

## COMMENTARY

# Enhancing public health through modern agronomy: Sustainable and nutrient-rich practices

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## Introduction

This commentary explores modern agronomy concepts aimed at enhancing public health through sustainable and nutrient-rich agricultural practices. We explore various innovative approaches, including precision agriculture, sustainable farming, efficient nutrient management, crop diversity, biofortification, climate-resilient farming, vertical farming and urban agriculture, digital agriculture, and agroecology (see Figure 1). Our commentary delves into each of these modern agronomy practices, unveiling their intricate web and profound implications for public health. We aim to demonstrate the potential of modern agronomy as a catalyst for improving public health and the quality of life for individuals and communities worldwide. These concepts collectively strive to elevate public

health by improving food quality, enhancing nutrition, and safeguarding the well-being of individuals and communities. By harnessing these cutting-edge agronomic concepts, we aspire to transform agriculture into a powerful force for improving public health and enhancing overall quality of life.

## Discussion

In a world facing complex health challenges and pressing environmental issues, the intersection of agriculture and public health emerges as a critical domain for transformative change. Agriculture exerts a profound impact on both the nutritional quality of our diets and the health of our ecosystems. Within this intricate landscape, we embark on a journey to explore how modern agronomy acts as a catalyst for enhancing public health through the promotion of sustainable and nutrient-rich practices. This exploration converges innovative strategies and scientific insights, aiming to redefine the relationship between agriculture and community well-being in an ever-changing world.

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**Figure 1. Innovative Approaches to Enhancing Public Health through Modern Agronomy Practices**

### Precision Agriculture

Precision agriculture is a transformative approach to farming that leverages cutting-edge technologies and data analytics to optimize resource utilization (Amanullah, 2024). This, in turn, ensures efficient crop production, minimizes environmental impact, and fosters the growth of healthier, more nutrient-dense crops, ultimately improving the quality of our diets. This section will delve into precision agriculture, its components, benefits, and provide citations to support the discussion.

#### *Significance of Precision Agriculture in Relation to Public Health:*

- Increased Productivity:** Precision agriculture allows for optimal resource allocation, ensuring that crops receive the right amount of water, nutrients, and care. This results in higher crop yields.
- Resource Efficiency:** By applying inputs where and when they are needed, precision agriculture minimizes resource wastage. This includes reduced water usage, lower fertilizer and pesticide application, and decreased fuel consumption due to optimized machinery routes.
- Environmental Sustainability:** Precision agriculture promotes sustainable farming practices by minimizing the environmental impact of agriculture. Reduced chemical usage and soil erosion contribute to improved ecosystem health.

- **Nutrient-Dense Crops:** Through the precise management of soil nutrients, precision agriculture can enhance the nutrient content of crops. This is particularly important in addressing nutrient deficiencies in staple foods.

Precision agriculture, a groundbreaking approach that leverages technology and data to revolutionize farming practices, offers substantial benefits in the face of a changing climate (Khanna & Kaur, 2019). By fine-tuning resource allocation and agricultural processes, it enhances crop yields, bolstering global food security. Furthermore, this precision-driven approach extends its impact to public health by producing nutrient-dense crops. As climate change disrupts traditional agricultural patterns, the adaptability made possible through precision agriculture becomes invaluable. By aligning with the objective of improving diets worldwide, it addresses food-security challenges and promotes public health through a consistent supply of essential nutrients (Myers et al., 2017). Precision agriculture emerges as an indispensable tool for strengthening our resilience against climate change and global health concerns.

### **Sustainable Farming Practices**

The promotion of sustainable farming practices, which include crop rotation, organic farming methods, and reduced pesticide usage, plays a pivotal role in enhancing soil health, reducing chemical contamination, and simultaneously benefiting the environment and public health (Amanullah, 2018).

#### *Significance of Sustainable Farming Practices in Relation to Public Health:*

- **Enhanced Soil Health:** Crop rotation and organic farming practices enrich the soil with organic matter, improve soil structure, and increase microbial diversity. Healthy soils are better at retaining moisture and nutrients, resulting in increased crop yields.
- **Chemical Contamination Mitigation:** Reduced pesticide usage minimizes the risk of the chemical contamination of soil and water. This not only safeguards the environment but also reduces the presence of

pesticide residues in food, benefiting public health.

- **Biodiversity Conservation:** Sustainable farming methods often support greater biodiversity on and around farms. This includes the proliferation of beneficial insects, pollinators, and other wildlife. Biodiversity is critical for ecosystem resilience and long-term food security.
- **Reduced Environmental Impact:** By reducing the use of synthetic fertilizers and pesticides, sustainable farming practices lower the environmental footprint of agriculture. This includes reduced greenhouse gas emissions and minimized pollution of bodies of water.

Sustainable farming practices promise to nurture healthier soils while acting as a shield against chemical contamination. In the face of a changing climate, these practices are even more critical. Through sustainable farming, we can boost crop yields while mitigating the risks associated with chemical contamination, ensuring a stable and nutritious food supply (Roberts & Mattoo, 2019). As we confront the challenges of climate change, sustainable farming practices are indispensable for safeguarding our agricultural systems. Moreover, the far-reaching impact of sustainable farming extends to public health. By reducing the presence of harmful chemicals in our food and environment, these practices contribute to the well-being of ecosystems and human populations (Garcia et al., 2020). They align with the objectives of enhancing agricultural sustainability and ensuring the health of our planet and its inhabitants. In a changing climate, sustainable farming emerges as a beacon of hope, offering solutions that simultaneously enhance yield, food security, and public health (Lipper et al., 2014).

### **Nutrient Management**

Nutrient management, in the context of agriculture and environmental sustainability, refers to the strategic and responsible handling of essential nutrients (primarily nitrogen, phosphorus, and potassium [NPK]), as well as secondary and micronutrients. The goal is to optimize nutrient use efficiency while minimizing adverse environmental impacts (Amanullah et al., 2023).

### *Significance of Nutrient Management in Relation to Public Health:*

- **Improved Crop Productivity:** Proper nutrient management ensures that crops receive the right amount of nutrients they need for healthy growth and optimal yields.
- **Environmental Protection:** Nutrient runoff from excessive fertilizer use can lead to water pollution, algal blooms, and ecosystem damage. Effective nutrient management helps prevent these environmental issues.
- **Resource Efficiency:** Nutrient management enhances the efficient use of fertilizers, reducing production costs for farmers and conserving nonrenewable resources, such as phosphorus.
- **Climate Mitigation:** The application of nitrogen-based fertilizers can release nitrous oxide (N<sub>2</sub>O), a potent greenhouse gas. Nutrient management practices that minimize nitrogen losses can contribute to climate change mitigation.
- **Regulatory Compliance:** In many regions, regulations govern nutrient management to protect water quality. Farmers who practice responsible nutrient management are more likely to comply with these regulations.

Effective nutrient management lies at the core of optimizing crop nutrition, and consequently it plays a pivotal role in elevating the nutritional content of our food (Krasilnikov et al., 2022). By meticulously providing crops with the precise nutrients they require, we not only increase agricultural yields but also bolster the overall nutritional quality of our harvests. This synergy between nutrient management and crop health results in a higher concentration of essential vitamins, minerals, and other vital nutrients in the produce we cultivate. In a world grappling with issues of food security and the need for more nourishing diets, this approach holds immense promise. As we continue to refine our understanding and application of nutrient management practices, we are poised to make significant strides in enhancing both crop productivity and the nutritional value of the food we grow, contributing to a healthier and more food-secure future (Amanullah, 2020).

### **Crop Diversity**

Crop diversity refers to the practice of cultivating a wide range of plant species and varieties within agricultural systems. This diversity is vital for human nutrition as it ensures a rich and varied supply of essential nutrients, contributing to improved dietary quality and overall health (Food and Agriculture Organization of the United Nations [FAO], 2017).

### *Significance of Crop Diversity in Relation to Public Health:*

- **Enhancing Dietary Diversity through Crop Diversity:** Crop diversity promotes dietary diversity by providing a wider array of foods with distinct nutritional profiles.
- **Nutrient-Rich Crops and Micronutrient Deficiency Mitigation:** Crop diversity allows for the cultivation of nutrient-dense crops, which play a crucial role in mitigating micronutrient deficiencies, such as vitamin A deficiency.
- **Enhancing Human Health and Resilience:** Crop diversity contributes to resilient food systems by safeguarding against crop failures and ensuring a consistent supply of diverse nutrients.

Crop diversity is a linchpin for fostering a nutritious diet and enhancing food system resilience. It bolsters dietary variety, providing access to a wider range of essential nutrients and addressing micronutrient deficiencies (Amanullah, 2024). Additionally, diverse crops help us adapt to climate change and reduce the risk of crop failure. This multifaceted significance extends to cultural preservation, where crop diversity supports traditional farming practices and local food systems. Beyond diversifying our plates, crop variety combats malnutrition, upholds cultural heritage, and enhances the well-being of individuals and communities. It is a vital component of sustainable agriculture and public health.

### **Biofortification**

Biofortification is a process that aims to enhance the nutritional content of crops by increasing the concentration of essential nutrients such as vita-

mins and minerals in the edible parts of plants (Amanullah et al., 2020). This agricultural approach holds great promise for improving human health, particularly in regions where nutrient deficiencies are prevalent.

#### *Significance of Biofortification in Relation to Public Health:*

- **Addressing Micronutrient Deficiencies:** Biofortification directly addresses micronutrient deficiencies, which can have severe health implications. The biofortified crops can combat deficiencies in essential micronutrients like iron, zinc, and vitamin A.
- **Improved Nutrient Intake:** Biofortified crops provide an effective means of improving nutrient intake, especially among vulnerable populations.
- **Enhancing Overall Health:** Consumption of biofortified foods can lead to improved overall health and well-being. For example, biofortified rice plays a large role in reducing anemia and improving cognitive function among children.

The deliberate cultivation and consumption of biofortified crops hold the potential to significantly boost nutrient intake, resulting in enhanced overall health and a noteworthy reduction in the prevalence of nutrition-related health problems, particularly in regions grappling with severe malnutrition. This approach not only addresses immediate dietary needs but also offers a sustainable solution to the long-term challenge of improving public health through improved nutrition (Avnee et al., 2023). By harnessing the power of biofortification, we can help build stronger, healthier communities and contribute to a brighter and more food-secure future.

#### **Climate-Resilient Farming**

Climate-resilient farming refers to agricultural practices and strategies designed to withstand and adapt to the challenges posed by climate change (Amanullah, 2024). These practices not only contribute to food security but also have significant implications for public health.

#### *Significance of Climate-Resilient Farming in Relation to Public Health:*

- **Stable Food Supply and Reduced Hunger:** Climate-resilient farming focuses on maintaining stable food production even in the face of climate variability. By ensuring a consistent food supply, these practices contribute to reduced hunger and malnutrition, which are fundamental public health concerns.
- **Diverse Diets and Improved Nutrition:** Climate-resilient farming often involves diversifying crop varieties and species to adapt to changing climate conditions. This diversification supports more balanced and diverse diets, ultimately improving nutrition and reducing the risk of nutrient deficiencies.
- **Mitigation of Climate-Related Health Risks:** Climate-resilient farming practices help mitigate health risks associated with climate change, such as heat stress and waterborne and vector-borne diseases. Sustainable farming systems can reduce exposure to extreme weather events and promote safe water and sanitation practices.

Climate-resilient farming practices are instrumental in bolstering public health on several fronts. Through the assurance of consistent food supplies, the promotion of diversified and nutritious diets, and the mitigation of climate-induced health hazards, these practices significantly enhance the overall well-being of individuals and communities (Amanullah, 2020). They serve as a multifaceted and proactive approach that not only addresses the pressing issues of food security but also the broader spectrum of public health challenges in the context of a dynamic and changing climate. In doing so, climate-resilient farming practices represent a cornerstone for fostering healthier and more resilient communities while simultaneously contributing to global efforts for a sustainable and secure future (Wheeler & von Braun, 2013).

#### **Vertical Farming and Urban Agriculture**

Vertical farming and urban agriculture are innovative approaches to food production that have the potential to significantly impact public health and environmental sustainability. These practices aim to

cultivate crops and raise livestock in urban areas, often in vertically stacked layers or controlled environments.

*Significance of Vertical Farming and Urban Agriculture in Relation to Public Health:*

- **Improved Access to Fresh Produce:** Vertical farming and urban agriculture bring food production closer to urban populations. This proximity improves access to fresh, locally grown produce, which is essential for promoting healthier diets and reducing consumption of processed foods.
- **Reduced Environmental Impact:** By utilizing vertical space and controlled environments, these practices can reduce the environmental impact of traditional agriculture. They often require fewer pesticides, herbicides, and water, contributing to lower pollution levels and healthier ecosystems.
- **Community Engagement and Education:** Vertical farming and urban agriculture often involve the community in food production. These practices provide opportunities for education about nutrition, sustainable agriculture, and environmental stewardship, which can lead to improved public health awareness.

Vertical farming and urban agriculture emerge as innovative solutions to tackle the complex challenges of public health and sustainability in urban environments (Chatterjee et al., 2020). These practices substantially enhance access to fresh, locally cultivated food, effectively reducing the environmental footprint associated with conventional food production and distribution. Additionally, they play an important role in fostering community engagement and education, promoting a deeper understanding of food systems and sustainability among urban dwellers. By amalgamating these benefits, vertical farming and urban agriculture contribute to the creation of healthier, more sustainable urban ecosystems, thereby addressing crucial public health concerns and paving the way for a greener and more vibrant urban future (Van Gerrewey et al., 2022).

## Digital Agriculture

Digital agriculture is a transformative approach that leverages technology and data-driven solutions to optimize farming practices and enhance agricultural sustainability (Gumbi et al., 2023). It has significant implications for public health and the development of more sustainable food systems.

*Significance of Digital Agriculture in Relation to Public Health:*

- **Precision Farming and Reduced Environmental Impact:** Digital agriculture emphasizes precision farming practices, where data-driven decision-making leads to the precise application of resources such as water, fertilizers, and pesticides. This targeted approach reduces the environmental impact of agriculture by minimizing resource waste and chemical runoff, contributing to cleaner water and healthier ecosystems.
- **Enhanced Food Safety and Traceability:** Digital agriculture enables real-time monitoring of food production and supply chains. This transparency enhances food safety by quickly identifying and addressing potential contamination issues. Consumers benefit from access to safer and healthier food products.
- **Nutrient Optimization and Improved Nutrition:** Digital agriculture technologies, including precision nutrient management, enable farmers to optimize nutrient levels in crops. This leads to improved crop quality and enhanced nutritional content. In turn, consumers have access to more nutritious food, contributing to better public health.

Digital agriculture serves as a potent instrument for advancing both public health and sustainability in the realm of agriculture (Zhang & Zheng, 2023). Its capacity to curtail environmental impacts, elevate food safety standards, and fine-tune nutrient content closely aligns with the overarching objectives of promoting the health of individuals and fostering more sustainable food systems. This digital revolution in agriculture not only amplifies agricultural efficiency but also contributes to the creation of a healthier and more ecologically sound future for all.

## Agroecology

Agroecology is a holistic approach to farming that integrates ecological principles into agricultural practices. It emphasizes sustainable, regenerative, and environmentally friendly farming methods (Amanullah, 2024). Agroecological practices have profound implications for public health, contributing to healthier ecosystems and safer food systems.

### *Significance of Agroecology in Relation to Public Health:*

- **Healthier Ecosystems and Reduced Environmental Hazards:** Agroecology prioritizes natural processes and minimizes the use of synthetic chemicals. This reduces the environmental hazards associated with conventional agriculture, such as pesticide exposure and soil degradation. As a result, ecosystems become healthier, with benefits for both the environment and human health.
- **Improved Nutrition and Food Quality:** Agroecological practices often focus on diverse cropping systems and nutrient-rich soil. This leads to improved crop quality and nutritional content, ultimately benefiting consumers' health by providing access to more nutritious food.
- **Enhanced Resilience and Food Security:** Agroecology emphasizes resilience in agricultural systems, making them better equipped to withstand climate-related challenges. This resilience contributes to food security by ensuring a stable food supply, reducing the risk of hunger and malnutrition.

Agroecology paves the way toward healthier ecosystems, elevated food quality, and fortified food security—vital constituents of public health

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and sustainability. Through the embrace of agroecological principles, we forge pathways that foster more symbiotic relationships between agriculture and the environment. In this pursuit, we not only protect the integrity of our ecosystems but also ensure the health and security of individuals and communities. Agroecology represents a holistic and visionary approach to harmonizing our agricultural systems with the well-being of our planet and its inhabitants, offering a promising framework for a healthier and more sustainable future (Deaconu et al., 2021).

## Conclusions

In this comprehensive exploration of modern agronomy concepts and their impact on public health, we have examined nine key parameters: precision agriculture, sustainable farming, nutrient management, crop diversity, biofortification, climate-resilient farming, vertical farming and urban agriculture, digital agriculture, and agroecology. The cumulative effect of these modern agronomy concepts on public health is substantial and diverse. By promoting sustainable farming practices, enhancing nutritional quality, mitigating environmental contamination, and ensuring consistent food supplies, these concepts provide a comprehensive framework for advancing public health. They effectively address nutrient deficiencies, reduce the risk of foodborne illnesses, mitigate climate-related health threats, and empower communities by providing access to healthier, locally sourced food choices. In essence, these modern agronomy concepts are central to fostering more resilient, sustainable, and healthier food systems, aligning with the overarching goal of enhancing the well-being and health of individuals and communities worldwide.



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