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## One Health and sustainable agricultural system in the 21<sup>st</sup> century

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## Abstract

*Integrative, long-term solutions are needed to address new and growing global health and agricultural sustainability issues in the 21<sup>st</sup> century. Sustainable agriculture protects biodiversity, the environment, and food security, making it essential to this transformation. The One Health approach, which promotes a single health paradigm and emphasizes human, animal, and environmental health, is also crucial. This approach requires collaboration between agriculture, veterinary science, human medicine, ecology, and environmental science to reduce zoonotic disease risks, improve food safety, and reduce agriculture's environmental impact. Sustainable agriculture, based on agroecological methods, precision agriculture, and organic farming, promotes soil vitality, reduces synthetic use, and increases agricultural biodiversity, supporting the One Health principles. Animal welfare in agriculture improves livestock health and reduces disease transmission between species. This holistic approach requires prudent livestock antimicrobial use to prevent antimicrobial resistance and protect species' health. Resilient crop varieties and effective water management practises improve agricultural framework health and sustainability, demonstrating the importance of integrated strategies in addressing complex global health and agriculture challenges. Interdisciplinary collaboration, innovative technologies, native intelligence, and public awareness can promote agricultural systems that prioritize human well-being, animal welfare, and environmental conservation, ensuring their long-term viability.*

## Essay

Environmental changes, animal diversity, and human-animal interactions have all contributed to the emergence and resurgence of numerous diseases. Although illness is already a significant barrier, zoonotic diseases-those transmitted from animals to humans-pose an increasing threat to global health. Since the 1970s, the World Health

Organization has reported new infectious diseases every year. Jones *et al.* [1] discovered in 2008 that animals transmitted more than three-quarters of these diseases. According to Turkson [2], zoonotic diseases account for two-thirds of all newly reported infections. Examples include Ebola, H1N1, H5, MERS, and SARS. Additionally, zoonotic diseases kill millions of people each year. Therefore, public health initiatives for animals, humans, and the environment must be collaborative.

The term "One Health" was coined at a 2004 Wildlife Conservation Society Conference during the 2003 SARS pandemic [3]. Mackenzie *et al.* [3] defined "One Health" as the understanding that human health is dependent on other living things. It is an interdisciplinary, cross-sectoral, and collaborative approach to enhancing human, animal, and environmental health. In addition, One Health is considered the collaborative efforts of local, national, and international organizations to improve human, animal, and environmental health. The One Health approach acknowledges that human, animal, and environmental health are interconnected and influenced by one another [4]. One Health promotes collaboration among experts in public health, ecology, agriculture, veterinary science, and medicine to reduce health risks and prevent new ones. According to Xie *et al.* [5], One Health policies and practices are based on scientific evidence, data analysis, and research findings.

The twenty-first century presents numerous challenges and opportunities in human health, animal welfare, and environmental sustainability. One Health, a comprehensive effort to improve human, animal, and ecosystem health, is critical to resolving these issues. This idea has gained traction as a foundation for protecting our planet and its inhabitants. Sustainable agriculture systems are taking the lead in addressing climate change, zoonotic diseases, and food insecurity, making One Health relevant. Agriculture in the twenty-first century must deal with climate change, resource depletion, and the need to feed

a rapidly growing population while also addressing the environmental consequences of pesticide use. Sustainable agriculture systems are transforming how we deal with climate change, zoonotic diseases, and food insecurity, making this goal attainable. This paper thoroughly investigates how One Health can benefit sustainable agriculture systems. Innovative agricultural methods that improve human, animal, and environmental health are discussed, as well as strategies for overcoming integration barriers. The ongoing discussion encompasses technology, community engagement, and strategic policymaking within a comprehensive and long-term agricultural framework.

### **Sustainable agriculture and its relevance to environmental and public health**

According to Afzal *et al.* [6], sustainable agriculture seeks to meet current agricultural needs while preserving the future of the agricultural sector. It is a growing field that studies long-term food and energy production for current and future generations. Sustainable agricultural systems are based on small, successful farms. These farms prioritize biodiversity conservation by utilizing production-appropriate technology and also adopting renewable energy usage. This safeguards the environment and public health in the face of complex environmental degradation concerns [6]. Sustainable agriculture has been understood to be dealing with climate change, rising food and fuel prices, global hunger, obesity, water and soil pollution, erosion, declining fertility, pest control, and biodiversity loss.

To build resilient and equitable food systems, environmental stewardship, economic sustainability, and social justice must all be combined. Sustainable agriculture prioritizes human, animal, and environmental health to address pressing issues and promote overall well-being. Observationally, agriculture depends on biodiversity to survive which promotes healthy ecosystems, genetic diversity, and pest and disease control, reducing the need for chemical

treatments. Sustainable agriculture promotes One Health by improving ecosystems, conserving biodiversity, and mitigating the risks associated with intensive farming.

### **Challenges facing agriculture in the 21<sup>st</sup> century**

Agriculture in the twenty-first century faces numerous challenges, including climate change, infectious and zoonotic diseases, antibiotic resistance, biodiversity loss, and ecosystem degradation. These conditions harm global food and animal production. According to Ricoch *et al.* [7], agriculture has faced significant challenges that threaten productivity and sustainability since the beginning of time. Climate change has been one of agriculture's most significant challenges in the twenty-first century. Temperature and precipitation patterns are changing, and more extreme weather events are threatening crop and livestock yields, as well as the long-term viability of agriculture. Furthermore, intensive farming leads to soil erosion, nutrient depletion, and fertility loss while monoculture and excessive chemical use jeopardize agricultural productivity and sustainability.

In the twenty-first century, pandemics exacerbate zoonotic and infectious diseases that impact agriculture. Human activities that encroach on wildlife habitats, intensive agricultural practices, environmental changes, and wild animal-to-human transmission have all contributed to the recent increase in zoonotic and infectious diseases. Agriculture is likely to be impacted in a variety of ways as a result of these drivers, affecting both its viability and benefits in the coming century. Agriculture development and intensification degrade natural habitats, reducing biodiversity. Small-scale mining, known locally as "Galamsey," has destroyed and fragmented habitats, causing a direct impact on the area's biodiversity. This loss of biodiversity jeopardizes ecosystem stability and resilience by eliminating pollinators required for agricultural production and disrupting ecological processes that promote agricultural growth. Based on these, agricultural

biodiversity necessitates conservation, habitat restoration, and biodiversity-friendly farming practices. Globalization and climate change also accelerate the spread of diseases and pests, disrupting pest control methods and jeopardizing food security and livelihoods. Biological control, crop rotation, and resistant crop varieties are examples of integrated pest management strategies that reduce pests and diseases while also reducing the need for chemical pesticides. Agriculture, like antibiotic resistance, a global health issue that occurs when bacteria develop the ability to withstand antibiotics, rendering them useless in disease treatment, cannot ignore this challenge in the twenty-first century. The claim that agriculture contributes to the spread of antibiotic-resistant bacteria is substantial even though antibiotic resistance stems from human medicine, animal husbandry, and environmental contamination. This poses significant challenges to agriculture, affecting animal health, food safety, and sustainable farming.

### **Historical development of One Health and sustainable agriculture movements**

Microbiology and epidemiology advanced in the 19<sup>th</sup> and 20<sup>th</sup> centuries. Louis Pasteur and Robert Koch pioneered germ theory and infectious disease [8]. These researchers explained zoonotic diseases. The 1918 influenza pandemic and the discovery of rabies and brucellosis show the importance of studying human-animal diseases. The One Health movement, inspired by medical and veterinary advances, helped veterinarians and doctors treat animal-transmitting infectious diseases. In the 20<sup>th</sup> century, global disease outbreaks occurred. The 1918 Spanish flu pandemic, 1980s HIV/AIDS pandemic, late 2<sup>nd</sup> and early 21<sup>st</sup> century Ebola, SARS, and avian influenza pandemics occurred. These incidents demonstrated the importance of coordinated responses and species-wide health. These activities encourage human, animal, and environmental health professionals to work together on new infectious diseases, antibiotic

resistance, food safety, and other global health issues. In Northern Ghana, international, private, and NGO efforts helped control the recent anthrax outbreak in the country [9].

The WHO, FAO, and OIE prioritize One Health methods in their policies and programmes. International coalitions like Global One Health address human, animal, and ecosystem health. One Health acknowledges human, animal, and environmental interdependence. The approach is multidisciplinary and cooperative wherein human, animal, and environmental health are interconnected; and improves health through collaboration, multisectoral, and transdisciplinary approach [10]. One Health promotes local, national, and global multidisciplinary collaboration to improve human, animal, and environmental health [10]. One Health promotes medical, veterinary, ecological, agricultural, and public health collaboration on complex health issues. One Health promotes a unified health approach that acknowledges the complex interdependence of all living things and their environments which optimizes health for current and future generations.

### **Role of sustainable agriculture in promoting One Health**

Sustainable agriculture is vital for One Health because environmental, animal, and human health are interconnected. The benefits of sustainable agriculture include the prevention of the spread of zoonotic diseases, the maintenance of antibiotic effectiveness, the mitigation of chemical exposures, and the improvement of food safety, ecological health, and food system resilience. The adoption of agroecological farming, responsible water, land, and energy utilization, animal welfare, ethical farming, chemical and pesticide reduction, and ecosystem conservation and restoration has been the target for advocacy on sustainable agricultural practices.

Zoonotic disease transmission can be diminished through ecological agriculture and livestock

management. Minimise interactions between humans and animals to prevent the spread of pathogens. Reduced antibiotic use, animal welfare, and stress allay the causes of antimicrobial resistance and zoonotic infections. Antibiotic resistance, a significant public health concern resulting from the misuse of antibiotics in agriculture, is among the problems that sustainable agriculture endeavors to tackle. Antibiotic-free sanitation, immunization, probiotic supplements, and traditional herbal remedies are all promoted by sustainable agriculture. Antibiotics remain effective for both animals and humans due to these procedures.

Conventional agriculture's reliance on synthetic pesticides, herbicides, and fertilizers poses risks to human and animal health, water pollution, and non-target organism harm. To reduce the use of chemicals and pollution, sustainability advocates for organic and agroecological agriculture. It decreases the accumulation of pesticides and herbicides in food, the environment, and human poisoning. Integrated pest management and organic farming reduce chemical exposure in food production by decreasing pesticide residues and foodborne illnesses, these techniques benefit the environment and public health. Because of this, food crops can be nourished more sustainably by prioritizing biodiversity and soil health, which in turn increases their resistance to disease and pests and provides consumers with safer, healthier food. Crop rotation, agroforestry, and cover crops all contribute to enhanced soil biodiversity, vitamin content, and resistance to diseases and pests in food crops. Pradyumna *et al.* [11] assert that these activities serve to preserve ecosystems, foster biodiversity, and avert soil and water depletion, all of which are advantageous for both human beings and animals.

Sustainable agriculture produces climate-resilient food systems. Local food networks, agroecology, and cropping techniques mitigate food shortages and price fluctuations. Sustainable agriculture reduces its impact on the environment through the efficient use of land, water, and energy.

Renewable energy, crop rotation, water conservation, and crop rotation are all methods of environmental protection. This stabilizes agricultural land and safeguards biodiversity, as it provides sustenance for the expanding global population. Sustainable agriculture is humane towards animals since it takes into account nutrition, space, and disease prevention. It is worth mentioning that natural behavior and decreased stress will improve the health of animals, which will have repercussions for human health via the food supply. Sustainable farming is a top priority for One Health in its efforts to combat antibiotic resistance, as it serves to enhance product quality and decrease antibiotic usage. Sustainable agriculture advances One Health through the implementation of Integrated Pest Management (IPM), an ecosystem-centric approach that employs resistant varieties, habitat modification, and biological control to manage pest populations. Over time, IPM prevents pest damage. Reducing the use of fertilizers and pesticides improves soil and waterway contamination, thereby enhancing environmental and human health. Diverse ecosystems enhance crop resilience and naturally regulate pest populations.

### **Challenges and opportunities of implementing One Health in sustainable agriculture**

The convergence of agriculture, human health, animal welfare, and environmental protection in the 21<sup>st</sup> century poses a significant number of obstacles as well as opportunities. The adoption of the One Health approach offers an integrated framework that can be utilized to address these intricate relationships and to promote sustainability across a number of different dimensions.

### **Challenges**

Sustainable agriculture integrates human health, animal welfare, and environmental protection. Despite the One Health concept being able to improve sustainability in agriculture, it also

presents some challenges. One Health in sustainable agriculture requires cross-disciplinary collaboration and integration. However, this is very difficult due to differences in priorities, language, and methodology. Because of this, overcoming disciplinary silos and encouraging efficient communication and collaboration are difficult. It can be difficult to use systems thinking to address the interconnection of human, animal, and environmental health due to its complexity. Systems thinking recognizes the interconnectedness of health. Resource constraints are another barrier to One Health in agricultural sustainability in the sense that One Health programmes are difficult to implement, especially in low-resource settings because of limited finances, infrastructure, and capacity-building [12].

Existing policies and regulations may also hinder One Health's implementation in agriculture. Fragmented governance structures may also hinder efforts to promote sustainable farming, integrate health into agricultural policy, and encourage cross-sector collaboration by creating conflicting mandates and bureaucratic hurdles. To adopt one health in sustainable agriculture, cultural norms, attitudes, and behaviors that affect agricultural practices and food consumption, as well as resistance to change and sociocultural factors, must be overcome. These cultural practices include using a cutlass with crocodile bile to kill grass cutters, using grass cutter stomach contents to make soup, using herbal concoctions to cook anthrax-infected meat, using guns to kill bushmeat, which can cause lead poisoning [8], and indiscriminately slaughtering donkeys and dogs with Rabies virus infection. All of these classic instances threaten the implementation of one health because they encourage the contraction and spread of zoonotic diseases.

## Opportunities

Agricultural systems can successfully manage diseases that impact both humans and animals thanks to the use of One Health initiatives. When

human health surveillance and animal disease monitoring are combined, it is possible to detect and respond to zoonotic illnesses at an earlier stage, which in turn reduces the likelihood of outbreaks and improves public health preparedness. Studies have also shown that One Health principles encourage food production systems that are both safer and more environmentally friendly [10]. It also showed that One Health is an advocate for sustainable agricultural methods as the system contributes to the preservation of the environment and biodiversity, which in turn supports the resilience of ecosystems. One Health also encourages the responsible use of antimicrobials in agriculture through the implementation of rational antimicrobial use practices the promotion of alternative disease prevention and control measures using plant extract and the promotion of ethnoveterinary practice.

In addition, the utilization of the native intelligence approach in the rural environment of Africa provides a more favourable opportunity to apply One Health in sustainable agriculture. Native intelligence, which is a community-based approach to the gathering of intelligence, is the most important factor in determining the health of every individual in rural areas. The participatory epizootiology approach, which is previously utilized for the control of Rift Valley fever, is utilized in this approach, which is a non-traditional source of information at the community level. In this approach, the involvement of women, men, district heads, chiefs, market women, hunters, trade groups, associations, established health institutions such herbalists, traditional healers and birth attendants, community health/animal health officers, food vendors, water carriers, palm wine, farmers and drink sellers in the control of zoonoses at the community level is critical and very informative in knowledge sharing to ensure an integrative approach to ensuring the health of the environment, animals and humans in the rural community [10].

## Technology, education, and public awareness in advancing One Health and sustainable agriculture

One Health and sustainable agriculture must be integrated in this era of unprecedented environmental and global health issues. Technology, knowledge sharing, public awareness, education, and policy integration must be the foundation of a more resilient, equitable, and sustainable future as climate change, population growth, and natural resource overexploitation bite. Technology facilitates data collection, analysis, and interpretation for evidence-based One Health and sustainable agriculture decisions. Precision farming, biotechnology, and sustainable farming equipment can maximize yields and reduce environmental impact. Drones and satellite imaging can precisely monitor crop health, soil moisture, and nutrient levels, enabling targeted interventions that conserve resources and reduce chemical inputs. Sharing knowledge across disciplines and regions improves human, animal, and ecosystem health. Training, workshops, and collaborative research can help farmers, agricultural professionals, and communities adopt sustainable, health-promoting practices. Educating farmers about zoonotic diseases can improve livestock management and protect animal and human health.

Policies that integrate health, agriculture, and the environment can encourage One Health. Advocacy can educate policymakers about the health and environmental benefits of sustainable agriculture, resulting in supportive legislation and funding for research and implementation. Communities have been known to be the drivers of agroecological change. Local participation in sustainable farming system design and management promotes social innovation and ensures that these systems meet local needs. Community-based initiatives can boost social cohesion and distribute sustainable agriculture benefits fairly.

Educational programmes encourage interdisciplinary collaboration and systems thinking to solve complex agriculture, health, and

environmental issues. Educational and outreach programmes raise awareness of One Health and sustainable agriculture. Thus, raising awareness of the links between agriculture, health, and the environment can change consumer behaviour, such as the demand for sustainable food. Farmers may adopt One Health practices due to market incentives. Public campaigns, educational programmes, and labeling can help raise awareness and change behaviour. Using the above opportunities, we can promote a holistic approach to health that recognizes the complex links between our food systems and the health of people, animals, and the planet. We need this integration to achieve sustainable development goals and preserve our agricultural systems.

## Conclusion

Integrating One Health principles into sustainable agricultural systems is essential to solving 21<sup>st</sup> century food production and environmental issues. One Health approaches promote resilience, equality, and sustainability in agriculture by acknowledging the interdependence of human health, animal welfare, and ecological integrity. Interdisciplinary collaboration, innovative technologies, and public awareness can make agricultural systems that prioritize human well-being, animal welfare, and environmental conservation sustainable for future generations. As the modern food system becomes more complex, we must emphasize One Health concepts in agricultural policy, practices, and research. By doing so, we can build a more resilient, equitable, and sustainable agricultural system that meets current and future needs while protecting people, animals, and the environment.

## Competing interests

The authors declare no competing interests.

## Authors' contributions

All the authors have read and approved the final version of this manuscript.

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