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Guest Editors' Column

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Overview

Humans and other lives on the earth are increasingly impacted by the rising of earth's temperature and climate change caused by both natural and human activities. The main anthropogenic factors responsible for climate change include the burning of enormous fossil fuels, deforestation and farming of livestock, thereby adding huge amounts of greenhouse gases (GHGs), namely, carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, etc. Farming of land animals is responsible for an estimated amount of 12% - 20% of global GHG emissions. The consequences of climate change or global warming, as predicted by the Intergovernmental Panel on Climate Change (IPCC) of United Nations, are going to increase the global average surface temperature between 1.8°C to 4.0°C by 2100 and with the increases of 1.5°C to 2.5°C temperature, it is expected that 20% - 30% of plant and animal species are at risk of extinction. Climate change is widely recognized to have a negative impact on the lives of the earth by means of natural calamities like extreme weather events, rising sea levels, and rising temperatures, leading to droughts, flooding, heat waves, wildfires, etc. Such disasters will destroy biodiversity and reduce the production and productivity of agriculture, livestock, and fisheries, resulting in devastating deaths due to pandemics or epidemics, food scarcity and malnutrition. To alleviate the effects of climate change, the IPCC reported that societies can respond to climate change by adapting to its effects and by reducing greenhouse gas emissions (mitigation) to decrease the rate and magnitude of change. The emergence and re-emergence of infectious diseases, especially zoonotic and vector-borne diseases, are normally linked to climate change. It is estimated that 60-75% of newly emerging infectious diseases have animal origins; such zoonoses are reportedly causing about 2.5 billion cases of human illness and 2.7 million human deaths every year. 'One Health' approach is contributing to maintain the wellbeing of human health, animal health and environmental health or ecosystem by collaboration across the fields. To protect the lives on the earth including animal and aquaculture resources, in a sustainable and ethical manner, people started exploring novel adapting and mitigation activities. For example, One Health has successfully mitigated zoonotic rabies infection in Bhutan. Scientists are working on fodder and additives, masks that can capture burped methane and gene-editing to change cows' microbiomes to reduce greenhouse gas emissions, etc.

'The Indian Journal of Animal Health' is dedicated to the advancement of animal and aquaculture health care and their productivity for the past more than six decades by publishing novel research findings. The current special issue is focussed on 'Technological inventions for sustainable development goals in animal and aquaculture resource management with respect to changing climatic scenarios and One Health', which will certainly help the livestock and fishery farmers, entrepreneurs, scientists and policymakers to address the challenges of climate changes.

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Guest Editors' Column

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Overview

Technological interventions are pivotal for achieving sustainable development goals (SDGs) in animal and aquaculture resource management, especially under changing climatic conditions and the One Health framework. Key advancements include precision farming (IoT sensors for health monitoring and resource optimization), climate-resilient breeds (via CRISPR and selective breeding), and AI-driven decision tools for disease prediction and environmental management. Circular economy models, such as converting waste into bioenergy and fertilizers, reduce environmental footprints. Renewable energy solutions, like solar-powered aquaculture systems, enhance sustainability, while blockchain ensures transparency in supply chains.

For climate adaptation, tools like remote sensing and early warning systems improve disaster resilience. In aquaculture, smart systems (RAS and IMTA) minimize water use and environmental impact. Integrated One Health approaches address zoonotic disease risks through surveillance systems and innovations like probiotics, reducing antimicrobial resistance.

Technological interventions play a critical role in achieving sustainable development goals (SDGs) in animal and aquaculture resource management, particularly in the face of changing climatic conditions and the One Health approach.

These technologies not only improve productivity and resilience but also align with SDGs such as Zero Hunger (SDG 2), Climate Action (SDG 13), and Life below Water (SDG 14), promoting a balance between human, animal, and environmental health.

1. Climate-Resilient Livestock and Aquaculture Systems

A. Precision Livestock Farming (PLF)

i. Use of IoT-enabled sensors to monitor animal health, productivity, and welfare
ii. Real-time data analytics for feed optimization, disease detection, and reducing methane emissions
iii. Example: Wearable devices to track movement, stress, and health indicators

B. Climate-Smart Aquaculture

i. Development of heat-tolerant and disease-resistant aquaculture species using genomics and selective breeding
ii. Automated feeding systems to reduce wastage and optimize feed conversion ratios
iii. Climate forecasting tools to predict harmful algal blooms or oxygen depletion in aquaculture systems

2. Disease Management through One Health

A. Integrated Surveillance Systems

i. Early warning systems combining animal, human, and environmental health data
ii. AI-driven analytics to detect and predict zoonotic disease outbreaks
iii. Example: Apps that integrate data from veterinarians, aquaculture farmers, and public health officials

B. Vaccination and Biotechnology

i. Development of vaccines and diagnostic tools for common diseases in livestock and aquaculture
ii. Genetic engineering to produce animals and fish resistant to specific diseases

3. Sustainable Resource Management

A. Water and Feed Management

i. IoT devices to monitor water quality parameters (temperature, pH, dissolved oxygen) in aquaculture
ii. AI-driven feed formulations to minimize environmental footprints and maximize nutrition

ii. Genetic engineering to produce animals and fish resistant to specific diseases

3. Sustainable Resource Management

A. Water and Feed Management

i. IoT devices to monitor water quality parameters (temperature, pH, dissolved oxygen) in aquaculture

ii. AI-driven feed formulations to minimize environmental footprints and maximize nutrition

B. Circular Economy in Animal Waste

i. Technologies to convert livestock and aquaculture waste into bioenergy, biofertilizers, and other value-added products

ii. Example: Anaerobic digesters for methane capture from manure

4. Climate Monitoring and Adaptation Strategies

A. Remote Sensing and GIS

i. Mapping of climate change impacts on grazing lands and aquatic ecosystems

ii. Real-time tracking of habitat changes for migratory species

B. Decision Support Systems

i. AI-based tools to recommend adaptive measures for farmers, such as adjusting stocking densities or shifting production cycles based on climatic data

5. Sustainable Practices and Consumer Engagement

A. Block-chain for Traceability

i. Ensuring transparency in the supply chain of animal products and aquaculture outputs

ii. Enhances consumer trust and promotes sustainable farming certifications

B. Consumer Education Tools

i. Mobile apps and platforms that inform consumers about the sustainability metrics of animal and aquaculture products

6. Policy and Collaborative Platforms

A. Open-Source Databases

i. Sharing climate and disease data across nations to promote collaborative research

ii. Example: Global databases for aquaculture health monitoring

B. Capacity Building Through E-learning

i. Training farmers on sustainable practices using virtual reality and online platforms

ii. Focus on low-cost interventions tailored for local conditions

7. Advanced Breeding and Biotechnology for Sustainability

A. CRISPR and Gene Editing in Livestock and Aquaculture

i. Development of heat-tolerant and disease-resistant livestock species

ii. Gene-edited fish for aquaculture with improved growth rates and environmental resilience

iii. Example: CRISPR-modified pigs resistant to porcine reproductive and respiratory syndrome (PRRS)

B. Molecular Diagnostics and Biosensors

i. Portable DNA/RNA-based diagnostic tools for early detection of diseases in livestock and aquatic animals

ii. Biosensors for monitoring pathogens and contaminants in water and feed

C. Probiotics and Microbiome Management

i. Use of probiotics to enhance gut health and immunity in fish and livestock, reducing dependence on antibiotics

ii. Microbiome engineering to improve nutrient absorption and waste management

8. Renewable Energy Integration

A. Solar-Powered Aquaculture Systems

i. Solar aeration systems to maintain oxygen levels in fish ponds, reducing dependency on fossil fuels

ii. Solar-powered pumps for sustainable water management in aquaculture

B. Biogas from Animal Waste

i. Technologies to convert animal manure and fishery waste into biogas, reducing methane emissions and providing clean energy for farms

ii. Example: Integrated biogas units on dairy farms that produce electricity and heat

C. Offshore Wind and Wave Energy:

i. Incorporating aquaculture systems with renewable energy infrastructure, such as wind farms, to create multi-use platforms

9. Artificial Intelligence (AI) and Machine Learning (ML)

A. AI in Disease Prediction and Control

i. ML algorithms to analyze patterns in disease outbreaks across regions, linking climate data with zoonotic disease trends

ii. AI-powered drones for monitoring wildlife health in real-time

B. Decision Support Systems (DSS)

i. AI tools to recommend optimal stocking densities, water quality adjustments, or feed types for aquaculture operations

ii. DSS to predict forage availability for livestock under changing climatic scenarios

C. Behavioral Monitoring

i. AI tools analyzing animal behavior to detect stress or illnesses early, improving welfare and productivity

10. Smart Aquaculture

A. Aquaponics and Integrated Multi-Trophic Aquaculture (IMTA)

i. Combining fish farming with hydroponic crop production to utilize waste nutrients, minimizing environmental impact

ii. IMTA uses species like shellfish and seaweeds to absorb excess nutrients, creating balanced ecosystems

B. Smart Ponds and Cages

i. IoT-enabled smart ponds with sensors to monitor water quality, temperature, and fish health

ii. Use of automated feeding systems and underwater drones for cage cleaning and inspection

C. Digital Twin Technology:

i. Creating virtual models of aquaculture systems to simulate different scenarios, optimize production, and forecast risks like disease outbreaks or algal blooms

11. Ecosystem Restoration and Conservation

A. Habitat Rehabilitation Technologies

i. Use of underwater drones and robotic systems for restoring coral reefs and mangroves, which are critical for aquaculture biodiversity

ii. Artificial reefs and fish aggregating devices (FADs) for sustainable fisheries

B. Wetland Conservation for Livestock

i. Technologies to monitor and manage wetland ecosystems, critical for grazing livestock and controlling waterborne diseases

12. Big Data and Cloud Computing for Resource Optimization

A. Data-Driven Insights

i. Centralized platforms to collect and analyze climate, animal health, and productivity data

ii. Cloud-based systems providing actionable insights to farmers in real time

B. Mobile Apps for Farmers

i. Apps offering localized weather forecasts, disease alerts, and market trends

ii. Platforms to connect farmers with veterinarians or aquaculture experts remotely

C. Blockchain for Sustainability Certification

i. Ensuring traceability of sustainable practices through blockchain, certifying animal products and aquaculture outputs for eco-conscious consumers

13. Addressing Antimicrobial Resistance (AMR)

A. Alternative Therapies

i. Phage therapy and nanotechnology-based antimicrobials to reduce dependency on traditional antibiotics in animal farming

ii. Immunostimulants for livestock and fish to enhance natural defenses against infections

B. Surveillance of Antimicrobial Use

i. AI tools to track antimicrobial use across farms and monitor resistance trends

C. Regenerative Antibiotics

i. Developing biodegradable or plant-based antimicrobials to lower environmental contamination risks

14. Climate-Resilient Feed Innovations

A. Insect-Based Feeds

i. Sustainable protein sources like black soldier fly larvae for livestock and aquaculture, reducing reliance on fishmeal or soy

B. Seaweed Feed Additives

i. Inclusion of red algae species in livestock diets to reduce methane emissions during digestion

C. Cultured Fodder and Algae Cultivation

i. Hydroponic systems to grow nutrient-rich fodder and algae as alternative feeds, minimizing land and water use

15. Community Engagement and Socio-Economic Impact

A. Technology Transfer Programs

i. Government and NGO-driven initiatives to disseminate affordable and scalable technologies to smallholder farmers and fishers

B. Women and Youth Empowerment

i. Training programs in aquaculture and animal farming technology targeting women and young entrepreneurs to promote inclusivity

C. Public-Private Partnerships

i. Collaboration between technology companies, research institutions, and governments to innovate and implement sustainable solutions

16. Integrated Land-Use and Water Resource Management

A. Agro-Pastoral Systems

i. Use of remote sensing and GIS for planning integrated farming systems that combine crop production with livestock grazing, optimizing land use and preventing overgrazing

ii. Smart fencing technologies that use GPS and AI to control grazing patterns and protect sensitive ecosystems

B. Water Harvesting and Recycling

i. Advanced water recycling systems for aquaculture, such as Recirculating Aquaculture Systems (RAS), which filter and reuse water to reduce dependency on freshwater resources

ii. Rainwater harvesting and solar desalination systems for livestock farms in arid regions

C. Integrated Watershed Management

i. Technologies for watershed modeling to balance water needs for livestock, aquaculture, and natural ecosystems while preventing soil erosion and sedimentation

17. Marine Spatial Planning for Sustainable Fisheries

A. Satellite-Based Monitoring

i. Use of satellite imagery and remote sensing to track illegal fishing activities, monitor fish stock migration, and protect marine biodiversity

ii. Real-time tracking of fishing fleets with GPS and AIS (Automatic Identification System) to ensure compliance with sustainable fishing practices

B. Ecosystem-Based Fisheries Management (EBFM)

i. Incorporating ecosystem modeling tools to assess the environmental impacts of fishing and aquaculture operations

ii. Example: Using tools like Ecopath with Ecosim (EwE) for evaluating food web dynamics in aquatic ecosystems

C. Digital Mapping for Marine Protected Areas (MPAs)

i. Interactive tools to identify and establish MPAs, ensuring sustainable use of marine resources while conserving habitats critical to aquaculture and wild fisheries.

18. Enhancing Livelihoods Through Financial Technologies

A. Microfinance for Technology Adoption

i. Mobile-based microcredit platforms that allow small-scale livestock and aquaculture farmers to access funding for adopting sustainable technologies

ii. Insurance products tailored to cover losses from climate-induced disasters or disease outbreaks

B. Digital Marketplaces

i. Platforms connecting farmers directly with consumers or suppliers, reducing intermediaries and ensuring fair trade for sustainably produced goods

ii. Use of blockchain for fair trade certification in animal and fish products

19. Climate and Disease Adaptation Through Indigenous Knowledge Integration

A. Blending Traditional Practices with Modern Tech

i. Documenting indigenous practices for sustainable livestock and aquaculture and integrating them into technology design

ii. Example: Incorporating traditional water management techniques into IoT-enabled aquaculture systems

B. Community-Based Monitoring Programs

i. Training local communities to use technology for tracking animal health, water quality, and climate changes, ensuring participatory management

20. Carbon Sequestration and Emissions Reduction

A. Livestock's Role in Carbon Management

i. Adoption of silvopastoral systems that integrate trees with pasturelands to enhance carbon sequestration while improving fodder availability

ii. Methane reduction technologies, including feed additives like nitrates and tannins

B. Blue Carbon Initiatives in Aquaculture

i. Restoration of mangroves and seagrass beds near aquaculture operations to capture carbon and improve ecosystem services

ii. Cultivation of seaweed species known for high carbon sequestration potential

21. Disaster Risk Reduction and Climate Resilience

A. Early Warning Systems

i. AI and IoT-based networks for predicting floods, droughts, and extreme weather events that can disrupt livestock and aquaculture systems

ii. Cloud-based alert systems integrated with mobile networks to provide timely warnings to farmers and fishers

B. Resilient Infrastructure

i. Climate-resilient aquaculture systems, such as floating cages and submersible pens, to withstand storms and rising sea levels

ii. Livestock shelters designed for extreme heat or cold conditions

22. Education, Training, and Outreach

A. Virtual Reality (VR) and Augmented Reality (AR)

i. Immersive training tools for farmers and aquaculture workers to learn sustainable practices

ii. AR apps to assist in real-time problem-solving, such as diagnosing animal diseases or optimizing aquaculture operations

B. Knowledge Hubs and Online Communities

i. Creation of platforms that bring together farmers, scientists, and policymakers to share experiences, best practices, and innovations

By integrating these technological solutions into the One Health framework, sustainable animal and aquaculture resource management can address key SDGs such as:

i. Zero Hunger (SDG 2): Ensuring food security through efficient, resilient systems

ii. Good Health and Well-Being (SDG 3): Reducing zoonotic risks and promoting safe, nutritious food

iii. Climate Action (SDG 13): Mitigating emissions and adapting to climate impacts

iv. Life below Water (SDG 14) & Life on Land (SDG 15): Conserving biodiversity and ecosystems

v. Responsible Consumption and Production (SDG 12): Promoting circular economy practices

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Guest Editors' Column

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Overview

Integrating One Health and Sustainable Development Goal to Address Climate Change Impacts on Global Health

Abstract

Climate change, driven by natural and anthropogenic activities, poses significant global threats to human, animal, and environmental health. This phenomenon, characterized by rising temperatures, extreme weather events, and ecosystem disruption, has direct and indirect impacts on global health, including increased zoonotic diseases, respiratory illnesses, malnutrition, and water scarcity. The One Health framework, which integrates human, animal, and environmental health, provides a holistic approach to addressing the complex challenges posed by climate change. Sustainable development initiatives, particularly in agriculture and public health, align with One Health principles to mitigate these impacts while promoting resilience. Adopting sustainable practices in sectors like energy, livestock, and agriculture is critical to reducing greenhouse gas emissions, preserving biodiversity, and ensuring food security. This review underscores the importance of cross-sectoral collaboration to combat climate change, highlighting the role of One Health as a strategic pathway for achieving long-term sustainability and ecological balance. Integrated global policies are crucial to addressing the multifaceted health risks of climate change and fostering a more resilient future.

INTRODUCTION

Climate change, defined as long-term alterations in temperature, humidity, wind patterns, and other climatic factors, results from both natural and anthropogenic activities that disrupt atmospheric balance (IPCC, 2021). Recognized by the World Health Organization (WHO) as one of the most significant global challenges of the 21st century, climate change and global warming pose existential threats to human, animal, and environmental health. Although the terms "global warming" and "climate change" are often used interchangeably, global warming specifically refers to the rise in global temperatures, which is just one component of the broader phenomenon of climate change (WHO, 2021). Scientific consensus attributes the majority of recent climate changes to rising concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHGs), primarily due to human activities such as industrial emissions, deforestation, and unsustainable agricultural practices (FAO, 2020). These activities lead to a cascade of environmental consequences, including increasing sea levels, temperature anomalies, more frequent and severe extreme weather events, and intensified droughts and wildfires. These disruptions have direct and indirect effects on human health, manifesting through heightened risks of zoonotic diseases, respiratory illnesses, heat stress, malnutrition, and reduced access to clean water (IPCC, 2021).

The global repercussions of climate change extend far beyond localized environmental degradation. The compounded effects lead to widespread disruption of ecosystems and resource depletion, further straining public health systems. Effective mitigation and adaptation strategies require not only understanding of complex climate models but also the formulation of coordinated policies at national and international levels to manage cross-sectoral impacts (United Nations, 2015). To enhance resilience against climate change, it is vital to foster collaboration across critical sectors such as energy, agriculture, and public health.

The concept of "One Health" has emerged as a crucial framework for addressing the intricate and interconnected challenges facing global health, particularly in light of increasing human, animal, and environmental interactions. Rooted in the understanding that the health of humans, animals, and ecosystems are inextricably linked, One Health advocates for a transdisciplinary approach that involves professionals from various fields such as medicine, veterinary science, environmental science, and public health. This approach is essential for tackling issues such as zoonotic diseases, antimicrobial resistance, food security, and biodiversity loss, all of which have far-reaching implications for global health and sustainability. Sustainable development, which promotes economic growth, environmental stewardship, and social equity, dovetails perfectly with the One Health initiative. It calls for long-term, forward-thinking solutions that not only address immediate concerns but also safeguard future generations. In agriculture, for instance, adopting sustainable livestock management practices can enhance food security, reduce environmental degradation, and improve animal welfare, which in turn contributes to human health and the overall balance of ecosystems. As livestock production is a significant contributor to environmental issues such as deforestation, greenhouse gas emissions, and water scarcity, integrating sustainable practices into this sector is key to achieving the United Nations' Sustainable Development Goals (SDGs). Furthermore, the rise in zoonotic diseases, such as COVID-19, highlights the urgent need for integrated approaches that combine environmental conservation, animal welfare, and public health. By fostering collaboration between these sectors, the One Health approach aims to create resilient systems that can mitigate the impact of future pandemics, while ensuring that sustainable development objectives—such as reducing poverty, enhancing food security, and promoting healthy ecosystems—are achieved globally. This review highlights the need for sustained, cross-sectoral efforts to combat climate change and its multifaceted impacts on global health, leveraging the One Health approach as a pathway toward achieving long-term sustainability and ecological balance.

Climate Change and Its Global Impact

Climate change poses a profound challenge with far-reaching consequences for ecosystems, human health, and economic stability worldwide. A comprehensive review of global climate change impacts reveals that rising temperatures, altered precipitation patterns, and an increasing frequency of extreme weather events lead to significant disruptions across various sectors (Bokhari *et al*., 2022). These impacts are particularly pronounced in vulnerable regions, where communities are confronted with heightened risks of food and water insecurity, health-related issues, and displacement due to natural disasters. The global implications of climate change extend to biodiversity loss, as ecosystems struggle to adapt to rapidly changing conditions, leading to species extinction and the disruption of natural habitats.

The International Journal of Scientific and Research Publications emphasizes that climate change significantly affects agricultural productivity, with altered rainfall patterns and increased temperatures leading to reduced crop yields and threatening food security (International Journal of Scientific and Research Publications, 2014). As extreme weather events become more frequent, agricultural productivity declines, jeopardizing food supplies and threatening livelihoods. Additionally, changing climate conditions contribute to the spread of infectious diseases, as shifts in temperature and humidity create more favorable environments for pathogens and vectors. The review further emphasizes that climate change exacerbates existing inequalities, disproportionately affecting marginalized populations with limited adaptive capacity (Bokhari *et al*., 2022).

To combat these challenges, effective adaptation and sustainable mitigation measures are crucial. Strategies such as transitioning to renewable energy sources, enhancing climate resilience in agricultural practices, and implementing integrated water resource management are essential for reducing vulnerability and promoting sustainability. Moreover, coordinated global efforts are necessary to ensure that the adverse effects of climate change are mitigated while advancing social equity and environmental sustainability (Bokhari *et al*., 2022). By fostering collaboration across nations and sectors, we can work toward a more resilient and sustainable future in the face of climate change.

Understanding One Health framework

The One Health framework recognizes the interconnectedness of human, animal, and environmental health, emphasizing that the health of each component is intrinsically linked to the others. This holistic approach addresses health challenges that arise at the interface of these domains, particularly in the context of zoonotic diseases, which are diseases that can be transmitted between animals and humans (Zinsstag *et al*., 2011). By integrating disciplines such as veterinary medicine, public health, and environmental science, the One Health framework aims to improve health outcomes through collaborative efforts and interdisciplinary strategies (World Health Organization, 2021).

The framework also underscores the importance of understanding the broader ecosystem dynamics that influence health, such as habitat destruction, climate change, and agricultural practices. For instance, land-use changes can disrupt natural habitats, increasing the likelihood of human exposure to wildlife pathogens (Jones *et al*., 2013). Furthermore, the One Health approach facilitates the development of comprehensive surveillance systems and response strategies to prevent and control disease outbreaks effectively. By fostering collaboration among stakeholders, including governments, healthcare providers, and communities, the One Health framework promotes sustainable health solutions that address the root causes of health threats at the human-animal-environment interface.

The Role of Greenhouse Gases in Climate Change

Greenhouse gases (GHGs) play a critical role in the phenomenon of climate change by trapping heat in the Earth's atmosphere, thus contributing to the greenhouse effect. Key GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases, each exhibiting varying degrees of heat-trapping capability. The Intergovernmental Panel on Climate Change (IPCC) has indicated that human activities, such as fossil fuel combustion, deforestation, and industrial processes, have significantly elevated the concentrations of these gases since the late 19th century (IPCC, 2021).

CO_2, for example, is primarily emitted through the burning of fossil fuels for energy and transportation, while methane is released during the production and transport of coal, oil, and natural gas, as well as from livestock and other agricultural practices (EPA, 2020). The cumulative effect of these emissions has led to an unprecedented increase in global temperatures, causing widespread environmental changes. According to the latest IPCC report, average global temperatures have risen by approximately 1.1°C since pre-industrial times, with far-reaching implications for weather patterns, sea level rise, and ecosystems (IPCC, 2021). Addressing GHG emissions through mitigation strategies such as transitioning to renewable energy and enhancing energy efficiency is crucial for combating climate change and safeguarding planetary health.

Health Implications of Climate Change

Climate change has profound health implications, affecting populations globally through a variety of direct and indirect pathways. Rising temperatures and increased frequency of extreme weather events—such as heatwaves, floods, and hurricanes—pose immediate threats to human health, resulting in injuries and fatalities (WHO, 2021). Additionally, the exacerbation of air pollution from increased temperatures and wildfires contributes to respiratory and cardiovascular diseases, disproportionately impacting vulnerable populations, including the elderly and those with pre-existing health conditions (Liu *et al*., 2019).

Moreover, climate change influences the distribution and prevalence of infectious diseases. Altered weather patterns can expand the range of disease vectors, such as mosquitoes and ticks, thereby facilitating the transmission of diseases like malaria, dengue fever, and Lyme disease (Ryan *et al*., 2019). Food and water security are also jeopardized; changing precipitation patterns and extreme weather can lead to crop failures and contamination of water supplies, resulting in malnutrition and waterborne diseases (FAO, 2020). The World Health Organization estimates that between 2030 and 2050, climate change will cause an additional 250,000 deaths per year, emphasizing the urgent need for integrated public health responses that address the health impacts of climate change and enhance community resilience (WHO, 2021).

The Urgent Need for Integrated Policy Responses

The escalating impacts of climate change necessitate urgent and coordinated policy responses that transcend traditional sectoral boundaries. Fragmented approaches often fail to address the complex interplay between climate change, public health, and socioeconomic factors, resulting in inefficiencies and missed opportunities for effective mitigation and adaptation. Integrated policy frameworks that encompass environmental, health, economic, and social dimensions are crucial for building resilience and promoting sustainable development (Bokhari *et al*., 2022).

For instance, incorporating climate considerations into health policies can enhance preparedness for climate-related health risks, such as heat-related illnesses and the spread of infectious diseases (WHO, 2021). Similarly, sustainable agricultural policies that promote climate-resilient practices can improve food security while reducing greenhouse gas emissions. The Paris Agreement underscores the importance of inclusive and participatory approaches in developing national climate action plans, advocating for the involvement of various stakeholders, including governments, civil society, and the private sector (UNFCCC, 2015).

To effectively respond to climate change, policymakers must prioritize collaborative efforts that align local, national, and global initiatives. This requires the establishment of interdisciplinary teams and platforms for knowledge sharing, fostering innovation, and facilitating resource mobilization (Bokhari *et al*., 2022). By embracing integrated policy responses, societies can better navigate the challenges posed by climate change while advancing social equity and environmental sustainability.

Zoonotic Diseases and Their Connection to Climate Change

Zoonotic diseases, which are infectious diseases transmitted from animals to humans, are increasingly linked to climate change, making the One Health approach essential for addressing these emerging health threats. Climate change influences the distribution and behaviour of disease vectors, such as mosquitoes and ticks, thereby facilitating the spread of zoonotic pathogens (Ryan *et al*., 2019). For instance, warmer temperatures and altered precipitation patterns can expand the habitats of these vectors, increasing the risk of diseases like malaria, dengue fever, and West Nile virus transmission in previously unaffected regions (Patz *et al*., 2005).

Moreover, the encroachment of human populations into natural ecosystems, driven by factors such as urbanization and agricultural expansion, increases the likelihood of zoonotic spillover events. Deforestation and habitat destruction can disrupt ecological balances, forcing wildlife into closer proximity with humans and domestic animals, thereby raising the potential for disease transmission (Jones *et al*., 2013). This interplay between climate change, land use, and zoonotic diseases underscores the need for integrated surveillance and control measures that address both environmental and public health dimensions.

Strategies for Promoting Sustainability through One Health

The One Health approach offers a comprehensive framework for promoting sustainability by addressing the interconnected health of humans, animals, and the environment. This integrated strategy emphasizes collaboration across disciplines to tackle complex health challenges, particularly those exacerbated by climate change. One effective strategy is the promotion of sustainable agricultural practices that reduce greenhouse gas emissions while enhancing food security. Practices such as agroecology, organic farming, and integrated pest management not only mitigate environmental impacts but also improve resilience against climate-related shocks (FAO, 2020).

Moreover, strengthening surveillance and monitoring systems for zoonotic diseases is crucial for early detection and prevention. By fostering collaboration between public health, veterinary, and environmental sectors, stakeholders can better identify and respond to emerging health threats (Zinsstag *et al*., 2011). Community engagement is another key component; empowering local populations to participate in decision-making processes fosters a sense of ownership and encourages the adoption of sustainable practices.

Investment in education and research is essential for advancing One Health initiatives. By increasing awareness of the links between health and environmental sustainability, we can cultivate a culture of responsibility and resilience. Furthermore, policies that incentivize sustainable practices, such as conservation financing and eco-labeling, can drive systemic changes toward a more sustainable future (Bokhari *et al*., 2022). Through these strategies, the One Health framework can effectively promote sustainability and enhance overall health outcomes.

Conclusion: Towards a Resilient Future

One Health initiatives have proven to be more effective than traditional public and animal health strategies in several areas, including climate change mitigation and adaptation, antibacterial sensitivity testing, and non-communicable disease surveillance (Rabinowitz *et al*., 2017). Despite this, a major obstacle remains the lack of multisectoral collaboration, particularly between the veterinary and healthcare sectors. Overcrowded curricula and limited time for interdisciplinary courses are often cited as barriers, even though evidence suggests that overspecialization increases costs and limits cross-sector interaction. To overcome this, integrating One Health into both medical and veterinary curricula is urgently needed (Rabinowitz *et al*., 2017).

Recirculating aquaculture systems (RAS) offer a promising adaptation strategy to climate change due to their controlled indoor environments, making them less susceptible to climate-related challenges such as altered rainfall patterns, floods, droughts, global warming, cyclones, salinity changes, ocean acidification, and rising sea levels. However, climate change still significantly affects rainfall patterns and intensity, leading to more frequent droughts and floods. If global temperatures increase by 2°C instead of 1.5°C, it is predicted that over 25% of the Earth will face severe drought by 2050. This trend is already evident in regions such as Africa, where annual rainfall is on the decline (Ahmed *et al*., 2021). While methane emissions from ruminant livestock contribute to climate change, a closer look reveals that the growth of animal production in developing countries has lifted millions of smallholder farmers out of poverty. However, the negative impacts of global warming, such as incre ased droughts, may force cattle herders to migrate into already populated areas, intensifying social challenges (Zinsstag *et al*., 2018)

Water, sanitation, and hygiene (WASH) play a critical role in both the One Health approach and public health by managing human and animal excretions. Coordinated efforts in this area are crucial, as poor waste management can lead to environmental contamination, including soil and water pollution, and the spread of antibiotic resistance. Increased runoff, often containing zoonotic pathogens from human and animal faeces due to practices like open defecation or manure-based fertilization, contaminates surface and drinking water. This problem is exacerbated by more frequent heavy rainfall linked to climate change, heightening the risk of disease outbreaks (Sterk *et al*., 2016).

In conclusion, addressing the multifaceted challenges posed by climate change requires a concerted effort that embraces the principles of the One Health framework. By recognizing the interconnectedness of human, animal, and environmental health, we can develop integrated strategies that promote sustainability and resilience. As we move toward a future marked by demographic changes and increasing environmental stressors, the urgency for integrated policy responses cannot be overstated. By committing to sustainable practices and prioritizing One Health initiatives, we can pave the way for a resilient future that safeguards the health of our planet and its inhabitants for generations to come (WHO, 2021; Bokhari *et al*., 2022).

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Guest Editors' Column

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Overview

The world foresees a big challenge of feeding the human population in future, which is expected to grow to over 9 billion in 2050, as per the World Population Clock 2020. Persistent overuse of natural resources (soil, water and biodiversity) and climate change due to global warming, driven by anthropogenic activities, have already degraded our precious resources nurturing the human populations and wildlife for ages. Intensive food production systems have affected soil quality, depleted groundwater resources and lead to (i) pollution of the environment with toxic/ harmful contaminants (pesticides, heavy metals, microbes etc.) and (ii) emergence of new diseases due to resistance of pathogens against drugs, antibiotics or pesticides, indiscriminately used for public health and health management (prophylactic and control measures) in agriculture and livestock farming systems. It has affected the productivity and quality of output from the food systems and resources.

Shrinking aquatic resources and cultivable land, with degraded ecological health; and declining forest cover are the biggest challenges for providing safe food/feed sustainably for feeding the human population/livestock and supporting the wildlife. The climate change has further aggravated the said concern, and it is very important to maintain the ecological balance between the land, water and biological resources to conserve their productivity for developing sustainable food production systems in harmony with the changing climate and other ecological threats, in special reference to pollution and food safety concerns. In this context, it is vital to shift to renewable energy resources like solar, wind, water and bioenergy, which can significantly reduce carbon footprint of production, storage and distribution of agri-food and animal food systems. Aqua Food Systems represent viable solutions offering opportunities to improve global food and nutritional security; support livelihoods and conserve the environment. Through consumer shift to aqua foods, nutrient rich animal protein can be produced with lesser carbon foot print and without intensive land use, otherwise required for grazing or fodder/feed production to support other animal food systems such as beef, mutton, cheese, pork and chicken. The earth is naturally gifted with aqua food laden aquatic resources, covering 71% of earth's surface, which need to be conserved for optimal economic utilization as a sustainable food resource to feed the human population.

Additionally, environment friendly resilient food production systems need to be transformed through diversification with climate smart species and farming systems, which can produce more food per unit land or water resource in a shorter crop cycle to achieve envisioned productivity targets with required food safety standards. Antimicrobial resistance (AMR) emerging in key pathogens, due to indiscriminate use (overuse and misuse) of antimicrobials in humans, livestock and crops, is matter of serious concern, in special reference to *One Health*. AMR is one of the biggest threats to public health, food systems and biodiversity, affecting overall health of the global ecosystem, involving people; crops and wild flora; domestic and wild animals; and the environment together. Modern medicine application is also at risk due to AMR, making infections harder to treat and making other medical treatments like surgery and cancer therapies much riskier. As per the World Health Organization, AMR is one of the top global public health and development threats, directly responsible for 1.27 million global deaths and contribution to 4.95 million deaths in 2019.The World Bank estimates that AMR could result in US$ 1 trillion additional healthcare costs by 2050, and US$ 1 trillion to US$ 3.4 trillion gross domestic product losses per year by 2030.

Hence, the major task is to evolve innovative climate smart technologies and policies to achieve the *Sustainable Development Goals* (SDGs) of the United Nations aimed for transforming the world, focusing on *Peace* and *Prosperity* of people and the planet by tackling climate change and conservation of the oceans and the forests. The said transformation is destined to be achieved through 17 SDGs, including *No Poverty* (SDG-1); *Zero Hunger* (SDG-2); *Good Health and Well-Being* (SDG-3); *Clean Water and Sanitation* (SDG-6); *Responsible Consumption and Production* (SDG-12); *Climate Action* (SDG-13); *Life Below Water* (SDG-14); and *life on Land* (SDG-15) by 2030, which relates to food production systems directly or indirectly.

The above SDGs could be realized by promoting regional food systems as per available aquatic and land resources; climate smart farming technologies; water efficient food production systems; organic farming practices; awareness and capacity building of stakeholders; biosafe production, storage and distribution of food with minimal spoilage; waste management under the concept of bio-circular economy; stringent regulatory system; and policy support. For the said purpose, linkages among the scientists, producers, industry and policymakers need to be corroborated to combat *Climate Change* and *One Health* collectively, to safeguard the global peace and prosperity; food security; public health and biodiversity as a whole.

I am confident that the articles published in this special issue of Indian Journal of Animal Health (IJAH) will offer an insight to understand the global issues of animal food sector in special reference to climate change, zoonoses, AMR and food safety under the umbrella of *One Health*, besides presenting innovative technological interventions for environmental, economic and social sustainability, as per regional needs and resource availability. I hope this issue will help the scientific fraternity in identifying the key gaps for required technological interventions and guide the policymakers in developing strategic action plans for developing climate smart livestock and fisheries sectors for sustainable livelihood, food and economic security across the globe in consonance with *One Health*.

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Guest Editors' Column

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Overview

Every year, the world's nutritional requirements increase, mainly due to the increase in the Earth's population. The population of the planet today is about 8 billion, with an annual increase of about 0.88%, and in 2050 it is estimated to reach about 10 billion [Worlodmeter, 2024]. This increase, combined with climate change, will create extreme pressures on food industries, which will have to respond to this need while protecting the environment and ensuring high food quality (Garcia *et al*., 2022).

Today, climate change is one of the most serious long-term challenges facing farmers and livestock owners around the globe. Climate change is widely considered to be one of the most potentially serious environmental problems ever confronting the global community. Climate change is causing rising concern in the current scenario, as it has a substantial impact on food-producing sectors, including aquaculture. Responses to climate change include (i) adaptation, to reduce the vulnerability of people and ecosystems to climatic changes, and (ii) mitigation, reduce the magnitude of climate change impact in the long term. However, neither adaptation nor mitigation alone can offset all climate change impacts. To respond to this threat, it will be prudent to focus both on mitigation, to reduce the level of emission of gases contributing to global warming, and on adaptation, to support local communities in dealing with the impacts. Besides being a major contributor to climate change, livestock play important roles in farming system in developing countries by providing food and income, draught power, fertilizer and soil conditioner, household energy and a means of disposing of otherwise unwanted crop residues. About 12% of the world's population depends solely on livestock for their livelihood. The livestock sector contributes significantly to global warming through greenhouse gas (GHG) emissions. At the same time, livestock is an invaluable source of nutrition and livelihood for millions of poor people. Therefore, climate mitigation policies involving livestock must be designed with extreme care. Technological interventions for sustainable development in animal and aquaculture resource management, particularly in the context of changing climatic scenarios and the One Health approach, are crucial for ensuring food security, environmental sustainability, and public health.

Climate change is an inevitable event that obstructs the output of aquaculture farms and culture-based fisheries in open waters. It poses a serious threat to global food security, altering biodiversity, ecosystems, and global fish output by displacing fish stocks from their natural habitats. When compared to freshwater aquaculture, marine/coastal aquaculture is more affected. To combat the effects of climate change, several mitigation methods and adaptations are being implemented, emphasizing future demands of affordable protein. Selective breeding, species diversification, and aquaculture systems like integrated multi-trophic aquaculture, aquaponics, and recirculating aquaculture system are some of the most widely accepted and adapted solutions. Further research on intervention in seed and feed in terms of quality improvement, bioresource utilization, and technological and genetic improvement is required. Climate change policies from the government are also essential.

Global demand for livestock products is expected to be double by 2050, mainly due to improvement in the worldwide standard of living. Meanwhile, climate change is a threat to livestock production because of the impact on quality of seed crops and forage, water availability, animal and milk production, livestock diseases, animal reproduction, and biodiversity. Climate is one of many factors with the potential to alter disease states and is expected to exert an overwhelming negative effect on the health of humans and animals. In addition, several studies suggested that the increase of temperature might reduce mortality and/or improve health and welfare related aspects in humans and livestock living in geographic areas with cold winters. The effect of climate change on animal may be either direct or indirect and may be due primarily to changes in environmental conditions, which include air temperature, relative humidity, precipitation, and frequency and magnitude of extreme events (i.e., heat waves, severe droughts, extreme precipitation events, and coastal floods). However, there is an involvement of risk that the altered climatic conditions will compromise animal health, welfare and productivity. The livestock sector therefore, needs to adapt to changes in the climate. The most promising approach for reducing methane emissions from livestock is by improving the productivity and efficiency of livestock production, through better nutrition and genetics. Greater efficiency means that a larger portion of the energy in the animals' feed is directed toward the creation of useful products (milk, meat, draught power), so that methane emissions per unit product are reduced. The trend towards high performing animals and towards monogastrics and poultry in particular, are valuable in this context as they reduce methane per unit of product. The increase in production efficiency also leads to a reduction in the size of the herd.

Designing and adoption of Climate-Resilient Breeding Programs: Advances in genetic engineering and selective breeding aim to develop animal and fish breeds that can withstand extreme weather conditions, diseases, and variable feed resources. This includes breeding for traits like heat tolerance and disease resistance. In order to be able to increase food production to meet future demand, while maintaining or even potentially requiring to increase in food quality, many difficulties and challenges must be addressed. These include more efficient food yield planning, more efficient prognosis, diagnosis and treatment of ailments in crops, fish, livestock, etc., more efficient management and so on. Innovative technologies can assist greatly in this cause. One of the important technologies is Artificial Intelligence (A.I.). A.I. is a branch of computer science that aims to empower computers with the ability to learn and make assessments based on the past, imitating living organisms. The most important factor is the knowledge necessary for the adoption of A.I. technologies, which is not limited exclusively to technical knowledge. Setting up a smart farm requires knowledge regarding which hardware and software is best suited for the requirements of the farm, knowledge regarding the installation of these technologies (in case no installation service is offered by the supplier), knowledge regarding the usage of these technologies and so on (Elbasi *et al.*, 2023). Lack of knowledge regarding usage, combined with the complexity of new technologies, keeps many stakeholders away from embracing them, even when these technologies are already present, installed and operational.

At a national policy level, stronger collaboration among different Ministries and Departments can also help to achieve more holistic outcomes. Tools that integrate scientific data with policy-making processes help create adaptive management strategies that account for climate change and ensure sustainable practices in animal and aquaculture management. Ministries of health, agriculture, and the environment can work together to identify and evaluate the impacts of climate mitigation strategies across various societal sectors. This collaboration can facilitate the integration of public health, animal welfare, and environmental concerns into climate policies, leading to more effective and balanced outcomes. Policymakers could introduce impact assessments that consider the broader implications of climate mitigation strategies, including for animal welfare (McCulloch and Reiss, 2017; Blattner, 2020), with quantitative tools increasingly emerging to understand magnitudes of animal welfare loss and bring animal welfare into policy analysis (Budolfson *et al.*, 2023). Such approaches can inform governments and the private sector in taking into account a broader set of considerations in their climate mitigation strategies. In summary, technological interventions in animal and aquaculture resource management are essential for adapting to climate change and implementing the One Health approach. These technologies enhance resilience, improve efficiency, and promote sustainability, ultimately supporting the broader Sustainable Development Goals.

The One Health approach emphasizes the interconnectedness of human, animal, wild life and environmental health. Technological interventions can support this approach by monitoring diseases that can affect all these domains (better surveillance systems), detecting and responding to emerging health threats (Early warning systems) and by fostering interdisciplinary research and collaboration. International collaboration amongst researchers as well as interdisciplinary collaboration between specialists such as epidemiologists, climatologists and ecologists has become all the more important, in order to expand the breadth of information. Epidemiological data can be shared with policy-makers to make necessary preventive policies. These inter-relationships are further complicated by the broader public health implications of climate change as well as the food security implications. The best cited instance would be the collaboration between Food and Agriculture Organization of the United Nations (FAO) and the World Organization for Animal Health (OIE) in order to step up their existing collaboration to control animal disease, ensure the safety of food from animal origin and promote safe trade eventually, to strengthen various compartmentalized systems (FAO News, 2014). By leveraging technological advancements and adopting a One Health approach, we can create more sustainable, resilient, and equitable animal and aquaculture systems that contribute to a healthier planet and a better future for all.

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Guest Editors' Column

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Overview

This anthropocentric geological era has not only witnessed unprecedented and irrevocable changes in geo-politics but has also witnessed significant challenges to zoo-phyto-geography and geo-climate in which the single dominant human species continued to flourish and adapt via extraneous technological breakthroughs, exploring, explaining, and exploiting natural resources and phenomenological attributes thereby enriching and extending ground-breaking solutions (for mankind, its immediate environment, the ecosystem in which it thrives and most, if not all living and non-living forces which it can manipulate). These advances in the frontiers of health sciences, environment, public health, personalized and point of care medicine, education, agronomy, environmental dynamics etc. Stochastic and pre-meditated alterations of natural resources have on the one hand brought about blights such as global pandemics, collapse of entire ecosystems, unpredictable and destructive weather phenomenon and on the other, human industry and intellect have pushed through the far corners of the galaxy and the minuest physico-chemical and biological possibilities such as nano-technology, discovery of the Crisper-CAS9 system, android robotics, artificial intelligence (AI), self-cloning therapeutics and bio-mimetics, to name just a few.

This special issue of the oldest continuously publishing journal from animal health and fishery sector, the Indian Journal of Animal Health, on **"Technological Interventions for Sustainable Development Goals in Animal and Aquaculture Resource Management with respect to Changing Climatic Scenarios and One Health"** shall showcase within its covers different research articles, reviews, commentaries and perspectives that will touch upon the theme.

Thus, in tune with the broad tenet of the thematic issue, respectively (in order of submission), pursuit of investigating into the developmental intricacies of the diploblastic Planaria (*Dugesia japonica*) to understand homologous and analogous elements that control wound healing, cell migration and regeneration as well as osmoregulation; exploring and mapping the nutrition partitioning dynamics through a systems biology approach to the agronomy that regulates the sequestration of bioactive compound that translates into viable functional food; bioprospecting for phytochemicals and validation studies using preclinical disease models; study of the intricate mesh of molecular signals controlling quorum in probiotic bacteria and the study and engineering of nutraceuticals – are all different facets of technological advancements towards one health as outlined in the United Nationa's Sustainable Development Goals (UN SDGs).

The need of the hour is to conduct translational outcomes research using clean, green technology and not only conducting drug discovery through innovation, novel formulations and fundamental research but also preserve the ecosystem through non-exploitative renewable means.

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Guest Editors' Column

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Overview

The intersection of sustainable development goals (SDGs), animal and aquaculture resource management, climate change, and the One Health framework is pivotal for fostering resilient ecosystems and food security. Technological advancements play a critical role in addressing the complex challenges posed by climate change and promoting sustainability within animal and aquaculture systems.

1. Climate Change Impact on Animal and Aquaculture Systems

The changing climate has exacerbated vulnerabilities in both terrestrial and aquatic food systems. Rising temperatures, erratic weather patterns, ocean acidification, and changing ecosystems have affected livestock production, fish stocks, and biodiversity, threatening global food security. These environmental shifts increase the risk of disease outbreaks, disrupt habitats, and diminish productivity, thereby endangering the livelihoods of millions who rely on these sectors.

- **Impact on milk production:** It has been estimated that the direct heat stress on lactating cows and buffaloes causes a production loss of more than 1.8 million tons of milk. The increase in thermal stress days due to temperature rise has been estimated to cause an additional loss in milk production of 1.6 million tonnes in 2020 accounting about Rs. 2365.8 crores at current price rate. Therefore, the annual loss in milk production due to combined thermal stress of summer and global warming on cattle and Buffaloes in 2020 are likely to be about 3.4 million tons milk costing more than 5000 crores at current price rate. The milk production in India is likely to be impacted more than 15 million tons in 2050 due to heat stress on livestock.
- **Impact on reproduction:** Heat stress may reduce the fertility of cattle and buffalos in summer by poor expression of oestrus due to a reduced oestradiol secretion from the dominant follicle developed in a low luteinizing hormone environment. A drop can occur in summer of about a 20-27% in conception rates or decrease in 90 days non-return rate to the first service in lactating dairy cows.
- **Impact on animal health:** As in the case of humans, climate change, particularly warming, greatly affects the health of farm animals, both directly and indirectly. Direct effects include temperature-related illness and death, and the morbidity of animals during extreme weather events. Indirect impacts follow more intricate pathways and include those deriving from the attempt of animals to adapt to thermal environment or from the influence of climate on rumen microbial populations, distribution of vector-borne diseases, host resistance to infectious agents, feed and water shortages, or food-borne diseases.
- **Impact on animal growth:** The Scientific Committee on Animal Health and Animal Welfare (SCAHW) suggested that the higher threshold temperature for beef cattle is 30°C with relative humidity below 80 percent and 27°C with relative humidity above 80 percent. But, above 30°C adverse effects are recorded on growth performance. In India, a small rise in temperature above 30°C negatively affected body growth due to increased thermal stress, heat balance and nutrient utilization.

2. Technological Interventions and Sustainable Development Goals

To mitigate these impacts and support the SDGs, particularly SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 14 (Life Below Water), a variety of technological innovations have been developed. These technologies aim to improve efficiency, enhance resource management, and minimize ecological footprints in animal husbandry and aquaculture.

- **Precision Farming:** Technological advancements such as sensors, drones, and IoT devices enable real-time monitoring of livestock health, water quality, and environmental conditions. These systems provide farmers and aquaculturists with data-driven insights to optimize feeding, reduce water use, and minimize waste, supporting SDG 12 (Responsible Consumption and Production).
- **Genomic Technologies:** Genomics and selective breeding strategies are being deployed to develop climate-resilient livestock and fish species. These technologies enhance resistance to diseases and stressors induced by environmental changes, contributing to SDG 3 (Good Health and Well-being) and SDG 15 (Life on Land).
- **Sustainable Feed Alternatives:** Research into alternative feed sources, such as insect-based or algae-based feeds, reduces dependency on traditional feedstocks like fishmeal and soybean, whose production can lead to deforestation and overfishing. These alternatives promote circular economies and align with SDG 14 (Life Below Water).
- **Aquaponics and Recirculating Aquaculture Systems (RAS):** Closed-loop systems like aquaponics and RAS have emerged as sustainable solutions for producing fish and crops with minimal water and energy inputs. These technologies reduce the environmental footprint of aquaculture, promote SDG 6 (Clean Water and Sanitation), and support local food production under climate-stressed conditions.

3. One Health Approach and Ecosystem Resilience

The **One Health** concept recognizes the interconnectedness of human, animal, and environmental health. Technological innovations contribute to the One Health framework by addressing the links between ecosystem degradation, zoonotic diseases, and public health risks.

- **Disease Surveillance and Monitoring:** Advanced molecular diagnostics, mobile health technologies, and big data analytics are used to monitor and predict outbreaks of zoonotic diseases, such as avian influenza and fish parasites, which may proliferate in response to climate change. These systems enable early detection and rapid response, mitigating risks to both human and animal health.
- **Antimicrobial Resistance (AMR) Management:** The overuse of antibiotics in animal farming and aquaculture accelerates AMR, posing a global health threat. Technological solutions like probiotic treatments, vaccine development, and biosecurity measures help reduce reliance on antibiotics, contributing to healthier ecosystems and aligning with SDG 3.

4. Challenges and Future Directions

Despite the potential of technological interventions, several challenges remain. These include unequal access to technology, especially in low-income regions, the high costs of implementation, and the need for capacity-building and education. Future innovations must focus on scalable, affordable technologies that can be adapted to different socio-economic and environmental contexts.

Additionally, as climate change accelerates, greater integration of AI, machine learning, and climate modelling will be necessary to anticipate future risks and optimize resource use in animal and aquaculture management. Collaborative efforts across sectors, guided by the One Health approach, will be essential to build resilient food systems that can withstand climate impacts.

Technological interventions are critical for advancing SDGs in animal and aquaculture resource management, especially under changing climatic scenarios. By embracing innovative tools and integrating the One Health framework, it is possible to create sustainable, climate-resilient systems that protect ecosystems, promote food security, and safeguard human health in the face of global challenges. In this issue of IJAH specially dedicated this burning topic and some latest research findings are incorporated.