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Review Article

Role of horticulture in addressing food security and global nutrition challenges

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When it comes to solving the interconnected problems of global nutrition and food security, horticulture is essential. Horticulture provides sustainable ways to increase food production while encouraging a varied and nutrient-rich diet in light of the world's expanding population and mounting demand on agricultural resources. Horticulture improves dietary diversity and fights malnutrition by increasing the availability of nutrient-dense food through the production of fruits, vegetables, herbs, and decorative plants. Horticulture's adaptation to many climatic circumstances is one of its main advantages. Horticultural approaches, which range from big commercial farms to little backyard gardens, may be customized to fit local conditions, enabling communities to grow their own food and lowering their need on imported items. In addition to improving food security, this decentralization of food production increases resilience against outside shocks like market volatility and climate change. Horticulture provides a wide variety of nutrient-dense crops that are necessary for a balanced diet, which helps to solve the problems associated with global nutrition. Antioxidants, vitamins, and minerals found in abundance in fruits and vegetables are essential for avoiding chronic illnesses and micronutrient shortages. Furthermore, horticulture commodities may be turned into value-added goods like jams, juices, and dried fruits, which will increase their year-round accessibility and shelf life.

Keywords: *food security, horticulture, global nutrition, nutrition challenges, nutrient-rich crops*

Introduction

Even though traditional staple crops are essential for feeding the globe, relying too much on a small number of types makes one more susceptible to shocks from the climate and the economy. The growing of fruits, vegetables, as well as other crops of great value is known as horticulture, and it provides a distinctive and significant response to the two pressing issues of global nutrition shortages and food security. In order to solve the issues of global nutrition and food security, horticulture is crucial. Horticulture is the study and practice of cultivating decorative plants, fruits, vegetables, flowers, and plants for food, according to the Food and Agriculture Organization of the United Nations (FAO). By offering a variety of nutrient-dense food alternatives, producing revenue for small-scale farmers, and enhancing the resilience of food systems to shocks like climate change, horticulture may help ensure food security. Horticulture may also improve global nutrition by making fruits and vegetables, which are necessary for a balanced diet, more widely available and accessible (UNicef, 2023) (Congreves, 2022a). It improves livelihoods, raises incomes, and enriches diets, horticulture is important for food security. The following are some crucial facets of horticulture's significance for food security. Dietary enhancement: Growing vegetables and fruits is a key component of horticulture, which offers vital

nutrients for a well-balanced diet. Diets deficient in fruits and vegetables are a major cause of some of the most common health problems in the globe. Increase earnings: Farmers that cultivate high-value crops, such fruits, vegetables, flowers, or herbs, regularly make more money than those who grow other types of commodities. A key component of agricultural and diversifying the economy is horticulture. Improving livelihoods: Horticulture may help farmers and their communities by boosting farmer profitability and expanding the variety of nutrient-rich foods. Urban horticulture: In response to concerns about food security, urban gardening is encouraged as a means of bolstering regional food supply. It provides an innovative approach to feeding the globe in more socially, economically, and environmentally responsible ways. Food resilience: By offering a range of ecosystem services, including regulatory, cultural, and supportive functions that act as positive feedback to further boost food production, urban horticulture can help promote food resilience.

Urban farming: In a number of contexts, including urban farming, which may support the smooth operation of food systems in times of crisis, urban horticulture has made a substantial contribution to food security and livelihoods. In short, because it enhances diets, raises incomes, enhances livelihoods, and supports urban agricultural production and resilience, horticulture is an essential part of food security. By emphasizing urban agriculture and horticulture techniques, we may move toward a more just and sustainable food system that benefits everyone (Dawson, 2018) (Congreves, 2022a).

Horticulture and global food security

Ensuring that every person has access to safe and nutritious food becomes an increasingly pressing concern as the world's population rapidly approaches 10 billion by the year 2050. Horticulture shows up as a ray of light in this dire situation, providing a wide range of answers to the challenging problem of global food security. There are several methods in which urban gardening might support global food security. It presents a viable plan for bolstering regional food production in the event of a food crisis, especially in cities. By making more fresh, wholesome, and culturally acceptable foods available, urban gardening may increase nutrition security and hence food security. Through community-based gardening initiatives, it also significantly contributes to the improvement of nutritional intake, the decrease of food insecurity, and the bolstering of family bonds. Furthermore, via enhancing public health, fostering environmental sustainability, and lowering reliance on international trade, urban gardening may assist sustainable food production systems. Overall, via encouraging environmental sustainability and enhancing public health outcomes, it can aid in addressing the complicated problem of global food insecurity. Furthermore, by giving importance to soil health, biodiversity, and ecosystem resilience, regenerative agriculture techniques like crop rotation and community-supported agriculture may promote sustainable food production systems (Congreves, 2022b) (McCauley, 2021) (*Urban Horticulture for Food Security*, n.d.).

Nutritional significance of horticultural crops

Vegetables and fruits are nutrient powerhouses! Rich in fiber, vitamins, and minerals, they are vital for preventing malnutrition and improving general health. They are efficient food providers, especially in confined settings like cities, because to their shorter growth cycles and better yields than staple crops. Horticulture provides a tasty and varied way to feed the globe with nutrient-rich deliciousness, from gardens in the backyard to vertical farms. A significant supply of nutrients for human nourishment comes from horticultural crops. They provide health advantages through the presence of vitamins, antioxidants, dietary fibers, and other secondary metabolites. A potential method to alleviate nutrient shortages and improve the nutritional content of crops is agronomic biofortification of minerals and vitamins in horticultural crops. The essential micronutrients that are absent from meat and dairy can be obtained via a diet high in fruits and vegetables. You can utilize certain fruits or vegetables to address specific dietary deficits. Horticultural crops may alleviate the severe issue of calorie-deficient meals and play a significant part in satisfying man's demands for vitamins and minerals. The highest source of protein is found in legume seeds, which are followed by starchy roots, fruits, and vegetables. Horticultural crops provide a significant amount of the total protein consumed, especially in some countries, even if they are not the primary source of protein in the diets of most people (Kathi et al., 2024a) (*Horticulture + Nutrition*, n.d.) (Chen et al., 2022).

Horticultural interventions for malnutrition

Horticultural interventions, such as indoor gardening and community farming, can be very effective in combating malnutrition, particularly in marginalized communities. These actions increase access to vital vitamins, minerals, and protein that are frequently deficient in malnourished diets by encouraging the cultivation and consumption of a wide variety of fruits, vegetables, and legumes. It has been discovered that agricultural interventions are successful in raising nutrition-related indices, such as food security and the nutritional status of children. Nutritional status, fruit and

vegetable consumption, micronutrient deficits, and improved mediators of healthy eating have all improved as a result of garden-based treatments. Undernutrition can be reduced by ongoing attempts to biofortify horticulture crops for more nutrition. Malnutrition may also be beaten using home vegetable gardens and other food-based tactics including enhancing food and nutrition education. It has been discovered that enhanced nutritional outcomes are linked to agricultural interventions that boost productivity, home gardening, bio-fortification, and other means of producing micronutrient-rich meals. According to a research, women benefit from horticulture nutrition interventions in which they participate (*Garden-Based Interventions and Early Childhood Health: An Umbrella Review - PMC*, n.d.) (Kathi et al., 2024b).

Sustainable horticulture practices

Sustainable horticulture practices include a range of techniques, such as organic and agroecological methods, that put social well-being, economic viability, and ecological balance first. Organic growing presents a significant opportunity to guarantee the sustainability of horticulture by tackling issues like soil erosion, chemical pollution, and climate change. In a similar vein, agroecology emphasizes the use of ecological concepts to build resilient agroecosystems through a transdisciplinary approach to sustainable agriculture operations. These methods improve soil fertility, insect management, and pollination services by using techniques such crop diversity, less tillage, and the use of natural inputs. Continuing research, service extensions, and policy support are necessary for the implementation of these practices in order to maximize their advantages and solve issues related to sustainable horticulture production.

Sustainable horticulture operations include a variety of tactics meant to maximize efficiency and conserve resources. Using native plants is one of these techniques as they are suited to the soil and temperature of the area, need less water and fertilizer, and benefit pollinators and wildlife. Sustainable gardening also entails using less water, less energy from fossil fuels, and ecologically responsible methods of disposing of "waste" from gardens and yards. Furthermore, by using techniques like landscaping, water conservation, and material recycling, sustainable landscaping seeks to create landscapes that are both ecologically benign and self-sustaining. These methods lower carbon emissions and increase soil carbon storage, which not only helps fight climate change but also save resources (Akanmu et al., 2023) (*Sustainable Gardening*, n.d.).

Climate smart horticulture

Climate-smart horticulture is the application of agricultural techniques and technology that increase resilience, lower greenhouse gas emissions, and increase production all at the same time. A comprehensive strategy to eradicate food hunger, adjust to climate change, and significantly lower greenhouse gas emissions is called climate-smart agriculture. A collection of farming methods and technology known as "CSA" work together to lower greenhouse gas emissions, increase resilience, and increase output. Using climate-smart gardening practices may help save water, cut emissions, and increase the amount of carbon stored in soil and plants. The USDA's Partnerships for Climate-Smart Commodities program is dedicated to assisting a wide variety of farmers, ranchers, and private forest landowners. To measure the impact of climate change on the horticulture sector, an evaluation of location-specific climate-smart horticulture's ability to mitigate climate change is required (*Climate-Smart Gardening – New Jersey Climate Change Resource Center*, n.d.) (*Partnerships for Climate-Smart Commodities | USDA*, n.d.).

Global innovative policies

Through several projects and programs, there are international efforts being made to promote horticulture for nutrition. Feed the Future, a project by the U.S. government to combat global poverty and ensure food security, highlights the importance of horticulture in promoting equitable agricultural growth, bolstering resilience, and enhancing nutrition for women and children. Through the coordination of a worldwide horticulture program, the Horticulture Collaborative Research assistance Program (Hort CRSP), headed by UC Davis, with funding assistance from the U.S. Agency for worldwide growth (USAID), strives to address food security and economic growth in many locations. Food security, better nutrition, and sustainable agriculture are all made possible by horticulture, according to Sustainable Development Goal 2 (SDG 2). Furthermore, groups like the Food and Agriculture Organization of the United Nations (FAO) aggressively promote initiatives aimed at enhancing agricultural output and improving nutrition in nearby communities. These programs emphasize on food security, encouraging sustainable farming methods, and use horticulture to improve the nutritional value of food.

Several policy frameworks can assist horticultural solutions. To protect air, water, and soil resources, create thriving and productive farms, ranches, woodlands, and communities, and restore ecological services in both rural and urban areas are just a few of the objectives of the USDA Agroforestry Strategic Framework. Climate change, energy efficiency,

biosecurity, and reducing food waste are just a few of the seventeen subjects that make up the four pillars of the Australian-Grown Horticulture Sustainability Framework, which is important for the sustainable production of fruits, vegetables, and other horticultural goods. Furthermore, by addressing societal issues via the preservation, sustainable management, and restoration of both natural and modified ecosystems, nature-based solutions may assist horticulture solutions (*Addressing Nutrition and Poverty through Horticulture*, n.d.) (*Food Security and Nutrition and Sustainable Agriculture | Department of Economic and Social Affairs*, n.d.).

Communities empowerment

Participating in small-scale horticulture in local communities can improve food and nutrition security by expanding access to fresh, healthful, and culturally appropriate foods; it can also foster social cohesion and a sense of community among participants; it can boost neighborhood pride and give residents a stronger sense of place. "Small-scale urban agriculture" refers to food production at the household level in communal gardens or at home, and it plays a vital role in achieving sustainable development objectives. Market gardens and small-scale farms are maintained in extremely remote locations as well, proving that small-scale farming is not just found in big towns. However, there are obstacles to small-scale farming, such restricted access to transportation and processing facilities, and farmers must gradually expand their businesses in order to customize their livestock and crops to the shifting demands of their clientele.

Encouraging farmers to use sustainable practices in horticulture is a complex process that encompasses a number of programs and strategies. The significance of enabling smallholder farmers and communities to embrace regenerative and sustainable agriculture techniques has been emphasized by a number of organizations and research studies. For example, Sustainable Harvest International has been working with smallholder farmers to promote organic farming and sustainable agriculture as means of reducing poverty for more than 25 years. Furthermore, the necessity for a unique framework to empower change for sustainable agriculture, notably through participatory approaches, is emphasized in a study on "Participatory Sustainable Agricultural Development (*The Contribution of Small-Scale Food Production in Urban Areas to the Sustainable Development Goals: A Review and Case Study | Sustainability Science*, n.d.) (*Full Article: Empowering Change for Sustainable Agriculture: The Need for Participation*, n.d.).

Challenges and barrier

There may be a number of obstacles to horticulture's integration with food security initiatives. Cultural customs, a lack of information, money, or expertise, worries about the safety of food produced using urban wastewater, growing crops or raising animals or poultry on contaminated soils, and the careless use of pesticides are a few of the obstacles, according to identifies the main obstacles to food security as being poverty, urban migration, a lack of resources, natural catastrophes, and conflict. However, indicates that home gardens may be a viable way to increase the food security and well-being of households, and that with better management, home garden cultivations may become agricultural endeavors by means of the possibilities and systemic restrictions, emphasizes that while there are hazards associated with urban gardening, they are outweighed by the benefits, which can be achieved by using urban horticulture wisely and cautiously. Lastly, indicates that in order to improve food security, value chain initiatives may need to create activities specifically aimed at homes experiencing food poverty, comprehend how food insecurity is distributed, and concentrate the benefits on these households (*Sustainability | Free Full-Text | Urban Horticulture for Food Secure Cities through and beyond COVID-19*, n.d.) (*Home Gardens: A Promising Approach to Enhance Household Food Security and Wellbeing | Agriculture & Food Security | Full Text*, n.d.).

Case studies and success stories

Food security has been greatly influenced by horticulture, particularly in urban areas. Urban horticulture has been acknowledged as a way to supply inclusive and equitable food access, a wide variety of nutritious foods, and sustainable food systems—especially in light of issues like pandemics, urbanization, and climate change. Urban horticulture has been shown to be able to avert supply-chain interruptions and assist maintain food systems functioning efficiently in times of crisis. Furthermore, home gardens have been recognized as a potentially effective way to improve household food security and well-being, acting as a flexible solution to alleviate food poverty in a range of difficult circumstances. Horticulture is therefore essential to guaranteeing food security and advancing sustainable food production, especially in urban and home garden settings.

Urban horticulture, for instance, may offer a variety of nutritious meals, inclusive and equitable food access, and cultural services including social inclusion, wellness, and positive health outcomes. Home gardens are a tried-and-true local tactic that are extensively used and implemented in many nations worldwide, enhancing the security of food and nutrition. In addition, horticulture may contribute to the global food crisis by promoting high-value, nutrient-dense crops

that yield higher yields per unit area and need less acreage. However, exposure to toxins is still a major worry in urban contexts, and certain gardening techniques may have unclear or detrimental ecological repercussions. Plant diseases can potentially impact food security by reducing output and causing plant death, which can reduce food supply (*Frontiers | Urban Horticulture for Sustainable Food Systems*, n.d.) (*Home Gardens: A Promising Approach to Enhance Household Food Security and Wellbeing | Agriculture & Food Security | Full Text*, n.d.).

Future prospective

New technologies in horticulture are revolutionizing the cultivation and management of crops, tackling issues like low labor, high energy costs, and losses after harvest. Top horticultural technology includes some of the following:

Automation for plant monitoring: This technology assists farmers in keeping tabs on the health and development of their plants, guaranteeing ideal circumstances for both growth and productivity.

Drones for managing and identifying diseases and pests: Drones with sensors and imaging capabilities can discover diseases and pests in crops, allowing earlier intervention and better management.

Machine learning and artificial intelligence: These tools enable data-driven precision farming and offer real-time information and suggestions for the best crop management practices. Modern imaging technology known as "digital phenotyping" measures and examines important plant phenotypic data to assist producers in making well-informed crop management decisions.

Technologies used in space science: Space science technologies can improve high-tech greenhouses by offering useful information for production forecast and crop registration.

Drying beads: Higher germination rates and greater production capacity are the results of these reusable, highly adjustable drying beads, which preserve good seed quality throughout storage.

Pest-exclusion nets: By putting up a barrier between crops and any dangers, these cheap, safe, reusable nets offer an efficient way to manage insect pests.

Growers are adopting new technology more frequently as the horticulture sector develops in order to better manage their crops, remove obstacles, and adjust to shifting consumer expectations (*Innovations in Horticulture to Look out for in 2022 and beyond Part 1*, n.d.-a) (*Innovations in Horticulture to Look out for in 2024 and beyond Part 1*, n.d.-b).

Conclusion

In summary, horticulture contributes to sustainable food production, biodiversity preservation, and the provision of nutrient-dense crops for balanced diets in a variety of ways, helping to solve issues related to food security and global nutrition. Developing the potential of horticulture is crucial to creating just and resilient food systems that support people and the environment as we face the challenges of a changing world.

Author contributions

All authors contributed to the study's conception and design. The study was created and the protocol was written by author Shahzaib Hanif. Material preparation, data collection, and analysis were performed by Iffat Tahira and M. Tahir Murad. The first draft of the manuscript was written by Shahzaib Hanif and Saman Rani commented on previous versions of the manuscript. Author Memoona Amam, Muhammad Abdul Rehman Shah, Ishrat Fatima the literature searches and contributed a lot in Strategies Portion. The final part of the manuscript is written by Muhammad Zubair and Iffat Tahira. References and citations were managed by Shahzaib Hanif. All authors read and approved the final manuscript.

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