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1. AGRICULTURE-HORTICULTURE

Vegetable Production through Aquaponics

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Introduction

The "integration of hydroponic plant production into recirculating fish aquaculture systems" is known as aquaponics. It is defined as "symbiotic cultivation of aquatic animals and plants in a balanced recirculating environment". In a symbiotic connection, the fish supply nitrogenous waste (such as ammonia), which plants use as a nutrient (such as nitrates), and the plants eliminate the nitrogenous compounds, cleansing the fish's water (Nelson, 2008).

WHAT is the need?

- Soil erosion
- Climate change
- Soil pollution
- Less area under cultivation
- Deforestation
- Urbanization
- Growing population

Why it is better over other system:

- Uses only fraction of water, which is about 10% of total quantity used in soil medium.
- Polyculture: harvest two products at a time.
- Purely organic: No pesticide and herbicides are used here.
- Can be used in drought prone areas
- No soil borne diseases, no tilling, no weeds.

Three basic biological components of Aquaponics (Nelson, 2008):

1. Bacteria: Nitrifying bacteria

   Ammonia-oxidizing bacteria (AOB):*nitrosomonas*

   Nitrite-oxidizing bacteria (NOB):*nitrobacter*

2. Plants:

   Commonly grown vegetables (FAO,2010):

   a. Any plant commonly grown in hydroponics will adopt to Aquaponics
   b. Leafy greens – lettuce, amaranthus, Chinese cabbage, spinach etc.
   c. Fruiting vegetables - tomato, pepper, eggplant, cucumber etc.

Brinjal

Tomato

Chinese Cabbage

3. Fish: Tilapia, Flathead mullet, Carp, Rainbow trout, Catfish

Fish feed and nutrition (FAO, 2010)

a. Correct balance of proteins, carbohydrates, fats, vitamins and minerals
b. Plant based proteins can include soya meal, corn meal, wheat meal.

c. Most commercial feeds are contain protein between 10 -35%.
d. Avoid fish meal based feeds as this source is not sustainable

Keeping fish healthy

a. pH-6-8
b. Ammonia and nitrites are very toxic to fish
c. Nitrates are fairly safe for fish(and great for plants)
d. Fish need oxygen (they can die in 30 min. without it)
e. Sensitive to light (avoid direct light)

Why do plants like Aquaponics?

- Provide nutrients constantly
- Don't have to search for the food
- Less effort needed in putting out roots
- All the energy goes UP not DOWN
- No weed competition

Nutrients

- Fish feed provides most of the nutrients required for plant growth. Majority of fish species utilize 20–30% of nitrogen (N) supplied by the diet.
- This means that about 70–80% of the N supplied by the feed are being released as waste into the water .
- Ammonia is the major end product in the breakdown of proteins in fish.
- Fish digest the protein in their feed and excrete ammonia through their gills and in their faeces (Piedrahita, 2003).

Water quality requirements for plants

Factors	Range
pH	5.5-7.5
Dissolved oxygen	>3mg/l
Temperature	18- 30 °C

- The addition of calcium carbonate and potassium hydroxide can be used to supplement calcium and potassium in aquaponics with the added benefit of buffering pH (Harry and Adam, 2009).

- Pest and disease control (Rakocy,2003):
- Chemical pesticides – not so followed in Aquaponics
- Choose healthy protected conditions - net houses, greenhouses *etc.*
- Aphids: spray diluted vinegar with water solution
- White flies and aphids: parasitic wasps and ladybugs
- Caterpillers: weekly twice spraying with *Bacillus thuringiensis* (a bacterial pathogen) and *Beauveria bassiana* (fungal pathogen).

Challenges & Opportunities

Challenges	Opportunities
High initial cost	Sustainable and intensive food production system
Chances of system imbalance	Extremely water efficient
Scientific knowledge about components	Completely organic
Can't grow all crops	Two products from one input
Power consuming	Environmentally safe

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2. SOIL SCIENCE

Role of Biochar for Enhancing Soil Fertility

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Introduction

Biochar is the by-product of biomass pyrolysis in an oxygen depleted atmosphere. It contains porous carbonaceous structure and an array of functional groups. Biochar's highly porous structure can contain amounts of extractable humic-like and fluvic-like substances. Moreover, its molecular structure shows a high degree of chemical and microbial stability. A wide range of common raw materials are used as the feedstock, including wood chip, organic wastes, plant residues, and poultry manure. The elemental composition of biochar generally include carbon, nitrogen, hydrogen, and some lower nutrient element, such as K, Ca, Na, and Mg. Biochar has a high specific surface area and a number of polar or nonpolar substances, which has a strong affinity to inorganic ions such as heavy metal ions, phosphate, and nitrate. Biochar was reported to improve soil chemical, physical and microbial properties. The combination of biochar with soils could improve soil structure, increase porosity, decrease bulk density, and enhance aggregation and water retention. In this connection, the mechanisms of biochar in the improvement of soil fertility were also discussed.

Biochar as a Source of Nutrient

Organic matter and inorganic salt, such as humic-like and fluvic-like substances and available N, P, and K, can serve as fertilizer and be assimilated by plants and microorganisms. biochars produced from Acacia saligna at 380 °C and sawdust at 450 °C contained humics (humic-like and fluvic-like materials) of 17.7 and 16.2 %, respectively. Biochar made from Lantana camara at 300 °C contained available P (0.64 mg kg^{-1}), available K (711 mg kg^{-1}), available Na (1145 mg kg^{-1}), available Ca (5880 mgkg^{-1}), and available Mg (1010 mg kg^{-1})). Similarly, fresh biochar had potential of nutrient availability and could release large amounts of N (23-635 mg kg^{-1}) and P (46–1664 mg kg^{-1}). Therefore, these data may indicate that biochar has great potential as available nutrients.

The Influence of Biochar on Properties of Soils

Biochar could improve soil physical properties including the increase of porosity and water storage capacity, as well as the decrease of bulk density. Biochar may also be used as a sustainable amendment to enhance soil chemical properties. For example, the content of ash in biochars ranged from 0.35 to 59.05%, which were rich in available nutrients, especially cationic elements, such as K (0–560 mmol kg^{-1}),Ca (3–1210 mmol kg^{-1}), Mg (0–325 mmol kg^{-1}), and Na (0–413 mmol kg^{-1}). The content of soluble base cations (K^+, Ca^{2+}, Mg^{2+}, and Na^+) ranged from 48 to330 cmol kg^{-1}. Moreover, ash content could increase soil pH which may determine cation exchange capacity of various charged soils and nutrient availability. Actually, the direct amendment of biochar on soil's properties, biochar can also alter microbial and nutritional status of the soil within the plant rooting zone through changing soil physical properties (e.g., bulk density, porosity, and particle size distribution). Overall, the improvement of soil properties is highly contributed to the increased of both nutrient and water use efficiency and crop productivity.

The Effect of Biochar on Physical Properties of Soils

The physical and chemical properties of biochar are keys to understand performances and mechanisms of biochar in the improvement of soil's fertility. Biochar has high total porosity, and it could both retain water in smallpores and thus increase water holding capacity and assist water to infiltrate from the ground surface to the topsoil through the larger pores after heavy rain. The biochar application could increase available water capacity from 0.12 to 0.13 m^3 m^{-3}. Moreover, the formation and stability of soil aggregates could increase the crop production and the prevention of soil degradation. The capacity of soil aggregation increased ranging from 8 to 36% after the application of rice husk biochar. The application of rice husk biochar application could increase soil pore structure parameters by 20% and shear strength, as well as decrease soil swelling by11.1%. In addition, biochar could ameliorate compaction by over 10 %, decrease bulk density from 1.47 to 1.44 mg m^{-3}, and increase porosity from 0.43 to 0.44 m^3 m^{-3}. Overall, the improved physical properties of soil, such as bulk density, water holding capacity, and aggregation ability, may increase the retention of both water and nutrients, which benefit to soil fertility directly.

The Effect of Biochar on Chemical Properties

The application of rice husk biochar could increased soil pH value of the tea garden soil (acid soil) pH from 3.33 to 3.63. The increase of soil pH could change the form of nutrients and facilitate some elements adsorption of the root. Cation exchange capacity of the highly weathered soil was increased from 7.41 to 10.8 cmol kg^{-1} after biochar treatment, which produced from Leucaena leucocephala. Moreover, the increase in the amount of exchangeable cations in the amended soils suggested an improvement in soil fertility and nutrient retention, which may be attributed to the high specific surface area and a number of carboxylic groups of the biochar. The amounts of the extractable nutrient elements (e.g., Na, K, Ca, and Mg) could be increased after biochar application.

The potassium content of soil increased from 42 to 324 mg kg^{-1} after biochar application. In addition, biochar treatment could increase base saturation percentage from 6.4 to 26 % and saturated hydraulic conductivity from 16.7 to 33.1 cm h^{-1}, decrease soil erosion rate from 1458 to 532 g m^{-2} h^{-1}, and increase total C from 2.27 to 2.78 % and total N from 0.24 to 0.25 % and available P from 15.7 to 15.8 mg kg^{-1}. These improvements in soil chemical properties could increase soil fertility by increasing the nutrient contents and availability

Absorption of Nutrients and Application as Slow-Release Fertilizer

Nitrate absorption capacity of biochar produced from bamboo at 900°C was approximately 1.2 mg g^{-1}, which was relatively higher than that of activated carbon (about 0.9 mg g^{-1}). The adsorption capacity of nutrient may be greatly influenced by biochar's properties, including pH, surface acidic groups, and ion exchange capacity. The mechanisms describing the adsorption capacity of polar and apolar compounds are attributed to chemisorption, including hydrophobic bonding, electron donor-acceptor interactions resulting from fused aromatic carbon structures and weak H-bonds. The mechanisms attributed to adsorption of NH_4^+ onto biochar surfaces include physical adsorption (Van Der Waals adsorption), NH_4^+ attraction to negatively charged surfaces, NH_4^+ reacting with acidic functional groups to form amides and amines, NH_4^+ binding to cationic species sites on the surface of biochars and π-π electron donor-acceptor interactions.

The Retention of Soil Nutrients by Biochar

The incorporation of biochar into soil effectively reduced N_2O emission from different soils. For instance, some studies reported that 50 % reduction of N_2O emissions was found under soybean systems while 80 % decrease of N_2O emissions was found for grass systems. Similarly, biochars treatment could decrease N_2O emissions from 1768 to 45–699 μg N_2O-N m^{-2} h^{-1}. Biochar's chemical and physical properties are greatly dependent on pyrolytic temperatures, and then the adsorption of nutrients would be influenced by biochar application. The reduced N_2O emissions is attributed to the content of polycyclic aromatic hydrocarbons in the low-temperature biochars (300–400 °C), but not in the high-temperature biochars (>500 °C), while the biochars produced at 200 °C temperature contained a relatively large amount of phenolic compounds and markedly reduced N_2O emission. Besides, when urea and fertilizers were applied, N_2O emissions were decreased in all biochar treatments compared to the control with an average of 53 % (from 618 to 295 μg N kg^{-1})

and 84 % (from 3356 to 529 μg N kg^{-1}), respectively.

Influence of Biochar on Microbial Activity

The pH of soils may change, after biochar additions, because of the acidity or basicity of biochar. Different living conditions will be formed for microorganisms with different pH of biochar. With the increase of pH up to values around 7, bacterial populations were possible to increase, whereas, no change in fungi abundance was observed. Biochar would be expected to cause a shift in the fungus: bacteria ratio, since fungi could be better placed to degrade lignin contained within biochar. Furthermore, changes in microbial community composition may be associated in some shifts in pH induced by the application of biochar. Under nutrient-limiting conditions, microbial abundance may be increased due to the greater nutrient availability after biochar application. Moreover, biochar, containing a well-developed pore structure, may provide living environment for microorganisms. Both bacteria and fungi are hypothesized to be better protected against predators or competitors by exploring pore habitats in biochar.

Besides, the diversity of microorganisms could be increased or decrease after addition of biochar to soil. For instance, bacterial diversity was increased by as much as 25 % in biochar-rich Terra preta soils compared to unmodified soils in both culture-independent and culture-dependent studies. The microbial abundance could increased from 366.1 (control) to 730.5 μgCg^{-1} after an addition of 30 t ha^{-1} biochar. Similarly, microbial abundance increased by 5–56 % with the increase of corn stover biochar rates (from 0 to 14 %) for the different pre incubation times (2–61 days). Microbial abundance could be increased after microorganisms sorb to biochar surfaces, which render them less susceptible to leaching in soil. Hydrophobic attraction, electrostatic forces, and precipitates forming are involved in the main processes of adsorption to biochar.

Conclusion

The application of biochar into soils has great potential for improving soils fertility and promoting plant growth. Moreover, biochar has huge surface area, well developed pore structure, amounts of exchangeable cations and nutrient elements, and plenty of liming. Because of these properties, soil properties could be improved after biochar treatment.

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3. HORTICULTURE

Minimal Processing and Value Addition in Fresh Vegetables

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Abstract

Value addition and minimal processing have become key tactics to satisfy the rising customer demand for safe, wholesome, convenient, and fresh vegetable products. The goal of minimal processing is to lengthen the shelf life of vegetables while maintaining their fresh-like freshness with gentle procedures such washing, trimming, peeling, cutting, and packing. Value addition improves convenience, nutritional value, and financial rewards, all of which increase marketability. These strategies are essential for boosting farmer income, lowering post-harvest losses, and advancing sustainable food systems. The principles, methods, applications, advantages, difficulties, and potential future developments of minimum processing and value addition in fresh vegetables are reviewed in this article.

Keywords: Minimal processing, value

addition, fresh-cut vegetables, post-harvest technology, vegetable preservation

Introduction

Particularly in underdeveloped nations, fresh vegetables suffer large post-harvest losses due to their high perishability. The demand for ready-to-use and ready-to-eat vegetable products has been fueled by shifting lifestyles, urbanization, and the rise of women in the workforce. These objectives are met by minimal processing and value addition, which preserve the fresh look and sensory qualities of vegetables while balancing convenience and nutritional quality (Rico *et al.,* 2007).

Concept of Minimal Processing

A collection of post-harvest procedures known as "minimal processing" preserve the freshness of vegetables while preparing them for consumption. It avoids harsh heat treatment and chemical preservation, in contrast to conventional processing. The main goal is to increase shelf life and guarantee safety without appreciably compromising nutritional and sensory quality (Artes and Allende, 2014).

Operations Involved in Minimal Processing

1. **Washing and Cleaning:** Vegetable surfaces may be cleaned of dirt, debris, and microbes. To lower microbial burden and improve food safety, typical sanitizing chemicals include ozone, organic acids, and chlorine (Rico *et al.,* 2007).
2. **Peeling, Cutting, and Trimming:** Convenience is increased by mechanical or hand peeling and cutting, but microbial spoiling and respiration rate are increased. Sharp cutting instruments and careful handling reduce tissue injury and quality degradation (Gil *et al.,* 2006).
3. **Anti-Browning and Quality Preservation Treatments:** Cut vegetables often undergo enzymatic browning. Treatments using ascorbic acid, citric acid, or calcium salts help maintain color, texture, and nutritional quality (Artes *et al.,* 2009).
4. Packaging and Storage: Refrigeration and modified atmosphere packaging (MAP) are frequently employed to reduce respiration, postpone senescence, and increase shelf life. Packaging materials are essential to preserving the quality of a product (Kader, 2002).

Value Addition in Fresh Vegetables

Value addition is the term used to describe procedures that improve vegetables' consumer appeal, convenience, and economic worth. Fresh-cut goods, prepackaged salads, mixed vegetable packs, baby veggies, and nutritionally improved goods are all included in this category (FAO, 2011).

Forms of Value-Added Vegetable Products

- Fresh-cut and ready-to-cook vegetables
- Ready-to-eat salads
- Pre-mixed vegetable combinations
- Vacuum-packed and MAP vegetables
- Functional and fortified vegetable products

These products cater to modern consumer preferences and increase market opportunities.

Nutritional and Economic Benefits

Because there is less heat exposure with minimal processing, the majority of vitamins, minerals, and antioxidants are retained. Value addition raises market prices, lowers post-harvest losses, increases farmer income, and generates job possibilities. Additionally, it helps small-scale agro-processing businesses (Rico *et al.,* 2007).

Food Safety and Quality Considerations

The increased surface area and microbiological contact of minimally processed vegetables raise serious concerns about food safety. To guarantee product safety, Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), and Hazard Analysis and Critical Control Points (HACCP) must be implemented (Gil *et al.,* 2006).

Challenges and Constraints

Microbial contamination hazards, cold chain needs, short shelf life, significant initial investment, and little customer awareness in some areas are among the challenges. Large-scale adoption is further hampered by inadequate infrastructure and skilled labor (Artes and Allende, 2014).

Future Prospects and Emerging Technologies

New possibilities to improve shelf life and safety are presented by emerging technologies such edible coatings, natural antimicrobials, pulsed light, UV therapy, and intelligent packaging. The future of fresh vegetable value chains will be shaped by the integration of digital traceability, sustainable packaging, and minimum processing (Rico *et al.,* 2007).

Conclusion

Fresh vegetable availability, quality, and profitability may be enhanced with minimal processing and value addition. These methods reduce post-harvest losses and promote sustainable horticulture by fusing convenience, nutrition, and safety. Long-term success and broader acceptance depend on ongoing innovation and infrastructure improvement.

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4. AGRICULTURAL: HORTICULTURE

Smart Irrigation Technologies for Sustainable Vegetable Farming

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Abstract

To maximize water use in vegetable farming, smart irrigation technologies integrate sensor networks, the Internet of Things (IoT), automation, and data-driven decision-making. These technologies save waste, increase water efficiency, and better match irrigation to actual crop requirements. By integrating real-time soil moisture monitoring, automated controllers, and AI-assisted predictive scheduling, smart irrigation contributes to sustainable agriculture by conserving water resources, reducing energy use, and enhancing crop performance. Such technologies are particularly effective in water-scarce regions and controlled environments like greenhouses. Challenges include the high initial costs, need for technical expertise, and infrastructure limitations, which must be addressed to enable widespread adoption in smallholder systems. Smart irrigation is essential for sustainable vegetable production, enabling higher yields with lower environmental impact.

Introduction

Vegetable crops are highly sensitive to water stress due to their shallow root systems and high moisture requirements. Climate unpredictability, decreasing groundwater levels, and growing water shortages have rendered traditional irrigation methods unsustainable and ineffective. In this regard, smart irrigation technologies have become a viable way to maximize water consumption in vegetable production while preserving productivity and environmental sustainability (FAO, 2017).

What is Smart Irrigation?

The use of cutting-edge technology like sensors, automation, data analytics, and decision-support systems to provide water in accordance with the real crop water need is known as "smart irrigation." In contrast to conventional time-based irrigation, smart irrigation ensures accurate water delivery and reduces waste by using real-time feedback from soil, plant, and atmospheric conditions (Kim *et al.*, 2008).

Key Technologies in Smart Irrigation

1. **Soil Moisture and Climate Sensors:** While climate sensors track temperature, humidity, rainfall, and evapotranspiration, soil moisture sensors (TDR, FDR, and capacitance sensors) detect the amount of water in the root zone. These sensors supply vital information for precise irrigation scheduling (Jones, 2004).
2. **Internet of Things (IoT):** Real-time monitoring and remote irrigation management via mobile or online apps are made possible by IoT technology, which links sensors, controllers, and cloud-based platforms. This integration lowers labor needs and increases efficiency (Zhang *et al.,* 2021).
3. **Automated Controllers and Valves:** Without the need for human interaction, automated irrigation controllers manage pumps and valves using sensor data. These technologies especially drip and micro-watering systems, improve accuracy and guarantee prompt irrigation (Pereira *et al.,* 2020).
4. **Artificial Intelligence and Decision Support Systems:** To forecast irrigation requirements, AI and machine learning algorithms examine enormous datasets pertaining to soil, crop growth, and meteorological variables. These tools support farmers in making wise choices and enhancing long-term water management plans (Liakos *et al.,* 2018).

How Smart Irrigation Works

Controllers or cloud-based platforms handle the field data that smart irrigation systems continually gather from sensors. Algorithms assess the information and calculate the amount and time of irrigation needed. This feedback-driven system increases irrigation efficiency and guarantees optimal water consumption (FAO, 2021).

Benefits for Vegetable Farming

Smart irrigation technologies offer several advantages:

- Improved water-use efficiency (up to 30–50% water savings)
- Enhanced crop yield and quality
- Reduced nutrient leaching and environmental pollution
- Lower energy and labor costs These benefits contribute significantly to sustainable vegetable production systems (Pereira *et al.,* 2020).

Applications in Different Production Systems

1. Open-Field Vegetable Production: In open-field conditions, smart irrigation combined with drip systems has shown positive results in crops such as tomato, chilli, onion, and cucumber by improving yield while reducing water consumption (Incrocci et al., 2019).
2. Protected Cultivation Systems: In greenhouses and polyhouses, smart irrigation systems synchronize with controlled environmental parameters to enhance water and nutrient use efficiency, leading to higher productivity (Shamshiri et al., 2018).
3. Urban and Vertical Farming: Urban and vertical farming rely heavily on sensor-based irrigation due to limited water availability and high precision requirements. Smart irrigation plays a vital role in ensuring sustainability in these systems (Benke & Tomkins, 2017).

Challenges and Limitations

Despite its advantages, smart irrigation faces certain challenges:

- High initial investment costs

- Requirement for technical knowledge and training
- Limited connectivity and power supply in rural areas Addressing these constraints is essential for widespread adoption (FAO, 2017).

Policy, Adoption, and Future Trends

The implementation of smart irrigation can be accelerated by government support through farmer training programs, digital agricultural initiatives, and subsidies. Future advancements that will make the technology available to smallholder farmers include solar-powered systems, inexpensive sensors, and AI-driven predictive irrigation algorithms (Liakos et al., 2018).

Conclusion

An important step toward sustainable vegetable cultivation is the use of smart irrigation systems. These technologies solve major issues brought on by water shortage and climate change by increasing production, minimizing environmental effects, and optimizing water consumption. Future food security and sustainable agriculture will depend heavily on the wider use of smart irrigation.

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5. HORTICULTURE

Smart Greenhouses: Automation and Sustainability in Vegetable Production

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Abstract

Smart greenhouses represent a major advancement in vegetable production by integrating automation, sensors, Internet of Things (IoT), artificial intelligence (AI), and decision-support *systems to optimize crop growth and resource use. These systems make it possible to precisely regulate environmental factors including temperature, humidity, light, irrigation, and fertilizer supply, which boosts sustainability, decreases resource waste, and increases output. In order to solve issues brought on by climate change, land scarcity, and rising food demand, smart greenhouses are essential. Widespread adoption is still hampered by problems including expensive capital costs, technological complexity, and smallholder farmers' restricted access. The main technology, uses, advantages, difficulties, and opportunities for smart greenhouses in sustainable vegetable production are reviewed in this article.*

Keywords: *Smart greenhouse, automation, protected cultivation, sustainable vegetable production, precision agriculture.*

Introduction

Environmental changes have a significant impact on the growth, output, and quality of vegetable production. Pest problems, water scarcity, and climatic unpredictability are becoming more and more of a problem for traditional open-field farming. Vegetables may be produced year-round in a regulated environment thanks to protected agriculture, especially greenhouses. Smart greenhouses, which offer real-time monitoring and precise control of crop-growing conditions, have emerged as a result of the combination of automation and digital technology, improving production and sustainability (Shamshiri *et al*., 2018).

Concept of Smart Greenhouses

A smart greenhouse is a complex protected growing system that controls the microclimate based on crop needs using sensors, automated control systems, data analytics, and clever algorithms. In contrast to traditional greenhouses, smart greenhouses employ data-driven decision-making to enhance production processes while requiring little human interaction (Zhang *et al*., 2020).

Core Technologies Used in Smart Greenhouses

1. **Sensor Networks and Data Acquisition:** The foundation of smart greenhouse systems is made up of sensors. Temperature, relative humidity, CO_2 concentration, light intensity, soil or substrate wetness, and nutrient solution characteristics (EC and pH) are all continually measured. Timely and precise control actions are made possible by accurate sensing (Jones, 2004).
2. **Automation and Control Systems:** Automated controllers regulate heating, cooling, ventilation, shading, irrigation, and fertigation systems. These controllers respond dynamically to sensor inputs, ensuring optimal growth conditions while minimizing energy and water consumption (Pardossi *et al.*, 2017).
3. **Internet of Things (IoT) Integration:** IoT connects sensors, controllers, and cloud platforms, allowing real-time data transmission, remote monitoring, and system management via mobile or web interfaces. This connectivity improves operational efficiency and decision-making accuracy (Zhang *et al.,* 2020).
4. **Artificial Intelligence and Decision Support Systems:** Large datasets are analyzed by AI-based models to identify stress situations, improve climatic settings, and forecast crop responses. Over time, machine learning algorithms aid in the improvement of control techniques, increasing yield and resource efficiency (Liakos *et al.,* 2018).

Automation of Key Greenhouse Operations

Climate Control: Smart greenhouses employ feedback control systems to automatically adjust ventilation, humidity, and temperature. For delicate vegetable crops like tomatoes, cucumbers, capsicums, and leafy greens, this guarantees a steady microclimaten (Shamshiri *et al.,* 2018).

Irrigation and Fertigation Management: Water and nutrients are accurately delivered by automated drip and fertigation systems based on the substrate conditions and crop growth stage. Sensor-based scheduling promotes sustainability by lowering water use and nutrient leaching (Incrocci *et al.,* 2019).

Lighting Automation: Natural light is either replaced or supplemented by LED lighting systems with customizable spectra. Increased photosynthetic efficiency and year-round and off-season vegetable production are made possible by automated lighting (Mitchell *et al.,* 2015).

Pest and Disease Monitoring: AI technologies and image-based sensors identify early indicators of illnesses and pests, enabling prompt treatments and lowering reliance on pesticides (Mahlein, 2016).

Role of Smart Greenhouses in Sustainable Vegetable Production

Smart greenhouses contribute to sustainability by:

- Improving water- and nutrient-use efficiency
- Reducing chemical inputs
- Enhancing energy efficiency through optimized climate control
- Enabling high productivity per unit area
  These systems align with the principles of climate-smart and resource-efficient agriculture (FAO, 2013).

Applications in Vegetable Crops

For high-value vegetables including tomatoes, cucumbers, capsicums, lettuce, spinach, and herbs, smart greenhouse technology is frequently utilized. Smart control further improves production consistency and quality in hydroponic and soilless systems (Pardossi *et al.*, 2017).

Benefits of Smart Greenhouse Technology

- Higher and more consistent yields
- Reduced water, fertilizer, and pesticide use
- Year-round production independent of climate
- Improved labor efficiency and profitability These advantages make smart greenhouses attractive for commercial vegetable production (Incrocci *et al.,* 2019).

Challenges and Limitations

Despite their advantages, smart greenhouses face several challenges:

- High initial investment and maintenance costs
- Requirement for skilled technical knowledge
- Energy dependence and infrastructure needs Addressing these issues is critical for wider adoption, especially among small and medium farmers (FAO, 2013).

Future Prospects and Emerging Trends

Future improvements include AI-driven autonomous greenhouses, integration of renewable energy, low-cost sensor technologies, and digital twin models for real-time simulation and optimization. These breakthroughs will further boost sustainability and accessibility (Liakos *et al.,* 2018).

Conclusion

By fusing automation, digital technology, and precise management, smart greenhouses provide a revolutionary approach to sustainable vegetable production. They provide a workable answer to the problems of resource scarcity, rising food demand, and climate change. Their broad implementation will depend on supporting legislation and ongoing technology improvements.

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6. INFORMATION TECHNOLOGY

AI- A Boon or Bane to Job Security

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Introduction

The rapid advancement of artificial intelligence (AI) has become one of the most significant technological trends shaping our world today. As AI systems increasingly occupy various industries—from manufacturing and healthcare to education and finance—questions surrounding their impact on employment have taken centre stage. Will AI enhance job prospects by creating new roles and increasing productivity, or will it lead to widespread job displacement and insecurity? This pressing dilemma has sparked intense debate among professionals, policymakers, and workers alike, prompting a closer examination of how AI will influence the future of job security across different sectors.

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Mrinank Sharma—a senior developer in a renowned company who holds a degree in Computer Engineering from Cambridge and a PhD in Technology from Oxford— resigned from his job (shared his decision on social platform X on 09.02.2026) , stating that the world is in danger. Mrinank is now pursuing a degree in poetry. Why poetry? Is it not a strange turn of events, yet one that compels us to think deeply.

A major debate nowadays, is unfolding across the globe: Will artificial intelligence increase employment opportunities, or will it take away people's jobs? Experts believe that the nature of jobs will undergo a transformation; while there will undoubtedly be a shortage of jobs in the market, new employment opportunities will also emerge. Although the balance between these two aspects may vary, experts nonetheless maintain that Artificial Intelligence will lead to an increase in productivity. Since a decline in employment is inevitable, a consequent reduction in demand is a natural outcome that can be expected in the times to come.

We are all compelled to wonder which jobs or professions remain secure in this era of artificial intelligence. Is it the accountant's or software engineer's? Is it the content writer's? Is it the plumber's or electrician's? Is it the doctor's or the entrepreneur's? There are countless other such professions—listing them all would result in an incredibly long list.

The question to consider now is: what are the specific fields of work in which job security is likely to be maintained—or, in other words, where an individual's work and employment will remain secure?

Therefore, rather than dwelling on that, this is the time to reflect on which jobs—or whose jobs—are likely to remain secure, and why. To understand it one must realise that if one possesses the capability and competence, the development of any form of technology will serve not as an obstacle to your work, but rather as an aid—provided, of course, that you utilize it correctly. The invention of computer came with the prevailing sentiment that it would eliminate people's jobs. Yet, even today, we observe that it has served to create jobs rather than take them away. Therefore, one should remain confident that the development of artificial intelligence will prove beneficial for human civilization in the long run—provided, of course, that government enact appropriate rules and regulations.

Speaking of the present—and considering the discourse among the world's intellectuals, as well as the speeches and exchanges of words that took place at the recent AI conference in India—a sense of apprehension has undoubtedly emerged; However, alongside this, these very intellectuals have also put forward numerous suggestions, asserting that if Artificial Intelligence is utilized correctly and appropriately, it could prove to be a boon for the advancement of human civilization.

Returning to the subject of job security, it is pertinent to mention here that in all tasks requiring manual dexterity or skill, there appears to be no risk of any form of job insecurity. As examples of such tasks, we can cite the work of teacher, plumbers, electricians, nurses, farmers working in the fields, hairdressers, doctors, cooks, and many others.

Take an example of a teacher. If a robot were assigned the role of a teacher, would it be able to discharge those duties successfully? No—absolutely not. Furthermore, what parent would ever wish for their children to be taught by a robot rather than by a human educator? If robots were to take up the task of teaching in schools, children would begin to shy away from studying. They would soon start to feel bored as well, and the consequences of this would be extremely terrible. Creativity, emotional depth, and curiosity in children will eventually vanish—a prospect that poses a matter of grave concern for human civilization and future generations. A child or a student always wishes to engage in discussion with the teacher, satisfy his or her curiosities, and find solutions to the problems. A human teacher would be capable of doing this, but for a robot, it would be impossible. A robot can never establish an emotional bond with children in the role of a teacher.At the same time a robot or AI can help a teacher to deliver lectures properly, to teach students with more creativity, to keep them updated. Therefore, an educator faces no threat of any kind from artificial intelligence. A robot can never be a replacement of a teacher but it can serve as an assistance.

Similarly, if we take the example of an entrepreneur, it is evident that artificial intelligence can never replace one. Starting a business invariably requires innovation, critical thinking, courage, curiosity, creativity, and keen observational skills. All these attributes can only be provided by a human being; neither machine nor any machine language can fulfill these requirements. Furthermore, market needs, consumer preferences, and market availability are requirements that can only be fulfilled by a human being. Therefore, it is evident that under no circumstances can artificial intelligence replace an entrepreneur. The author firmly believes that artificial intelligence cannot be a substitute for humans, although it can assist in performing various tasks.

Conclusion

It is not possible to discuss every type of employment here; therefore, it is appropriate to state that wherever human labour is required—or wherever specialized skills are needed—there is absolutely no risk of employment coming to an end. The AI does not pose any danger to such jobs. However, there are many white-collar jobs in which people's employment is at risk—or could be. Recent research indicates that computer programming, customer service, data entry operations, computer support services, and certain other fields are areas where artificial intelligence could reduce employment opportunities. But at the same time the new areas will too open in AI era. So please keep fingers crossed, update yourself with latest developments to keep your job secured.

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7. HORTICULTURE-FLORICULTURE

Nyctanthes: Night Flowering Jasmine

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Nyctanthes is a small tree, growing to a height of 10 meters. The bark is rough flaky and grey. The plant native to Southern Asia including habitats in Pakistan and Nepal. Northern India and Southern Thailand are also good places to look for it. The plant can be found growing as undergrowth in dry deciduous forests and on rocky soils in dry slopes. It grows in the outer Himalayas and on tracts of Jammu and Kashmir, Nepal, East Assam, Bengal, Tripura, and the Central area up to the Godavari in the south in India. The ideal conditions for their successful cultivation are warm summer and mild winter with ample water supply. It is well suited for rich sandy loam to clay soils and also grows in all types of soils with soil pH of 6.6 to 7.5 is good for more flower production.

Botanical Name	*Nyctanthes arbor-tritis*
Kingdom	Plantae
Order	Lamiale
Family	Oleaceae
Genus	*Nyctanthes*
Species	*arbor-tritis*

Other common names include Coral jasmine, Night jasmine in English, Harshinghar, Sihau, Seoli in Hindi,Parijata, Parijath, Sephalika in Sanskrit, Jayaparvati, Parijatak in Gujarati, Sephalika, Seoli in Bengali, Manjhapu, Pavala-malligai in Tamil, Kapilangadustu, Pagadamalle, Parijat in Telugu.

The leaves are opposite, oval or acuminate, and have an entire or serrated edge. Petioles are lengthy and hairy, measuring 5-7 to 7.7-10 mm in length and with an axial concavity. The venation is reticulate and unicostate. The lamina is elliptical in shape, with a pointed or acute apex. With thin, hairy, and short trichotomous cymes, the flowers are modest and fragrant. Calyx 6-8 mm long, narrowly campanulate, bracts broadly oval 6-10 mm long, apiculate, hairy on both sides. The corolla tube is orange in colour, and the corolla is glabrous. The fruits are heart-shaped, flat, brown, and have two portions, each with a solitary seed. It thrives on loamy soil. The seeds are exalbuminous, compact, and have thick testa. The outer layer is big, translucent, and has a lot of blood vessels.

Nyctanthes is planted in home gardens, in religious place for the numerous scented flowers which fall off and form a white carpet on the surface in the morning. It is popularly known as the 'Tree of sadness' because it blooms only at night. The flowers open toward the evening and drop off in the early morning; the area beneath the tree then gets covered with flowers. The flowers are used in the preparation of a dye. Flowers contain modified diterpenoid nyctanthin, flavonoids, anthocyanins and an essential oil. The orange tubular calyx of the flower contains carotenoids. Nyctanthine, an alkaloid found in Nyctanthes leaves. Seed kernels yield 12-16% of the pale-yellow brown fixed oil, which consists of glucosides of linoleic, oleic, lignoceric, stearic, palmitic acid and b-sitosterol.

Medicinal value

Besides, being an ornamental plant, valuable source of several unique products for the medicines against various diseases.

- The juice of the leaves is used as a digestive aid, a reptile venom antidote, a tonic, a laxative, a diuretic, and a diuretic.
- The powdered stem bark is used for treatment of rheumatic joints pain, malaria and also used as an expectorant.
- The flowers are bitter in taste and used as astringent, ophthalmic, stomachic and carminative.
- Leaves and stems are the potential source of natural antioxidants.

- Flowers are used in dyspepsia, flatulence, graying of hair and baldness, astringent, stomachic, ophthalmic, gout treatment.
- Seed are used for treatment of Piles, baldness, scurvy and hair tonic.
- Oil from the leaves, seeds and bark possesses a wide spectrum of antibacterial action against gram negative and gram-positive microorganisms.
- Dry cough: Take the leaf juice with honey.
- Skin problems: A special herbal oil prepared by boiling fresh leaves in mustard oil is used.
- The leaf juice given with honey and sugar and mixed with common salt is used in treatment of intestinal worms mainly in children.
- The decoction of seeds is used as hair tonic and to get rid from dandruff and lice.
- Decoction of roots is used in enlargement of spleen.

Growing it in Nursery

The seed heads need to be dried on the plants to remove and collect seeds. Seedlings raised in April are transplanted in May/June. It grows to a height of 2 m by August and flowering starts in September/October of the same year. National Botanical Research Institute, Lucknow have been propagated by budding also practiced.

Planting Method : Pits of 45-90 cm3 are prepared depending on the type of soil and are exposed for a week. The pit is filled with top soil after mixing with about 10-15 kg of well rotten farmyard manure or compost and then watered to settle down the soil properly. Rainy season is best time for planting.

Spacing : They are planted at spacings of 8-10 ft. (2.4-3 m), 10-12 ft (3.3 – 4 m) and closer spacing of 2 × 1.5m^2.

Intercultural operations : Proper training and pruning are necessary in order to make it grow in to a good shape. If not pruned regularly, it grows into a small tree. Pruning should be done in the last week of January.

Flowering : Flowering occurs in Late spring / early summer / mild summer / late summer.

Harvesting : The flowers are harvested when they are fully open. After harvesting, the flowers are packed in small and big bamboo baskets. The shrub bears a rich crop of flowers from September to November. The long woody branches are cut completely after the flowering is over if a bustier shape is required. Generally, the heading back is done to a height varying from 90-120 cm after the flowering is over.

Flower yield : A yield of 10-15 kg flowers / plant / year.

Pests and Diseases : Leaf blight is the severe disease in nyctanthes. Affected leaf margins show inward curling and become hard brittle. Spray Bavistin 0.1% a.i effectively controls the leaf blight.

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8. SOIL SCIENCE

Soil Piping

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Introduction

Soil erosion is not only a geomorphologic, but also a land degradation process that may cause environmental damage affecting people's lives. This process is caused both by overland and subsurface flow of water. Over the last decades, most studies on soil erosion by water have focused on surface process, such as sheet, rill and gully erosion, although subsurface erosion by soil piping has been reported to be a significant and wide spread process. Dispersive nature of soils and seepage were found to be the main reason for piping to occur. Various identification methods are developed for distinguishing dispersive soils with ordinary erosion resistant clays. Soil piping erosion or tunnel erosion is one of the factors which lead to formation of land subsidence. It is defined as the hydraulic removal of subsurface soil, causing the formation of underground channels and cavities. The evidences shows that piping performs as a function of drainage and erosion but the drastic collapse of roof of the soil strata makes it one of the silent triggers. Piping has been observed in both natural and anthropogenic landscapes, in a wide range of geomorphologic, climatological and pedological settings. This is not a Universal process but it is important to certain localities. Soil piping has been reported in almost all climatic zones of the world, i.e. from arid and semi-arid through tropical, temperate conditions.

Piping Erosion Process

Soil piping is a unique phenomenon. It was first described by Downes (1946, 1949). Piping erosion has been observed on a variety of soil types, ranging from duplex, loess and uniform clayey soils. It occurred on many climates with wide variation in temperature, rainfall and seasonality of rainfall. Both Impermeable and highly permeable soils containing highly expansive montmorillonite and kaolinite clays are discovered to undergone piping failures. Studies shows that piping results from a complex interaction of physical, chemical processes associated with dispersion of clay, mechanical scouring and mass wasting (slope movement).

The field erosion may be initiated by a range of process including loss or disturbance of vegetation which results to the development of cracks and generation of subsurface runoff, formation of gully erosion which provides the water to flow outlet, poor consolidation and disturbance of dispersive clays or increased infiltration due to ponding. Piping erosion initiates from the dispersion of sodic clays in low electrolyte water. Two particles of clay with a high concentration of adsorbed sodium ions when sit close to one another, the double electron layers of these ions overlap or interact. Thus a difference in osmotic pressure is developed between the clay platelets and the soil solution which draws water between the particles, causing them to hydrate and swell. If the water is of low electrolyte nature then the clay platelets swell to the point that clay platelets detach from each other, this process known as spontaneous dispersion. Rainfall and excess run off after the initiation of the piping erosion entrain more dispersed clay particles, resulting in both head ward and tail ward expansion of cavities until a continuous pipe is formed. And at the final stage piping may reach to an extent where complete roof collapse occurs and erosion gullies form.

Forms of Piping

According to study conducted by NCESS (Sankar et.al, 2014) there are mainly 4 types of soil pipes can be observed in field. These kinds of pipes which depend upon geomorphology, soil type, hydrogeology, etc. The classification is done on the basis of the diameter of each pipe. The four types of soil pipes are as follows:

Micro Pipes (Juvenile Pipe):- Micro pipes or juvenile pipe are the initial stages of piping. The diameter of pipe is ranges from < 5cm. Clayey and lateritic soils are favorable for the formation of juvenile pipes. Juvenile pipes are commonly found in the besides of railway track.

Small Pipes (Younger Pipes):- Small pipes are the second stages of development of the soil pipe. The diameter of pipe is ranges from > 5cm to 30 cm. It may combine together or individually developed as the formation of small pipe.

Typical Pipes (Mature Pipes):- Mature pipe is the third stage of development of pipe. The diameter of pipe ranges from 30 cm to 5 m. It may have an outlet; it acts as an underground drainage.

Oversized Pipes (Huge Pipes):- It is next stage of pipe after development of a typical pipe. The diameter of huge pipe is >5m. It may have an outlet. It acts as an underground drainage, it has no definite shape.

Conditions for Occurrence Of Piping

Soil piping is not an instant or as sudden process; it takes years depending on the area and type of soil present over there. Rosewell (1970) identified two preconditions that required for the formation of piping erosion (1) the soil must disperse into the water that moves through the soil and (2) the soil must have sufficient permeability in either the soil matrix or macro pores to enable the movement of dispersed clay particles without blockage. The physical properties which favors for the cause of piping are slope, elevation, and rate of flow of underground water, structure, texture, porosity, and permeability of erodible material, chemical properties of soil like, clay mineralogy, pH, sodic soils, and electrical conductivity of soils. No single factor or group of factors is universally responsible for the development of piping, but the initiating factors vary in different situations.

The importance of both physical and chemical soil properties in soil piping has been discussed by several authors. The importance of both physical and chemical soil properties in soil piping has been discussed by several authors, expressed by high values of SAR and ESP. Also, the presence of swelling clays enhances pipe development. Some double layer clay minerals (e.g. smectite) with sodium present on the exchange complex swell and disperse upon wetting, rendering them very erodible. However, it seems that chemical soil properties are more important in arid and semi-arid environments, especially in badlands. Further more, in temperate regions the geochemistry of the soil is assumed to be less relevant to pipe initiation. Physical soil properties that control soil erodibility, and thus soil piping are texture, structure, consistency, porosity, and bulk density. Soil piping has been reported in almost every soil texture, even in sands and loamy sands Na^+ characterized by high pH, significant content and high biological activity. It is most often reported in fine- and medium-grained textures, especially in silt-rich soils, which mainly develop in loess sediment.

Land Subsidence by Piping Erosion

Land subsidence is a gradual is a gradual settling or sudden sinking of Earth's surface due to movement of earth materials. In highlands of Kerala during monsoon season land subsidence has become a very common phenomenon which is a threat to human life in all aspects. Land subsidence occurs naturally and artificially. In order to produce surface subsidence, the erosion mechanism is believed to require three conditions (Aalen, 1969): (1) an impermeable stratum at the top of pervious easily erodible material to form as a roof for the tunnel formed, (2) water must have access to the erodible material with sufficient head to transport grains of silts or sand and (3) proper outlets available for the disposal of flowing water and carrying sediments.

In the Western Ghats, it usually occurs in the lateritic terrains. Land subsidence due to soil piping was first reported in Thirumeni village, Kannur district, where a large ground subsidence occurred in 2005. A detailed field inspection by CESS (now NCESS) indicated that this subsided area is connected with large underground tunnels. In the beginning it was thought that this was an isolated incidence. But subsequently several such incidences were noticed in different part of the highlands. Investigations Carried out by NCESS have indicated that the areas adjoining Kannur/ Kasaragod districts in the Coorg locality of Karnataka are the most infested zones with soil piping. Apart from Kannur and Kasaragod other districts such as Kozhikode, Wayanad, Palakkad, Ernakulam, Kottayam, Idukki, and Pathanamthitta are also reported to be prone to soil piping.

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