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Review Article

Review on Climate-Smart Horticulture Practices in Ethiopia

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Abstract

This review explores climate-smart horticulture practices in Ethiopia, focusing on sustainable strategies amidst challenging climatic conditions. It delves into water management techniques, soil health management, Integrated Pest Management (IPM), conservation agriculture, climate-resilient crop varieties, sustainable land management, protected cultivation, and agroecology. Emphasizing resilience and resource optimization, it discusses challenges, opportunities, and the importance of innovation in horticulture. Future research directions, policy support, and continuous adaptation are highlighted for sustainable agricultural development. This comprehensive analysis aims to guide stakeholders, researchers, and policymakers towards fostering climate-smart practices crucial for Ethiopia's agricultural sustainability and food security.

Keywords: Climate, Smart, Agriculture, Horticulture and production

INTRODUCTION

Climate change poses significant challenges to agricultural productivity and sustainability worldwide. Ethiopia, with its diverse agro-ecological zones, is particularly vulnerable to the impacts of climate variability, including erratic rainfall patterns, increased frequency of droughts, and temperature fluctuations. These changes threaten the country's agricultural sector, which is the backbone of its economy and a critical source of livelihood for a majority of its population. The urgency to address these challenges is paramount, as the nation's food security and economic stability are closely intertwined with the health of its agricultural systems (Deressa TT et al., 2011; Conway D et al., 2011).

Horticulture, encompassing the cultivation of fruits, vegetables, and ornamental plants, plays a vital role in Ethiopia's agricultural landscape. It contributes significantly to food security, income generation, and employment. The horticulture sector is also integral to the country's nutrition strategy, providing essential vitamins and minerals that are crucial for public health. However, the sector faces unique challenges due to its high sensitivity to climatic conditions. Factors such as unpredictable weather patterns, water scarcity, and soil degradation directly impact horticultural yields and quality. Consequently, there is an urgent need for resilient agricultural practices that can withstand and adapt to these changing conditions.

Climate-Smart Horticulture (CSH) emerges as a sustainable solution to enhance the resilience of horticultural systems in Ethiopia. CSH practices integrate climate change adaptation and mitigation strategies while improving agricultural productivity and ensuring food security. These practices include the use of improved crop varieties, efficient water management techniques, soil health improvement, integrated pest management, and the adoption of agroforestry systems. For instance, drought-resistant crop varieties can help farmers maintain yields during dry spells, while efficient irrigation systems can optimize water use in increasingly arid conditions.

The implementation of CSH practices in Ethiopia involves a multi-faceted approach that spans policy frameworks, technological innovations, and capacity-building initiatives. Government policies play a crucial role in creating an enabling environment for the adoption of CSH practices. Technological innovations, such as precision farming tools and remote sensing, provide farmers with critical data to make informed decisions about crop management.

Capacity-building initiatives, including farmer training programs and extension services, equip local farmers with the knowledge and skills needed to implement CSH practices effectively.

This review aims to provide a comprehensive overview of the current state of climate-smart horticulture practices in Ethiopia. It will explore various strategies employed by farmers and researchers to mitigate the adverse effects of climate change on horticulture. The review will also examine the role of policy frameworks, technological innovations, and capacity-building initiatives in promoting the adoption of CSH practices. By analyzing successful case studies, this review seeks to highlight best practices and lessons learned that can be replicated and scaled up across the country.

In addition, the review will identify key challenges that hinder the widespread adoption of CSH practices, such as limited access to financial resources, inadequate infrastructure, and gaps in research and development. It will also explore the opportunities that exist for enhancing the resilience of Ethiopia's horticultural sector, including the potential for public-private partnerships, international collaborations, and increased investment in agricultural research.

By highlighting successful case studies and identifying challenges and opportunities, this review seeks to contribute to the broader discourse on sustainable agricultural development in Ethiopia. It underscores the importance of adopting climate-smart practices to ensure the long-term viability of the horticultural sector, thereby supporting the country's overall economic growth and food security goals. Ultimately, this review aims to provide valuable insights for policymakers, researchers, and practitioners working towards a more resilient and sustainable horticultural sector in Ethiopia.

LITERATURE REVIEW

Climate-smart practices in horticulture

Climate-Smart Horticulture (CSH) practices are essential for enhancing the resilience and sustainability of horticultural production in Ethiopia. These practices integrate climate change adaptation and mitigation strategies to improve agricultural productivity, ensure food security, and support the livelihoods of farmers. The key climate-smart practices in horticulture in Ethiopia include the use of improved crop varieties, efficient water management techniques, soil health improvement, integrated pest management, and the adoption of agroforestry systems.

Agroforestry systems

Agroforestry systems, the integration of trees and shrubs into agricultural landscapes, are a cornerstone of climate-smart horticulture in Ethiopia. These systems offer a multifaceted approach to enhance the resilience and sustainability of horticultural production. By incorporating trees and shrubs alongside crops, agroforestry systems provide numerous environmental, economic, and social benefits that are crucial in the context of climate change.

Environmental benefits: Agroforestry systems significantly improve soil health and reduce erosion. Trees and shrubs act as natural barriers that protect soil from wind and water erosion. Their root systems enhance soil structure, increase organic matter, and improve water infiltration and retention. These improvements in soil health are vital for maintaining productivity in horticultural systems, especially in regions prone to soil degradation and nutrient depletion.

Furthermore, agroforestry systems contribute to biodiversity conservation. The diverse plant species in these systems create habitats for various wildlife, including beneficial insects, birds, and small mammals. This biodiversity supports pest control and pollination services, which are essential for the productivity of horticultural crops. Additionally, agroforestry systems sequester carbon, helping to mitigate climate change by capturing and storing atmospheric carbon dioxide (Nair, 2011).

Economic benefits: Agroforestry systems offer economic advantages by diversifying farmers' sources of income. The trees and shrubs in these systems can produce fruits, nuts, timber, fodder, and other non-timber forest products that can be sold or used by the farming household. This diversification reduces farmers' reliance on a single crop, thereby spreading risk and enhancing economic resilience. In times of crop failure due to adverse weather conditions, the products from trees and shrubs can provide a crucial financial safety net.

Moreover, agroforestry systems can increase overall farm productivity. The complementary interactions between trees, shrubs, and crops can lead to higher yields. For instance, trees can provide shade that protects crops from excessive heat and reduces water evaporation from the soil. Nitrogen-fixing trees can enhance soil fertility, benefiting the adjacent crops. These synergies can result in more stable and sustainable agricultural production systems.

Social benefits: Agroforestry systems contribute to the social well-being of farming communities by improving food security and nutrition. The diverse array of products from these systems can enhance dietary diversity and provide essential nutrients. For example, fruit trees can offer a source of vitamins and minerals, while legumes can provide protein. Improved food security and nutrition are critical in regions where malnutrition is a concern (Kiptot E et al., 2012).

Additionally, agroforestry systems promote gender equity by creating opportunities for women. Women often manage home gardens and small-scale agroforestry plots, where they can grow a variety of crops for household consumption and sale. This involvement empowers women economically and socially, contributing to their overall well-being and the development of their communities.

DISCUSSION

Water management techniques

Effective water management is crucial for enhancing the resilience of horticultural systems to climate variability and change in Ethiopia. Several water management techniques have been implemented to optimize water use efficiency and ensure sustainable horticultural production under changing climatic conditions. Here, we discuss some of the key water management practices adopted in Ethiopian horticulture.

Drip irrigation: Drip irrigation is a highly efficient method that delivers water directly to the root zone of plants through a network of valves, pipes, tubing, and emitters. This method minimizes water loss due to evaporation and runoff, making it particularly suitable for areas with limited water resources. In Ethiopia, drip irrigation systems have been introduced to improve water use efficiency, especially in regions prone to drought (Alemu D et al., 2014). Studies have shown that drip irrigation can significantly enhance crop yield and quality while conserving water.

Rainwater harvesting: Rainwater harvesting involves collecting and storing rainwater for agricultural use. This technique helps to mitigate water scarcity during dry periods and reduces dependence on groundwater and surface water sources. In Ethiopia, rainwater harvesting systems, such as rooftop catchments and surface runoff collection, have been promoted in rural and peri-urban areas. These systems provide a supplementary water source for irrigation, contributing to improved crop resilience and productivity.

Mulching: Mulching is the practice of covering the soil surface with organic or inorganic materials, such as straw, leaves, plastic, or gravel. Mulching helps to conserve soil moisture, reduce soil temperature fluctuations, and suppress weed growth. In Ethiopian horticulture, mulching has been widely adopted to enhance water retention in the soil, reduce evaporation, and improve soil health. Organic mulches, in particular, also contribute to soil fertility by decomposing and adding organic matter to the soil.

Use of drought-tolerant varieties: The selection and cultivation of drought-tolerant crop varieties are critical water management strategies in climate-smart horticulture. These varieties are bred to withstand water stress and maintain productivity under limited water conditions. In Ethiopia, research institutions and agricultural development programs have been working on developing and disseminating drought-tolerant varieties of key horticultural crops. These varieties help to stabilize yields and reduce the risk of crop failure during drought periods.

Deficit irrigation: Deficit irrigation involves applying water below the full crop water requirements, allowing plants to experience mild water stress during certain growth stages. This technique can enhance water use efficiency by reducing water consumption without significantly impacting crop yield. In Ethiopia, deficit irrigation has been explored as a strategy to optimize water use in horticultural production, particularly in water-scarce regions. Implementing this practice requires careful monitoring and management to balance water savings with crop performance.

Soil moisture monitoring and scheduling: Advanced soil moisture monitoring tools and irrigation scheduling techniques are essential for precise water management in horticulture. Technologies such as soil moisture sensors, tensiometers, and remote sensing are used to assess soil water content and inform irrigation decisions. In Ethiopia, integrating these technologies into horticultural practices helps farmers apply the right amount of water at the right time, reducing water waste and improving crop water productivity.

Conservation agriculture: Conservation agriculture practices, including minimal soil disturbance, permanent soil cover, and crop rotations, contribute to improved water management in horticulture. These practices enhance soil structure, increase water infiltration, and reduce erosion and runoff. In Ethiopia, conservation agriculture has been promoted as a holistic approach to sustainable land and water management, benefiting both water conservation and soil health.

Soil health management

Soil health management plays a pivotal role in climate-smart horticulture practices in Ethiopia, where the agricultural sector heavily relies on soil quality. In Ethiopia, integrating legumes into cropping systems helps fix atmospheric nitrogen, enriching soil fertility naturally. Lal emphasizes the significance of soil health for sustainable agriculture and its relationship with climate change. Blanco-Canqui and Lal discuss various soil conservation techniques such as conservation tillage and cover cropping, highlighting their role in preventing soil erosion and maintaining soil structure.

Franzluebbers stresses the importance of balanced nutrient management and organic amendments in enhancing soil fertility and productivity. Brady and Weil emphasize the need for soil testing and monitoring to assess soil health parameters accurately. Altieri and Nicholls advocate for integrated pest management strategies to preserve soil biodiversity and ecosystem resilience.

Wall and Kimball discuss soil water management techniques like drip irrigation and rainwater harvesting, which optimize water use efficiency and enhance drought resilience. Verbruggen and Hermans explore the connection between soil health and climate resilience in plants, highlighting the importance of healthy soils in mitigating climate stressors. Umar and Hussain underscore the significance of farmers' education and capacity building in adopting climate-smart soil management practices effectively.

Lal discusses the role of soil organic carbon management in climate change mitigation and food security. Adimassu Z et al., (2017) examine the effectiveness of soil conservation structures in northern Ethiopia. Bünemann EK et al., (2015) delve into soil health indicators and their role in assessing soil biological activity. Lehmann and Rondon discuss soil amendments like biochar in enhancing soil structure and fertility.

Munns and Tester address strategies for managing soil salinity and alkalinity, common challenges in certain regions of Ethiopia. Tscharntke and Klein discuss the relationship between soil health and biodiversity conservation, emphasizing the importance of diverse plant and microbial communities. Snapp and Gentry advocate for climate-smart cropping systems and agroecological approaches in maintaining soil health. Lastly, the FAO highlights the role of policy support and institutional frameworks in promoting soil health management practices at a larger scale.

Integrated Pest Management (IPM)

Integrated Pest Management (IPM) plays a crucial role in climate-smart horticulture practices in Ethiopia. IPM is a sustainable approach to managing pests that focuses on minimizing pest damage through a combination of biological, cultural, physical, and chemical control methods. In the context of climate-smart practices, IPM becomes even more important due to the changing climate conditions affecting pest populations and their dynamics (Asfaw A et al., 2017). Climate change can exacerbate pest and disease pressures. IPM combines biological, cultural, mechanical, and chemical tools to manage pests sustainably. Ethiopian farmers use biopesticides, natural predators, and resistant crop varieties to reduce reliance on chemical pesticides, thus promoting a healthier ecosystem.

Here are some key points to include in your review paper regarding IPM in climate-smart horticulture practices in Ethiopia:

Biological control: Highlight the use of natural enemies such as predators, parasitoids, and pathogens to control pest populations. Discuss the effectiveness of biopesticides derived from living organisms in managing pests while minimizing environmental impact.

Cultural practices: Emphasize the role of cultural practices such as crop rotation, intercropping, and use of pest-resistant varieties in reducing pest pressure. These practices not only help in pest management but also contribute to soil health and biodiversity conservation.

Physical control methods: Include information about physical barriers like nets, traps, and screens that can prevent pests from infesting crops. Also, discuss the use of mechanical methods like tillage and sanitation practices to disrupt pest life cycles.

Chemical control: While chemical control is a part of IPM, stress the importance of using pesticides judiciously and as a last resort. Discuss the selection of low-toxicity pesticides, application timing, and integrated approaches like using pheromones for mating disruption (Asfaw A et al., 2017).

Monitoring and decision-making: Describe the importance of regular pest monitoring using traps, scouting, and predictive models. Explain how data from monitoring can inform timely and targeted pest management decisions, reducing reliance on blanket pesticide applications.

Capacity building and training: Highlight the need for training programs and capacity building among farmers, extension workers, and agricultural stakeholders on IPM principles and practices. This can empower them to implement effective pest management strategies in a climate-smart context.

Economic and environmental benefits: Discuss the economic benefits of adopting IPM, such as reduced input costs from pesticide use, improved crop yields, and enhanced environmental sustainability by minimizing pesticide residues and protecting non-target organisms.

Conservation agriculture

Conservation Agriculture (CA) stands as a cornerstone in the realm of climate-smart practices for horticulture, embodying principles that safeguard soil health, water resources, and biodiversity while concurrently bolstering crop productivity. These practices are gaining traction in Ethiopia as they improve soil structure, reduce erosion, and increase resilience to climate variability. As highlighted by FAO, CA pivots on three fundamental principles: minimum soil disturbance, permanent soil cover, and crop rotation or diversification. This approach, as evidenced by Derpsch et al., not only minimizes soil erosion but also nurtures soil structure and augments nutrient accessibility crucial for horticultural crops. Lal's research underscores CA's pivotal role in water management, with practices like mulching and cover cropping adeptly conserving soil moisture and reducing irrigation demands. Moreover, Hobbs et al. emphasize CA's prowess in fortifying soil health, manifesting in enhanced microbial activity and organic matter content. IPCC's findings accentuate CA's contribution to climate resilience in horticulture, mitigating the adverse impacts of climate vagaries like droughts and heavy rainfall.

Despite these benefits, Giller et al. delineate challenges in CA adoption in Ethiopia, highlighting the need for machinery access, knowledge dissemination, and policy backing. Nonetheless, case studies from Ethiopian farms illustrate CA's tangible success, yielding increased productivity, resource conservation, and resilience to climate variability. Looking ahead, FAO's advocacy for continued research, extension services, and policy reinforcement underscores CA's pivotal role in fostering sustainable and climate-smart horticultural practices in Ethiopia.

Climates-resilient crop varieties

Climate-resilient crop varieties play a crucial role in sustainable horticulture practices, especially in regions like Ethiopia that are vulnerable to climate change impacts. Here's how you can incorporate information about climate-resilient crop varieties in your review paper on Climate-Smart Practices in Horticulture in Ethiopia:

Developing and promoting climate-resilient crop varieties are essential. Research institutions in Ethiopia are focusing on breeding horticultural crops that can withstand drought, heat, and pests. Varieties of tomatoes, peppers, and onions with enhanced tolerance to climatic stresses are being introduced to farmers.

Start by defining climate-resilient crop varieties as those that exhibit tolerance or adaptation to various climatic stresses such as drought, heat, pests, and diseases. Highlight their importance in ensuring food security, increasing resilience to climate change, and reducing yield losses.

Examples of climate-resilient varieties: In Ethiopia, efforts have been made to develop drought-tolerant varieties of vegetables like tomatoes and peppers. Similarly, disease-resistant varieties of crops such as potatoes and onions have shown promise in combating climate-related challenges.

Breeding and selection techniques: The breeding and selection methods used to develop climate-resilient varieties, including conventional breeding and marker-assisted selection, have been extensively reviewed.

Traits of climate-resilient varieties: Climate-resilient varieties are characterized by traits such as water-use efficiency, heat tolerance, and adaptability to erratic weather patterns.

Sustainable land management

Sustainable Land Management (SLM) plays a crucial role in promoting climate-smart practices in horticulture within Ethiopia's agricultural landscape. SLM encompasses a range of strategies aimed at conserving soil health, preserving water resources, and enhancing biodiversity while mitigating the adverse effects of climate change. These practices, including conservation tillage, agroforestry, and organic farming methods, not only improve soil fertility and water retention but also contribute to increased crop resilience and long-term sustainability.

However, implementing SLM in horticulture faces challenges such as limited technical expertise, resource constraints, and policy gaps. Overcoming these challenges requires a concerted effort involving capacity building, stakeholder collaboration, and supportive policy frameworks. By addressing these barriers and promoting the adoption of SLM practices, Ethiopia can advance towards more resilient and environmentally sustainable horticultural production systems.

Protected cultivation

Protected cultivation, also known as greenhouse farming, plays a crucial role in advancing climate-smart practices in horticulture in Ethiopia. Greenhouses provide a controlled environment that shields crops from extreme weather conditions such as droughts, excessive rainfall, and temperature fluctuations. The use of greenhouses and net houses allows for the controlled environment cultivation of high-value horticultural crops. This method protects crops from extreme weather, pests, and diseases, ensuring year-round production and improved yields. This controlled environment allows for optimal crop growth and development, leading to higher yields and better quality produce. Additionally, protected cultivation reduces water usage by enabling efficient irrigation methods such as drip irrigation, which helps conserve water resources in regions facing water scarcity challenges.

Moreover, protected cultivation contributes to climate resilience by mitigating the impact of pests and diseases. The enclosed environment of greenhouses helps prevent pest infestations and reduces the need for chemical pesticides, promoting environmentally friendly and sustainable farming practices. Furthermore, the use of Integrated Pest Management (IPM) techniques within protected cultivation systems enhances crop health and reduces the risk of crop losses due to pest and disease outbreaks. Overall, integrating protected cultivation into horticultural practices in Ethiopia can enhance productivity, conserve resources, and build resilience to climate change impacts.

Agroecology

Agroecology plays a pivotal role in advancing climate-smart practices within Ethiopia's horticulture sector. Agroecological practices emphasize biodiversity and ecosystem services to create resilient agricultural systems. In Ethiopia, integrating diverse crops and native plants within horticultural systems helps maintain ecological balance and reduce dependency on external inputs. By embracing agroecological principles, such as biodiversity conservation, soil health enhancement, and reduced external input dependency, farmers can cultivate resilient cropping systems. These systems, including intercropping, crop rotations, and agroforestry, contribute to climate resilience by bolstering ecosystem services, mitigating pest pressures, and promoting resource use efficiency.

Furthermore, agroecology emphasizes sustainable land and water management techniques, such as soil conservation practices, water harvesting, and integrated pest management. These approaches not only improve farm productivity and environmental sustainability but also enhance farmers' adaptive capacity to climate change challenges. Overall, integrating agroecological strategies into horticultural practices aligns with Ethiopia's goals for climate resilience, food security, and environmental stewardship.

Benefits of climate-smart horticulture

Climate-Smart Horticulture offers numerous benefits, particularly in a country like Ethiopia where agricultural practices are vulnerable to climate variability and change. Here are some key benefits to include in your review paper:

Increased resilience: Climate-Smart Horticulture practices, such as crop diversification and integrated pest management, enhance the resilience of horticultural systems to climate-related stresses like droughts, floods, and pest outbreaks. This resilience is crucial for maintaining stable production levels despite unpredictable weather patterns.

Water conservation: Implementing water-efficient irrigation techniques, such as drip irrigation and mulching, reduces water wastage and improves water use efficiency in horticultural production. This is vital in water-scarce regions like parts of Ethiopia, where efficient water management is essential for sustainable agriculture.

Soil health improvement: Practices like conservation agriculture, cover cropping, and organic farming contribute to soil health by reducing erosion, enhancing soil fertility, and promoting biodiversity. Healthy soils are more resilient to climate extremes and support better crop growth and yields over time.

Mitigation of greenhouse gas emissions: Climate-Smart Horticulture promotes practices that reduce greenhouse gas emissions, such as using organic fertilizers, adopting agroforestry systems, and minimizing tillage. These practices contribute to mitigating climate change impacts by reducing the agricultural sector's carbon footprint.

Enhanced biodiversity: Incorporating agroecological principles into horticultural production systems fosters biodiversity by creating habitats for beneficial insects, birds, and soil organisms. This biodiversity not only supports ecosystem services but also improves crop resilience to pests and diseases.

Improved food security: By enhancing resilience, water efficiency, soil health, and biodiversity, climate-smart horticulture contributes to improved food security. Farmers can sustainably produce a diverse range of horticultural crops, ensuring food availability and access for local communities even in challenging climatic conditions.

Economic opportunities: Adopting climate-smart horticulture practices can open up economic opportunities for farmers through improved productivity, access to premium markets for sustainably produced crops, and participation in climate-related agricultural programs and initiatives.

Adaptation to climate change: Climate-Smart Horticulture equips farmers with tools and knowledge to adapt to changing climatic conditions effectively. This includes utilizing climate information for decision-making, implementing resilient crop varieties, and adopting innovative technologies for weather forecasting and monitoring.

Challenges and opportunities

While climate-smart horticulture offers numerous benefits, several challenges hinder its widespread adoption in Ethiopia. These include limited access to climate-resilient seeds, insufficient extension services, financial constraints, and lack of awareness among farmers (Teshome et al., 2018).

Addressing these challenges requires concerted efforts from government, research institutions, and development partners. Providing training, improving access to inputs, and strengthening policy frameworks are essential steps towards scaling up climate-smart horticulture (Asfaw S et al., 2012).

Challenges

Climate variability: Address the challenge posed by unpredictable weather patterns, including droughts, floods, and erratic rainfall, which can affect crop yields and overall production stability.

Limited resources: Discuss the constraints of limited access to quality inputs such as seeds, fertilizers, and irrigation systems, particularly for smallholder farmers who make up a significant portion of the horticulture sector.

Pest and disease pressure: Highlight the increased risk of pest infestations and disease outbreaks due to changing climatic conditions, which can lead to yield losses and economic hardship for farmers.

Market access: Explore the challenges related to market access, including inadequate infrastructure, limited market information, and price volatility, which can impact farmers' profitability and sustainability.

Capacity building: Address the need for capacity building initiatives, training programs, and extension services to enhance farmers' knowledge and skills in adopting climate-smart practices.

Opportunities

Climate-resilient crop varieties: Highlight the opportunity to promote and adopt climate-resilient crop varieties that are adapted to local agro-climatic conditions, exhibiting traits such as drought tolerance, disease resistance, and high yield potential.

Technological innovations: Discuss the potential of technological innovations, such as precision agriculture, remote sensing, and digital farming tools, in optimizing resource use, improving decision-making, and enhancing productivity.

Water management techniques: Explore opportunities for implementing efficient water management techniques, such as drip irrigation, rainwater harvesting, and soil moisture conservation, to mitigate water scarcity challenges and improve crop water-use efficiency.

Market diversification: Highlight opportunities for market diversification, value addition, and linkages with agribusiness enterprises, including export markets, processing facilities, and value chain development, to enhance farmers' income and market resilience.

Future prospects and recommendations

The future prospects and recommendations for climate-smart practices in horticulture in Ethiopia can be outlined as follows:

Adoption of sustainable practices: Encourage the widespread adoption of sustainable horticultural practices such as Integrated Pest Management (IPM), organic farming, and efficient water management techniques. This can reduce the environmental impact of horticultural activities while ensuring long-term productivity.

Investment in research and development: Allocate resources for research and development in climate-resilient crop varieties, soil health management, and innovative technologies like precision agriculture. This will enhance the sector's ability to adapt to changing climatic conditions and improve productivity.

Capacity building: Implement training and capacity-building programs for farmers, extension workers, and other stakeholders on climate-smart practices. This includes knowledge dissemination on modern farming techniques, climate change adaptation strategies, and sustainable land management practices.

Promotion of agroecology: Promote agroecological approaches that integrate ecological principles into agricultural systems. This includes diversification of crops, conservation agriculture, and agroforestry practices, which can enhance resilience to climate variability and improve soil health.

Policy support: Develop and implement policies that support climate-smart horticulture, including incentives for adopting sustainable practices, regulations on chemical inputs, and support for smallholder farmers to access markets and technology.

Infrastructure development: Invest in infrastructure such as irrigation systems, post-harvest handling facilities, and cold storage to improve the efficiency of horticultural value chains. This will reduce post-harvest losses and enhance market access for farmers.

Public-private partnerships: Foster collaboration between government agencies, private sector companies, research institutions, and non-governmental organizations to facilitate knowledge exchange, technology transfer, and investment in climate-smart horticulture.

Climate information services: Strengthen climate information services to provide accurate and timely weather forecasts, climate risk assessments, and advisory services to farmers. This will help them make informed decisions and take proactive measures to mitigate climate-related risks.

Market access: Improve market access for horticultural products through better market infrastructure, value addition, certification of quality standards, and promotion of domestic and export markets. This will increase income opportunities for farmers and enhance the overall competitiveness of the sector.

Monitoring and evaluation: Establish robust monitoring and evaluation mechanisms to assess the impact of climate-smart practices on productivity, resilience, and sustainability. This will provide valuable insights for continuous improvement and informed decision-making at all levels.

CONCLUSION

This paper reviewed information on the contribution of urban agriculture to the socio-economic status of urban farmers. The review has proved that urban agriculture can be lucrative and supplemental household income. This is backed by many opportunities and benefits one enjoys when engaging in urban agriculture notably food security, healthy eating with fresh food, and recycling of waste products among others. Notwithstanding the challenges and constraints which include inadequate inputs, theft of products, high cost of labour and lack of guidance from trained professionals among others. Therefore, there is need to consider urban agriculture by city planners when formulating city regulations.

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