of plants that grow in nature. Such as the plant *Thaumatococcus daniellii*, which is a source of income in the destitute areas of Africa if it is properly and fully exploited [36].

The FAO suggests that three-quarters of the varietal genetic diversity of agricultural crops has been lost in the past 100 years [37]. Climate change and its impact on biodiversity are thus one of the major threats to global food security [38]. The world population is expected to rise to 9 billion by 2050, therefore, this increase requires more food sources and if we assume the continuation of monoculture by the current approach, this will require the conversion of more land to agricultural land, and this conversion at the expense of biodiversity and the provision of ecosystem services. One billion hectares of natural habitats will be converted into agricultural land, in addition, the effects of climate change on biodiversity and hence on crops [39]. Climate change is one of the greatest threats to food security through its impact on biodiversity. Severe weather changes will affect crop yields and crop yields in Africa alone are estimated to fall by more than 30% by 2050. This dramatic decline in crop yields will clearly affect the world's poor in addition, they will be unable to buy crops due to high prices due to tight supply. Unexpected climate patterns have made food insecure three of Africa's newest famines have increased due to poor harvests and poor production [8]. Climate change is the main cause of rising commodity prices. It hit an all-time high [41]. For example, the harsh impact of weather is devastating for crops like the drought in Russia the floods in Australia, China, Pakistan, and Europe as well as higher temperatures that will directly affect farmers [42].

Biodiverse' multi-functional landscapes are more resilient to extreme weather effects and can provide a "natural insurance policy against climate change". Where, preserving and repairing natural habitats, as well as the diverse range of species they support, is crucial for mitigating emissions and adjusting to the effects of climate change [35]. Greater crop diversification by integrating a diversity of crops and varieties into small-holder systems will increase resilience to severe changes in weather patterns leading to calls for "sustainable agriculture", "conservation agriculture", "agro-ecological" and "eco-agriculture" approaches [43]. The trend to this type of farming more diverse (sustainable agriculture) makes farming systems more resilient to harsh conditions where ecosystems are like the natural ecosystem, in addition, this type of sustainable agriculture leads to increased crop yields. A review of the method of "agroecological" in Africa showed that cereal crops improved by 50% to 100% when this kind of agriculture was promoted [44]. The importance of agricultural biodiversity encompasses socio-cultural, economic, and environmental elements. All domesticated crops and animals result from the management of biodiversity, which is constantly responding to new challenges to maintain and increase productivity under constantly varying conditions and population pressures. Agricultural biodiversity is essential to satisfy basic human needs for food and livelihood security [45].

4. Measures to reduce the impact of climate change on biodiversity food security

Apart from the obvious role of plant and animal biodiversity in providing a variety of different foods that are consumed by humans, the positive interactions between a diverse array of organisms, including annual crops, animal pollinators, trees (in farmland and associated habitat), micro-organisms, livestock, and aquatic animals, are required or at least provide important support to the production of many foods globally, in terms of enhancing and stabilizing production [46]. Mixed crop and livestock production accounts for about 60% of global livestock production they provide fertilizer that supports crops the use of animals in tillage, as well as crop residues, are used as animal feed [47]. The assessing the amount of nitrogen 13% of the total nitrogen fertilizer income was obtained from livestock fertilizer. This integration of livestock and crop production can support adaptation to the impact of climate change [48]. The use of plant forages including trees such as *Leucaena* and *Calliandra* mitigates some of the climate impacts of livestock production and minimizes competition for grains which are also important human foods [49]. Aquatic agricultural systems (AAS) that are often ecotones of terrestrial and aquatic resources in spatially and seasonally complex shifting mosaics [50]. These systems play a significant role in generating ecosystem services and enhancing landscape multi-functionality. For example, they contribute to the management of water resources for fisheries or aquaculture, irrigation, hydropower production, flood prevention, drinking water supply, and biodiversity conservation. The dynamics described here include the interplay of many ecosystem services that support the livelihoods and well-being of communities, with both synergistic and trade-off effects. Common trajectories of change in AAS encompass the expansion and intensification of terrestrial agriculture, the decline in condition and productivity of natural fisheries, the increased irrigation of crops leading to water abstraction and diversion, the encroachment and loss of wetland habitats like mangroves, and the expanding and intensifying of aquaculture [64].

A meta-analysis of fish and rice co-culture in paddy fields, found positive effects on rice yields and lower usage of pesticides when fish were present compared to rice monocultures, with organic nitrogen from fish providing a renewable source of fertilizer to promote rice growth and fish controlling rice pests [51]. The rates of organic matter accumulation and methane emissions in such systems have been reported to be relatively high and low, respectively, when compared to conventional rice production, supporting production and mitigating climate change [52]. In China, silkworms are fed on the leaves of the mulberry tree grown around fishponds, and fish are fed on the mulberry and silkworms. An integrated system is created by fish waste fertilizing mulberry production [53]. The IPCC (Intergovernmental Panel on Climate Change) asserts that roughly 20% to 30%, varying from 1% to 80% among regional biotas of species assessed so far (in an unbiased sample), are likely to be at increasingly high risk of extinction as the global mean temperature exceeds 2 to 3 °C above pre-industrial levels. Loss of biodiversity will affect food and agriculture and may well lead to significant losses of genetic diversity within the species most important for food and agriculture [54].

The sustainable use of genetic resources for food and agriculture will be the foundation for many of the adaptation strategies required in food and agriculture. To adapt to climate change, plants, and animals important for food security will need to adjust to abiotic changes such as heat, drought, floods, and salinity [55]. As climate change brings new pest and diseases, new resistances will be required for animal breeds, fish breeds and crop and forest varieties [56]. Genetic diversity which is currently underutilized may become more attractive to farmers because of climate change [57]. A summary of the usefulness of genetic diversity in food and agriculture in adapting to climate change impacts in production systems is given in Table 2 [35]. Analysing whether climate change may constitute a threat for biodiversity in the future requires understanding the extent and distribution of biodiversity for food and agriculture, and its vulnerability and adaptation patterns. Matching this information with that available from climate change models will be a basic requirement to inform conservation and adaptation strategies. Lack of characterization and evaluation of genetic resources for food and agriculture will be an obstacle in developing adaptation mechanisms to climate change. Evaluation is currently an important bottleneck across all types of genetic resources. Improving information systems for genetic resources and the dissemination of relevant information to users will be an important priority for the future [58].

A modern method is being used that can be used to preserve biodiversity and preserve healthy disease-free genes and pure genetic strains. This process comes on cryopreservation it is a process of freezing of biological materials and keeping them for later use at very low temperatures up to (−196°C) during this process, the biochemical and most physical processes of the biological material are interrupted. Plant material can be stored for unlimited periods. Plant parts such as seeds or tissues are frozen and preserved for reproduction. Plant genetic resources are of great importance for species conservation and food security, which can then be used to produce new crops. High yield crops, in the sense of the production of plants resistant to biological pressures and the environment [59]. Another advantage is that plants preserved in

Table 2. Most examples described have been taken from two sources: FAO. 2007. The state of the world's animal genetic resources for food and agriculture. Rome (Italy). FAO. 1998. The state of the world's plant genetic resources for food and agriculture. Rome (Italy) [35].

	Genetic diversity usefulness				
	Plant	Animal	Forestry	Aquatic	
Adaptation to	Genetic resources				Examples of traits and management practices
New abiotic stress	X	X	X	X	• Adaptation of crop varieties to allow new timing of sowing or harvesting. • Improvement of crops to increase water use efficiency, tolerance to heat stress or use of nutrients. • Establishment of forest breeding populations with different relationships between latitude and temperature climate. • Selection of animal breeds with effective thermoregulatory control. • Use of fish species and strains adapted to low quality waters. • Use of underutilized species, breeds or varieties adapted to harsh environments. • Community-based management of a wide portfolio of plant genetic diversity to allow adaptive capacity.
New biotic stress	X	X	X	X	• Use of disease-resistant cultivars, multi-lines, or farmers' composite mixtures to strengthen crop resilience and resistance. • Enhancement of the resistance or tolerance to disease by management of animal genetic resources. • Use of diversification strategies to increase the number of species and genetic diversity being farmed to reduce vulnerability.
Extreme climate events	X		X		• Breeding of boreal forest species to control timing of spring growth to avoid late frosts. • Use of genetic diversity of fire- tolerant forest species. • Community conservation of particular local varieties adapted to cope with extreme climatic events.

this way are genetically stable in most cases, keeping gametes in this way prevents genetic drift, when cryopreservation, we usually select the best valuable genetic strains in the process (cryopreservation) to maintain genetic integrity. Increases generation time and allows the further contribution of genetics on reproductive lifespan, ease of transportation of genetic stock, and decrease disease transmission. As well as this process, also ensure that plant genetic resources are preserved and protected from extinction as a result, we maintain biodiversity [60].

One of the modern ways to preserve and protect species from extinction is plant tissues through which pure plants are selected free of genetic diseases and try to multiply them in environmentally friendly ways without the need for large amounts of water and within a small agricultural area compared to traditional agriculture [61]. Where growth-regulating hormones are added to the culture media under controlled conditions of lighting and temperature that ensure obtaining healthy and disease-free plants, and many studies are carried out on them such as the production of callus or re-germination for the purpose of improving them and obtaining high-quality crops that are resistant to climate change. Also, some genetic modifications are made to the plant during plant tissue cultivation that increase crops and improve their quality [61, 62].

5. Conclusion

Based on the information provided, it is evident that climate change has a substantial and immediate effect on worldwide food security. Therefore, it is imperative that we make earnest efforts to identify and implement solutions. The effect arises from the influence of climate change on the many components of the ecosystem and their interdependence. Any alteration in the sequence of ecosystem services has repercussions on the environment, including people. Humans have the greatest influence on the health of the global climate. The pollution caused by the contemporary industrial revolution and the release of different gases have had a substantial negative effect on the climate. In addition to advancements in agriculture, the conversion of land for agricultural purposes has resulted in significant biodiversity loss. A diverse woodland ecosystem that includes several plant species, insects, animals, bacteria, parasites, and other organisms, is converted into an agricultural land limited to one or more crops exclusively used by humans for sustenance. Consequently, humans have significantly depleted the biodiversity of these forests, resulting in harmful side effects for food production, climate regulation, and carbon. An essential determinant for the conservation of climate and biodiversity is seeing the human person as an integral component of the environment, rather as its proprietor. Hence, it is essential to promptly implement efficient measures to adapt the agricultural system and minimize the use of pesticides, which pose a significant threat to several beneficial species. The report recommends the use of environmentally sustainable agricultural practices to ensure the preservation of biodiversity and healthy ecosystem.

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