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Original Article

Climate Change and Its Effects on Biodiversity Conservation and Gastronomy

El cambio climático y sus efectos en la conservación de la biodiversidad y la gastronomía

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ABSTRACT

Climate change is one of the main concerns currently faced by humankind. Its effects are numerous in economic, social, and environmental terms. This article addresses the implications of biodiversity conservation in Peru and its close relationship with gastronomy, one of the country's principal economic activities and a fundamental pillar in the recognition and preservation of its cultural identity. The objective is to analyze the effects of climate change on biodiversity and its impact on Peruvian gastronomy. The study is qualitative and descriptive, based on three thematic axes. The findings indicate that climate change is generating significant effects on biodiversity conservation, altering the distributional limits of populations and modifying population patterns, thereby placing the survival of many species at risk. Additionally, the study highlights that biodiversity is the essential source of inputs that supply Peruvian cuisine; therefore, efforts aimed at its conservation will directly contribute to the sustainability of gastronomy in the country.

Keywords: Gastronomy, climate change, biodiversity, flora and fauna.

RESUMEN

El cambio climático es una de las principales preocupaciones que afronta la especie humana en las actuales circunstancias. Los efectos que de ello se derivan son muchos en términos económicos, sociales y ambientales. En el presente artículo nos referimos a las implicancias de la conservación de la biodiversidad en el Perú y su estrecha relación con la gastronomía, una de las principales actividades económicas del país y un pilar fundamental en el reconocimiento y la preservación de nuestra identidad cultural. El objetivo es analizar los efectos del cambio climático sobre la biodiversidad y su impacto en la gastronomía peruana. La investigación es cualitativa y descriptiva, tomando como base tres ejes temáticos. Se concluye que el cambio climático está generando efectos

significativos en la conservación de la biodiversidad, alterando los límites de distribución de las poblaciones y modificando los patrones poblacionales, lo que pone en riesgo la supervivencia de muchas especies. Asimismo, se destaca que la biodiversidad es el eje fundamental de insumos que abastecen la cocina peruana, por lo que los esfuerzos para su conservación contribuirán directamente a la sostenibilidad de la gastronomía en el país.

Palabras clave: Gastronomía, cambio climático, biodiversidad, especies de flora y fauna.

INTRODUCTION

Climate change, population growth, the global economy, national defense, health, food security, and poverty are pressing concerns that demand our attention, even as the uncertainties surrounding their evolution and development continue to grow. In the current context of demographic expansion, global trends suggest we are shaping a different vision of the future, one in which current patterns of human development may no longer be viable. This is particularly evident when considering that politics, economics, culture, religion, and environmental change have shaped the course of events throughout history (Fuertes *et al*., 2017).

The use of natural resources and the generation of all types of waste over thousands of years of civilization are pushing the Earth's capacity to its limits. In recent times, demographic growth, intensive access to abundant and low-cost energy sources, and the widespread use of technology to intervene in nature have dramatically disrupted ecosystems (Olivera-Carhuaz & Pulido-Capurro, 2023). In recent decades, the excessive rise in extraction, transformation, production, transportation, consumption, and waste generation has surpassed the planet's geological and physicochemical thresholds, triggering an environmental crisis with serious social and economic consequences at a global scale (Prats *et al*., 2016).

In this scenario, climate change has caused an increase in average land and ocean surface temperatures, altered precipitation patterns, significant shifts in the intensity and frequency of climate events, and a rise in mean sea level (Intergovernmental Panel on Climate Change [IPCC], 2023). Planetary temperature records over the last 100,000 years reveal that climate fluctuations were abrupt during the first 90,000 years, whereas the last 10,000 years have shown a trend toward stability (Lovejoy, 2008). Historically, this latter period saw the beginnings of permanent human settlements, the rise of agriculture, the expansion of livestock rearing, and the onset of deforestation. Human civilization has evolved under the assumption of a stable climate; however, the current scenario reveals that rising greenhouse gas concentrations are intensifying the greenhouse effect and causing drastic climatic changes (Uriarte, 2010).

Since the mid-20th century, the concentration of greenhouse gases has driven a 0.75 °C increase in global average temperature. As a consequence, the physical environment has undergone striking changes: earlier spring ice breakup in lakes, the retreat of glaciers in Alaska and Greenland, the melting of tropical ice caps such as those on Mount Kilimanjaro and in the tropical Andes, and the rapid decline of Arctic sea ice, an expected outcome given

the heat-absorbing capacity of open water compared with ice. A pessimistic projection forecasts an ice-free Arctic by 2030. Sea levels are also rising due to the thermal expansion of seawater (Schoolmeester *et al*., 2019; Pallmall, 2021).

According to the IPCC (2023), global warming is expected to increase by 1.5 °C between 2030 and 2035 unless swift action is taken. By the end of the 21st century, surface temperature is projected to rise between 2.6 °C and 4.8 °C, and mean sea level could increase by 45 to 82 centimeters. Additionally, precipitation intensity is projected to increase in high latitudes and near the equator, while decreasing in subtropical regions.

Another critical indicator is the significant rise in forest fires across all five continents. These fires are associated with the destruction of forest, livestock, and agricultural resources, and in some cases, loss of human life and infrastructure, although fire does play a natural ecological role in some landscapes. Longer and warmer summers, along with earlier snowmelt, have created drier environments with greater vulnerability to fire. Drought-induced dryness of vegetation is a key factor in fire propagation (Pausas, 2020). The increase in tropical cyclones follows a similar trend. In August 2017, satellite images from Greenland showed active fires even in this typically cold and sparsely vegetated region (Úbeda & Francos, 2018).

In Peru, the climate has been shifting gradually in recent years due to irregular increases in sea surface temperature. Climate projections show amplified precipitation variability linked to warmer El Niño conditions, which have triggered extreme climate events that impact agriculture, livestock, public health systems, infrastructure, and social, economic, and governance structures. The 2017 El Niño event was the third strongest in recent history, with devastating economic losses and significant health impacts from heavy rainfall and river flooding (Yglesias-Gonzalez *et al*., 2023).

At the same time, biodiversity is being directly transformed by the effects of climate change, despite having played a major role in species evolution. Biodiversity (the sum of genetic, species, and ecosystem diversity) is not evenly distributed across the planet. Relatively small areas, particularly in the high Andes, contain significant concentrations of endemic species with narrow distribution ranges, making them areas of exceptionally high species richness and endemism.

Furthermore, there are also biodiversity hotspots, which are areas of high biological diversity that are currently threatened by human activity. These areas, located mainly in the tropics and high mountains, have escaped some of the effects of glaciation (Myers *et al*., 2000; Ministerio del Ambiente, 2019; Hernández-Ruedas *et al*., 2019).

In this context, Peru has developed a gastronomy that reflects extraordinary richness and benefits millions of Peruvians through its economic and social impact. As such, it generates significant implications for the economic and social relationships within the various settings in which food industry actors participate, particularly regarding the flow of biodiversity from rural to urban areas, job creation, and the activation of services such as hotels, restaurants, and supply chains. This has contributed to Peru being recognized as one of the world's best gastronomic destinations (Guardia, 2020).

For precisely this reason, Peru, one of the most biodiverse countries on the planet, has fostered the development and evolution of a bountiful gastronomy. Coastal cuisine is well known for its desserts and raw seafood preparations; Andean cuisine for its consumption of tubers, corn, and meats such as llama, alpaca, and guinea pig; and Amazonian cuisine for its abundance of forest resources, including wild meats such as deer, peccary, and agouti, fish such as paiche, dorado, and gamitana, fruits like camu camu and aguaje, and other preparations like root macerations (Luza, 2014).

The interrelationship of these three variables leads this article to analyze the effects of climate change on biodiversity conservation and its influence on Peruvian gastronomy.

MATERIALS AND METHODS

This study was conducted using a qualitative approach with a non-experimental and descriptive design. No variables were manipulated; instead, the aim was to understand and analyze the effects of climate change on biodiversity and its impact on Peruvian gastronomy from an interpretive perspective (Hernández *et al*., 2014; Katayama & Pulido, 2017; Pulido-Capurro *et al*., 2024).

The analysis was structured around three main thematic axes:

- Climate change in the Peruvian context,
- Alterations in biodiversity (flora and fauna species), and
- Implications for traditional and contemporary Peruvian gastronomy.

Study Design

This was a non-experimental, cross-sectional, and documentary study, relying on the collection and analysis of pre-existing information without direct intervention in the observed phenomena. The analysis was based on secondary sources and relevant scientific literature, allowing for an in-depth approach to the issue across environmental, ecological, and cultural dimensions.

Procedure and Data Collection

A systematic documentary search of scientific and academic literature published between 2005 and 2024 was conducted to ensure the inclusion of recent and relevant studies. The databases used were Scopus, Web of Science, and SciELO.

The search was performed in both Spanish and English, using Boolean operators (AND, OR) and the following keywords:

- “Climate change” AND “Peru”
- “Biodiversity” OR “native species” OR “flora and fauna”
- “Peruvian gastronomy” OR “traditional food”
- “Climate impact on food”
- “Climate change” AND “food systems” AND “gastronomy”

International organization reports were also reviewed, as they provide updated data on the effects of climate change in the Andean and Amazonian regions of Peru.

Inclusion and Exclusion Criteria

Inclusion: Academic journal articles, technical reports, peer-reviewed papers, official documents, and gray literature addressing at least one of the three thematic axes within the Peruvian or South American context.

Exclusion: Articles without academic support, journalistic notes lacking scientific sources, studies prior to 2005, or papers addressing the topics only theoretically with no connection to Peru.

Information Analysis

Collected data were organized and examined using a thematic analysis matrix, which allowed the identification of patterns, relationships, and effects linking climate change, biodiversity, and gastronomy. Additionally, a critical discourse analysis was applied to key documents to identify predominant narratives on sustainability, cultural identity, and gastronomic adaptation in the context of climate change.

RESULTS AND DISCUSSION

Climate Change in Peru

The intensity and impacts of climate change in each country are closely related to structural factors and environmental and socioeconomic characteristics. Although such impacts have existed for centuries, they have intensified since 1970 due to global surface temperature variations, which increased by approximately 0.99 °C between 2001 and 2020 compared with 1850–1900. Moreover, the stratospheric ozone layer decreased by about 2.2% between 60°N and 60°S from 1980 to 2017 due to human-generated pollution (Gulev *et al*., 2023). These changes compromise various productive sectors, economic activities, public health, and life zones across the planet (IPCC, 2023; Cabezas, 2023).

In Peru, as elsewhere, the progressive rise in average land and Pacific Ocean temperatures has contributed to glacier retreat, altered precipitation patterns, rising mean sea levels, and increased frequency and intensity of El Niño and La Niña events. These phenomena have triggered climate variability, including extreme events, driven by increasing greenhouse gas emissions. Consequences include reduced per-capita income, decreased industrial efficiency, damage to road infrastructure, reduced electricity generation, increased natural disaster risk, heightened precipitation intensity, weakened nutrient-rich upwelling, shifts in the distribution of fisheries and marine resources, reduced freshwater availability, decreased agricultural and livestock productivity, degradation of agro-silvopastoral and fishing systems, savannization of tropical forests, flooding and salinization risks in coastal zones, habitat loss, and changes in the physical, chemical, and biological properties of lakes and rivers, all affecting biodiversity composition (Vargas, 2009; Navarro Guzmán *et al*., 2020).

Since 1992, Peru has taken important steps by joining the United Nations Framework Convention on Climate Change (UNFCCC), which it ratified in 1993, thereby committing to stabilize greenhouse gas concentrations and prevent dangerous anthropogenic interference with the climate system. This commitment was reaffirmed in 2002 when Peru joined the Kyoto Protocol (Ministerio del Ambiente, 2016).

Additionally, the National Adaptation Plan for Climate Change (an input for updating the National Climate Change Strategy) has been in effect since 2021. It is a milestone in climate action, mandated by the Climate Change Framework Law and its Regulation. The plan focuses on climate adaptation planning and guides the update of the National Climate Change Strategy (Ministerio del Ambiente, 2021).

Peru has 28 of the 35 recognized global climates and ranks third worldwide in climate-related vulnerability. In 2021,

25.9% of the population lived in poverty, with 4.1% in extreme poverty; 34.6% were at risk of falling into monetary poverty due to potential economic shifts. A large percentage of the population depends on agriculture, fishing, and other climate-sensitive activities. Additionally, 90% of the population lives in arid, semi-arid, or sub-humid zones (Chirinos, 2021; Ministerio del Ambiente, 2021).

Climate change is impacting biodiversity across Latin America and the Caribbean, requiring populations dependent on agriculture, livestock, fishing, and hunting to adopt new strategies for conserving biological and ecosystem resources. Climate change directly affects biological processes at the individual, population, and ecosystem levels. For individuals, it alters development, physiology, growth phases, reproduction, migration, and behavior (Pulido *et al*., 2021). Changes in rainfall patterns and temperature shifts affect species distribution, population size, structure, and abundance. Climate-induced shifts in the hydrological cycle also alter species interactions, nutrient cycles, and ecosystem structure and functioning, ultimately affecting ecosystem services (IPCC, 2023).

Since the late 20th century, a near 1 °C increase in average temperature has been recorded. Although this increase may appear modest, it has serious consequences, including reduced crop yields in developing countries (potentially leading to famine), glacial melting and disappearance (threatening water supplies), and loss of ecosystem components (Chirinos, 2021). According to Peru's Third National Communication (2014), 64% of national emergencies were climate-related events such as droughts, rains, floods, and cold spells. Over the last 15 years, emergencies due to natural hazards have increased significantly, 72% of which were climate-related (Ministerio del Ambiente, 2016).

In response to increasingly intense climate events, the Ministry of the Environment has implemented various adaptation and mitigation measures. In 2010, the Adaptation and Mitigation Action Plan was introduced to guide regional climate change risk management. In December 2019, the Ministry published the Catalog of Mitigation Measures, which includes 62 guidelines across sectors such as energy, industrial processes, waste management, agriculture, livestock, and land use. The goal is for Peru to achieve net-zero greenhouse gas emissions by 2050 (Ministerio del Ambiente, 2016; Chirinos, 2021).

Biodiversity

There are references indicating that, since Columbus's second voyage to the Americas in 1493, the introduction of cultivable plants and domesticated animals, mainly from Europe and other regions, began (Capdevila *et al*., 2006). Since the arrival of Europeans in the Americas in the sixteenth century, they contributed to the understanding of geological structure and the identification of numerous new species, thus expanding biodiversity. From that moment, and through a long historical process marked by the voyages of explorers, it became possible to record in detail the exchange of species between Europe and the Americas (Hernández-Ruedas *et al*., 2019). One of the first explorers, between 1799 and 1804, was the renowned German scientific explorer, geographer, and naturalist Alexander von Humboldt, who, together with the French botanist Aimé Bonpland, traveled through Venezuela, Ecuador, Colombia, and Peru. The findings of their research were published in Voyage

to the Equinoctial Regions (Escobar-Mamani & Pulido-Capurro, 2021).

These journeys and exchanges intensified beginning in the eighteenth century. Between 1857 and 1869, the Italian scholar Antonio Raimondi explored the coast and the Andes, gathering valuable information that was later published, starting in 1875, in six volumes of his monumental work El Perú (Escobar-Mamani & Pulido-Capurro, 2021). However, it was in the twentieth century that the development and modernization of transport systems facilitated the movement of living organisms by reducing travel duration, which in turn increased the exchange of species (Bendjoudi *et al*., 2015). In 1945, Augusto Weberbauer, a German naturalist and professor of Botany at the Universidad Nacional Mayor de San Marcos, published an essential contribution to the knowledge of Peruvian flora in his work The Plant World of the Peruvian Andes (Pulido, 2023).

In 1951, Russian botanist and geneticist Nikolai Ivanovich Vavilov emphasized that the Andean region is one of the world's centers of origin and diversification of crops. For ten thousand years, plants and animals have been domesticated, resulting in new varieties created by pre-Inca and Inca cultures in highly sustainable and productive lands (Vavilov, 1951; Krapovickas, 2010).

Today, Peru is one of the world's seventeen megadiverse countries, as it contains more than 70% of the planet's biodiversity, represented by a wide range of ecosystems, flora and fauna species, and genetic diversity. These not only form part of the national heritage but also contribute to regional and global development and sustainability. More than 20,375 species of flora have been recorded, along with 530 mammals, 1,892 birds, 446 reptiles, 1,070 marine fish, and 873 freshwater fish; additionally, Peru contains 84 of the planet's 117 life zones and more than 73 million hectares of forests. Five species of wild fauna and 182 species of native domesticated plants have been domesticated, 174 of which are of Andean origin, including well-known crops such as potato (*Solanum tuberosum*), maize (*Zea mays*), ulluco (*Ullucus tuberosus*), oca (*Oxalis tuberosa*), and quinoa (*Chenopodium quinoa*). Introduced species include the rock pigeon (*Columba livia*), rainbow trout (*Oncorhynchus mykiss*), and Nile tilapia (*Oreochromis niloticus*) (Brack, 2003; Cossíos, 2010; Ministerio del Ambiente, 2019; Olivera-Carhuaz & Pulido-Capurro, 2023).

In the Andes, approximately 182 species of domesticated native plants have been recorded, 174 of which are of Andean origin, including potato (*Solanum tuberosum*), maize (*Zea mays*), ulluco (*Ullucus tuberosus*), oca (*Oxalis tuberosa*), and quinoa (*Chenopodium quinoa*), among other valuable species. There are nearly 200 species of potato distributed throughout the Andes of Peru, Bolivia, and Argentina; the principal species, *Solanum tuberosum*, was domesticated in the Lake Titicaca region (Brack, 2003). There is also the inventory The Grasses of Peru by Óscar Tovar, who in 1993 described 680 species of native agrostological flora (Brack, 2003; Escobar-Mamani & Pulido-Capurro, 2021). Peru has contributed five native species of domesticated animals inhabiting the Andes: llama (*Lama glama*), alpaca (*Lama pacos*), guinea pig (*Cavia porcellus*), Muscovy duck (*Cairina moschata*), and cochineal (*Dactylopius coccus*) (Brack, 2003; Cossíos, 2018; Pulido, 2023).

Ecosystem representation is protected within the National System of Protected Natural Areas (SINANPE), which administers 76 protected natural areas (PNA) under different categories, such as National Parks, National Sanctuaries, National Reserves, Wildlife Refuges, Landscape Reserves, Communal Reserves, Protection Forests, Hunting Grounds, and Reserved Zones. These areas cover 29,768,595.74 hectares, representing 17.90% of the terrestrial area protected by PNAs and 7.89% of the marine area protected by PNAs within national territory. These areas safeguard Peru's rich biodiversity, scenic beauty, and the heritage of Andean and Amazonian Indigenous populations (Myers, 1990; Ministerio del Ambiente, 2023; Servicio Nacional de Áreas Naturales Protegidas por el Estado (SERNANP), 2024).

Peru contains a significant number of wetlands, located on the Pacific, Atlantic, and Titicaca basins, with an estimated preliminary area of nearly 8 million hectares. There are also 13 wetlands of international importance, or Ramsar sites, covering 6,784,042 hectares, registered under the Ramsar Convention. Their importance is highlighted in the National Wetlands Strategy of Peru, which establishes guidelines for the protection of these ecosystems, their biodiversity, and the environmental services they provide (Ministerio del Ambiente, 2015).

Glaciers in the Peruvian Andes cover an area of 2,042 km², representing 77% of the world's tropical glaciers. Over the last 30 years, 22% of their surface area has been lost. These glaciers account for 71% of all tropical glaciers worldwide, and it is estimated that by the year 2030, due to global warming, all glaciers below 5,000 meters will disappear or drastically shrink. This loss represents 7 billion cubic meters of water, equivalent to ten years of water consumption for the population of Lima. The energy sector would also be affected since nearly 80% of electricity is generated in hydroelectric plants (Schoolmeester *et al*., 2019).

Agriculture is a first-order system of adaptation, as its mission is to feed populations so that they can fulfill their assigned functions (Córdova, 2020). Twenty-seven crops have been identified, such as potato, maize, and rice, that constitute basic household staples and are vulnerable to climate change. In the Amazon, the largest expanses of forest are the areas of greatest biodiversity and the most vulnerable. These habitats hold the greatest diversity of flora and fauna, providing food sources such as aguaje and camu-camu, as well as medicinal resources like cat's claw and oje. The Andean highlands are among the most affected zones, as they are home to the poorest populations in Peru, whose survival depends on small-scale farming for family consumption. In the Andes, a temperature increase is somewhat favorable because it allows crops to develop more quickly and extend to higher elevations than they currently reach. However, higher temperatures also cause stress in crops, reducing their productivity, especially those located in the desert coast and intended for agro-export, such as avocados, asparagus, blueberries, and grapes (Ministerio del Ambiente, 2019; Lozano-Povis *et al*., 2021; Escobar-Mamani *et al*., 2025).

In the oceans, natural systems connected to snow, ice, and frozen terrain are being affected by rising temperatures, indicating that global warming alters both climatic and biological systems. Evidence shows a retreat of snow cover and sea ice

in the Northern Hemisphere, shorter durations of frozen seasons in lakes and rivers, glacier melt, rock avalanches in mountain regions, changes in some Arctic and Antarctic ecosystems, and shifts of animal and plant species toward higher latitudes and elevations. If the global average temperature increases by 1.5–2.5 °C, approximately 30% of plant and animal species will likely face extinction risks (Vargas, 2009; Ministerio del Ambiente, 2016; Gulev *et al*., 2021).

The vulnerability of the Peruvian coast is impacted by water scarcity and drought and is also one of the regions most affected by the El Niño Phenomenon, which is increasingly frequent and intense. One of the main effects of El Niño is the rise of ambient temperature above average levels, even higher than those typically experienced in summer. It also brings increased relative humidity and torrential rains in the northern part of the country, causing severe economic and infrastructural losses (Ministerio del Ambiente, 2019).

Gastronomy

To speak of Peruvian gastronomy, one must probably trace its origins back 5,000 years, to the first civilization that inhabited the Americas, Caral, in the Supe Valley north of Lima. Since then, and over the centuries, gastronomy has broadened its horizons, enriched by extraordinary biodiversity and multiculturalism, expressed through the interaction of coastal, Andean, and Amazonian cultures. Peruvian cuisine is recognized as one of the most exquisite and diverse worldwide, with a rich heritage rooted in pre-Inca and Inca periods, as well as interactions with foreign culinary traditions from other Latin American countries and from Europe (Spanish, Italian, French), Asia (Chinese-Cantonese, Japanese), and Africa (Arab). The delicate flavors of gastronomy arriving from four continents have produced a vast diversity of iconic dishes in the Peruvian culinary arts, dishes that are in continual evolution.

Thus, gastronomy is perceived as an important cultural expression that manifests flavors, aromas, and delicate combinations of animal components, plants, fungi, and diverse microorganisms. All of this is the result of a long historical process that began in pre-Columbian societies and has been revitalized today as an expression of profound cultural heritage. The concept of heritage is understood as the art of inheritance, tradition, past, identity, culture, and nostalgia (Luza, 2014; Mauro Martín *et al*., 2019; Guardia, 2020; Manallay, 2022).

Gastronomy structures its foundations on a value chain that begins with the production and processing of food, continuing through distribution and transformation, and culminating in consumption. It is estimated that this value chain represents 11.2% of the national GDP. Gastronomy provides employment to more than two million people across nearly 200,000 establishments throughout the country. The development of this process is supported by values such as gastronomic landscapes, cultural and culinary identity, and tangible and intangible heritage, and it is related to other factors such as public policy, administrative regulations, available infrastructure, academic training, research, and innovation (Pizarro-Ramos *et al*., 2024). It is part of the social and economic context of communities throughout the country and serves as a powerful tool for national, regional, and municipal development (Aguilar, 2016). Additionally, Peru's privileged megadiverse territory includes 84 of the planet's 117 life zones, giving rise to a rich

flora with 20,375 species, including the production of 4,400 native plants, as well as species from aquatic environments, especially freshwater and marine algae (Ministerio del Ambiente, 2019). This helps explain the extraordinary variety of flavors and textures in Peruvian cuisine.

Another important aspect is the sustained growth of gastronomy, the evolution of its recognition and global positioning, the increase in restaurants and in tourists attracted by Peruvian cuisine, the recovery of native products, traditional recipes, and ancestral cooking techniques, the production of specialized literature, and the growing interest of young people in professional culinary training, all of which have contributed to expanding the range of academic certification alternatives (Quea-Campos, 2024).

However, Peruvian cuisine, represented by diverse stakeholders such as entrepreneurs, chefs, professional associations, media outlets, universities, and journalists who have driven the promotion of Peruvian cuisine would be seriously affected by disruptions in the biological cycles of biodiversity and by climate change.

A series of changes will occur, altering the functionality of ecosystem services provided by biological communities such as tropical forests, wetlands, and grassland prairies. These changes will lead to the emergence of forest pests and recurring damage that affects the survival, reproduction, and dispersal of organisms. There will also be impacts on ecological relationships, such as disproportionate increases in producers, competitors, parasites, and predators, thereby altering the trophic chain. At the ecosystem level, the frequency and intensity of forest fires will increase due to warmer and drier climatic conditions, compounded by irresponsible human activities. By 2030, as a result of global climate change, 15% of Protected Natural Areas (both state and private) will experience persistent conditions of exposure, risk, and adaptive capacity, placing them under high vulnerability to climate change. This will cause drastic reductions in biodiversity, modification and redistribution of biological communities, increased desertification, soil erosion and salinization, more frequent droughts, and atypical and unpredictable rainfall events. These changes will result in scarcity of forest resources that provide animal- and plant-based foods, as well as water, to rural and Indigenous communities (Ministerio del Ambiente, 2019; Córdova, 2020).

In the coastal and Andean regions, high temperatures will produce excessive humidity, loss of agricultural land due to soil salinization, reservoir sedimentation, destruction of productive infrastructure, lower meat and milk production, and decreases in crop yields—particularly disastrous for the Andean farmer, affecting potato crops and the 174 species of Andean-origin plants, such as ulluco, oca, and quinoa. Thus, climate change presents a risk to farmers and agricultural workers, as well as to the country's food security. This situation is exacerbated by the fact that 55% of people living in poverty work in activities supporting the primary food production systems of the country, and 14 million Peruvians are vulnerable to food insecurity (Arteaga & Burbano, 2018; Chirinos, 2021; Lozano-Povis *et al*., 2021).

In the ocean, there will also be direct consequences for the productivity and spatial distribution of both pelagic and benthic hydrobiological resources due to rising sea temperatures, potential displacement

of marine currents, and changes in CO_2 concentration. The rise in sea level causes erosion of the shoreline and threatens existing infrastructure, affecting artisanal fisheries, coastal fishing towns, tourism, and recreational activities. The upwelling system, driven by the dynamics of marine currents along the coast and serving as a catalyst for high fishery productivity, will be affected, causing losses due to reduced fishery resources, whether from low productivity or from the displacement and migration of species toward areas with more favorable temperatures. In coastal zones, damages will occur in aquaculture systems due to climatic conditions associated with El Niño events, characterized by significant sea temperature increases and torrential rains on land. It is important to note that all aquaculture species are poikilothermic, meaning that temperature variations can significantly affect their overall metabolism, growth rates, and total production levels (Serrano *et al*., 2016; Torres, 2019; Córdova, 2020; Navarro, 2020).

CONCLUSIONS

Climate change is producing significant effects on biodiversity conservation, modifying the distributional ranges of animal, plant, fungal, and microbial populations, severely altering population patterns and endangering the survival of many species.

Given that biodiversity is the primary source of inputs that supply Peruvian cuisine, efforts directed toward its conservation will have a direct impact on the sustainability of gastronomy in the country.

Efforts to mitigate global warming require a commitment to restructure our energy base and manage carbon within ecosystems, which implies a transition that promotes ecological development aligned with the sustainability framework necessary for biodiversity conservation.

The sustainability of Peruvian gastronomy depends largely on the efforts undertaken by the government and civil society to reduce greenhouse gas emissions that intensify climate change, as well as on actions aimed at conserving biodiversity in protected natural areas, agroforestry systems, agri-food systems, small- and medium-scale agriculture, and both extensive and enclosed livestock production.

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