



Review on Sustainable Practices in Agricultural Food Chains

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ABSTRACT

Sustainability in agricultural food chains is critical to addressing global challenges such as climate change, resource scarcity, and food insecurity. This abstract examines the adoption of sustainable practices across various stages of agricultural food chains, from production to consumption. Key strategies include regenerative farming, which enhances soil health and biodiversity; precision agriculture, which optimizes resource use and minimizes waste; and circular economy approaches, such as recycling organic waste into compost. Furthermore, advancements in supply chain management, including efficient transportation and distribution for transparency and efficient logistics, contribute to reducing carbon footprints and food loss. Consumer-driven trends toward sustainable sourcing and ethical certifications are reshaping market dynamics, encouraging stakeholders to adopt environmentally and socially responsible practices. The integration of these measures not only enhances the resilience of food systems but also ensures long-term profitability and equity. This review paper emphasizes the need for interdisciplinary collaboration, policy support, and community engagement to scale sustainable solutions and foster global food security in the face of evolving environmental and economic challenges. This paper explores the potential open doors accessible for food organizations to urge shoppers to eat better and more nutritious weight control plans, to put resources into more practical assembling and dissemination frameworks and to foster obtainment frameworks in view of additional maintainable types of horticulture. The significant variables in growing more maintainable stock chains are distinguished as the kind of store network included and the singular business disposition to expanding liability regarding item quality into social and ecological execution inside their own stock chains. Relational trust and working to principles are both vital to fabricate more economical nearby and many rationed food supply chains, yet deficient to change standard horticulture and unrefined substance supplies to the produced and item food markets. Collaboration among food producers, retailers, NGOs, administrative and ranchers' associations is crucial to increase expectations for some stock chains and to empower farmers to embrace more economical farming practices.

Keywords: *Sustainability, Resilience, biodiversity, Supply Chains, Consumer Driven*

INTRODUCTION

Green sustainable store network are characterized as the contribution of natural perspectives in the maintainable cycle, including item plan, material obtaining, and choice, fabricating process, conveyance of the eventual outcome to the buyers, as well as end-of-life the board of the item after its helpful life (Mardani et al., 2020). Food frameworks are at the core of the 2030 Plan for Manageable Turn of events (Cf, 2015) a worldwide obligation to destroy destitution and craving while at the same time guaranteeing decrease of natural and financial effects. Among the Assembled Countries Maintainable Advancement Objectives, Objective 2 "end hunger, accomplish food security and further developed sustenance and advance manageable horticulture" and Objective 12 "guarantee feasible utilization and creation designs" (Sala et al., 2017). The term agribusiness food supply fastens has been authored to depict the exercises from creation to dissemination that bring rural or green items (Aramyan, Ondersteijn, Van Kooten, & Lansink, 2006) from the farm to the table. Agri-food supply chains ordinarily face huge and complex difficulties in accomplishing feasible turn of events, including monetary, ecological, and social angles. For instance, the commitments of the food business to the increment of waste and ozone depleting substance outflows are in accordance with the examples of development in utilization in the created world as well as low-pay nations (Li, Wang, Chan, & Manzini, 2014). While the food business actually fights with food security, waste, cultivating, and general wellbeing, new difficulties have arisen, for example, environmental change, oil reliance, fair exchange and localism. There is a developing worry about friendly and ecological supportability of the food business. Essential inquiries that had once subsided from regular daily existence are turning out to be more urgent to discuss - whether food can be provided, dispersed and devoured in a more supportable way without compromising expenses; how might norms be set and advancements be utilized to work on practical turn of events, limit food squander and diminish working expenses together; what will be the effects of principles and innovations on the manner in which food supply chains are working? It is fundamental for partners in the food business to look past their hierarchical limits to foster a supportable food production network including ecological, administrative, logical, market, innovation, and social-financial elements (Li et al., 2014). The meaning of food security has developed and changed throughout recent years, including the presentation of the four regularly referred to mainstays of food security: accessibility, access, use, and solidness, which have been significant in molding strategy (Berry, Dernini, Burlingame, Meybeck, & Conforti, 2015).

Methodology

To complete this review paper, a systematic approach was employed. Relevant literature was identified using academic databases such as Google scholar and Scopus. Keywords and Boolean operators (e.g., AND, OR) were used to refine the search. Inclusion criteria focused on peer-reviewed articles published in English, with relevance to the research objectives. Articles were screened based on titles and abstracts, followed by a detailed review of selected full texts. A thematic analysis was conducted to synthesize findings, identify patterns, and highlight gaps in the existing literature. Relevant information was extracted from selected studies, including authorship, publication year, study objectives, methodologies, and key findings. Extracted data were analyzed thematically to identify common trends, gaps, and emerging patterns. Key themes were then synthesized to provide a comprehensive understanding of the subject matter. This methodology ensured a comprehensive and unbiased review process.

Sustainable Agricultural Production

Agro ecological is the coordination of exploration, schooling, activity and change that carries maintainability to all pieces of the food framework: environmental, financial, and social. It's transdisciplinary in that it esteems all types of information and involvement with food framework change (Gliessman, 2018). The arising worldview in crop assurance — agro ecological ways to deal with bug the executives for economical agribusiness — stresses on the joining of natural standards into difficulty the board while guaranteeing high efficiency and productive harvests without hurting the environment. The rebuilding of the harvest creation framework to consolidate protection biological measures that hold life forms back from arriving at bother status is the drawn out bug the executive's procedure. The utilization of natural cycles has been given accentuation for agro ecological crop insurance through biodiversity while safeguarding as well as further developing soil wellbeing for example ripeness, organic movement and construction (Reddy, 2017). Intercropping frameworks, otherwise called blended trimming or polyculture, a conventional cultivating practice with enhanced crop development, utilizes nearly low sources of info and works on the nature of the agro-biological system. Intercropping guarantees numerous advantages like improvement of yield, ecological security, creation supportability and more prominent biological system administrations. In intercropping, at least two yield species are developed simultaneously as they exist together for a critical piece of the harvest cycle and connect among themselves and agro-environments. Vegetables as part crops in the intercropping framework assume flexible parts like organic N obsession and soil quality improvement, unexpected yield including protein yield, and making of utilitarian variety (Maitra et al., 2021). A significant number of these agro biological procedures that decrease weaknesses to environment changeability incorporate yield expansion, keeping up with neighborhood hereditary variety, creature joining, soil natural administration, water protection and gathering, and so on. Understanding the agro natural elements that underlie the strength of customary agroecosystems is a pressing matter, as they can act as the establishment for the plan of adjusted farming frameworks (Altieri, Nicholls, Henao, & Lana, 2015).

Soil Health and Conservation:

Soil wellbeing is introduced as an integrative property that mirrors the limit of soil to answer farming intercession, so it keeps on supporting both the horticultural creation and the arrangement of other environment administrations. Protection horticulture has been proposed as a broadly adapted set of the board principales that can guarantee more supportable farming production. The name protection agribusiness has been utilized to separate this more feasible agriculture from the thin characterized preservation culturing. Preservation culturing is a generally utilized phrasing to mean soil amangement frameworks that outcome in atleast 30% of the dirt surface being covered with crop deposits subsequent to cultivating of crops. Conservation culturing eliminates the accentuation from the culturing compoenent alone and addresses a more improved idea of the total agricultural system. It consolidates the folowoing standards:

1. Reduction in Culturing

The goal is to acheieve zero culturing however the framework might include controlled culturing seedings frameworks that don't upset the dirt of more than 20-25%.

2. Retention of satisfactory amount of yield buildups and soil surface cover

The goal is to retain surface residues on the dirt and safeguard the dirt from water and wind disintegration, reduce water overflow and dissipation, further develop water efficiency and overall upgrading thje physivcal , cehmical and natural properties ofg soil to accomplish a decent soil part which will p[romoyte better vrop development.

3. Use of crop rotations

The goal is to utilize differentiated harvests to direct/relieve possible weed, illnesses and nuisance issues to use the helpful impacts of certain yields on soil conditions and on prodcutivity of ensuing yields and laslty to furnish ranchers with financially feasible condition for plant development.

These protection agricultural principales are pertinent to many harvests prodcution frameworks from low yielding , dry , downpour took care of to high yeilding watered fields (Verhulst et al., 2010). Farm yard fertilizer application constructs soil natural matter saves and initiates quicker paces of supplement cycling by supporting microbial biomass instead of by changing its local area creation. Land utilization of yard fertilizer is a far and wide agronomic practice used to upgrade soil ripeness, yet its drawn out impacts on soil microbial carbon and nitrogen cycling have not been examined exhaustively (Ma et al., 2020). Overseeing soil fruitfulness with natural data sources guarantees that natural creation is a naturally unique cycle, which

makes supplement the executives in natural frameworks complex. Creature fertilizers were one of the primary wellsprings of supplements for vegetables before food handling issues turned into a central issue. Treating the soil creature excrement eases a significant number of the worries about food handling issues. By utilizing cover yields or green composts that is, plants filled in a field to be turned under and utilized as manure typically developed during nonproduction times of vegetables. Cover crops are utilized to add supplements to the dirt, further develop soil structure, smother weed development, and safeguard the dirt from disintegration brought about by wind and water (Brust, 2019).

Water Management:

Around the world, horticulture is the biggest client of freshwater, with water system withdrawals or deliberations addressing roughly 70% of all out water use (Fischer, Tubiello, van Velthuizen, & Wiberg, 2007). To increase water-use proficiency in farming and other fundamental administrations to people and animals, horticultural water executives should adopt a coordinated approach by embracing innovations such as water reaping, miniature water systems, and asset preservation cultivation.

(Patle, Kumar, & Khanna, 2019). Usage of accessible water assets in agribusiness, given the due worry for water capacity, movement and dispersion, should be anticipated the maintainability of horticulture all through the water-scant nations. The innovations to collect water at source e.g., rooftop gathering for homegrown designs are to be made compulsory so that tension on neighborhood dissemination is limited essentially during the lean time frame. The incorporated utilization of surface and groundwater, reception of effective water the executive's procedures and existing plans of modernization ought to be fortified. Huge scope reception and utilization of trickle, sprinklers and conjunctive water use water system techniques need more consideration, especially for little and minimal ranchers. Water reaping might be worked by gathering water in lakes, tanks and other stockpiling tanks made for the particular reason (Alrajhi, Beecham, Bolan, & Hassanli, 2015). Water collecting structures comprise of burrow lakes, dike type lakes, really take a look at dams, and so on. Agronomic and designing measures are helpful for water collecting. For arable land at ranch level, it very well might be finished through agronomic strategies like shape development, mulching, channel estate, wrinkle water system, profound culturing, form cultivating, raised bed procedures of development and edges (B. Sharma, Molden, & Cook, 2015).

Trickle water system is one of the high level techniques for water system by which water can be provided straightforwardly into the root zone of the dirt. There are a few strategies for pressure water system, like sprinkler water system, focus turn, miniature planes, dribble/minature or stream water system and surface or subsurface water system. Trickle water system frameworks are more proficient than other surface water system techniques as far as water reserve funds, yield and water use effectiveness. There is an expansion in crop yields and decrease in the expense of manures, pesticides and power for water system while utilizing this strategy for water system. In this manner, trickle water system limits customary misfortunes like profound permeation, spillover and dissipation (Houria, 2023).

Sustainable Supply Chain Practices

Efficient Transportation and Distribution:

Compelling energy the board turns into an exceptionally normal issue the green store network becomes one of the main issues to convey the items among customers (Banerjee & Mishra, 2017). Green Inventory network The board has been presented as a preventive methodology and an answer for work on the presentation of big business cycles and items (Chin, Tat, & Sulaiman, 2015). Regard for the green store network assists with expanding the capacity to plan items, make markets and business processes, and metropolitan ITS cycles. At present, the green store network is utilized as a system for acquiring an upper hand (Dubey et al., 2017). Green supply chain management in organizations serves to economical vehicle, green bundling, reusable compartments to reusing, and the utilization of harmless to the ecosystem bundling materials. (Dubey et al., 2017; V. K. Sharma, Chandna, & Bhardwaj, 2017)

Correspondence innovations contributes towards manageability along the pecking order like creation, handling, appropriation, utilization. Horticulture as a food creation model that coordinates numerous ICTs. ICTs can add to agro-food manageability progress by expanding asset efficiency, lessening shortcomings, diminishing administration costs, and further developing order of things coordination. (El Bilali & Allahyari, 2018).

Local and Direct Marketing:

The supportability of worldwide pecking orders and serious horticultural creation has become sketchy. Simultaneously, the shoppers' advantage hard to come by chains and direct deals from makers has expanded. Short inventory fastens are associated with supportability by specialists. Their positive maintainability credits depend generally on broad creation techniques and short vehicle distances. Short stockpile chains are associated most broadly to circularity and manageability by the subjects of ecological weight like vehicle, creation strategy, outflow, wellbeing, food quality, purchasers' way of behaving, maker buyer connections, and neighborhood economy. As indicated by our experience, these elements can't be summed up across a wide range of short chains. Their round financial and maintainability highlights are subject to their spatial area, type, and individual mentalities of the elaborate customers and makers (Kiss, Ruskai, & Takács-György, 2019). The exchange of new items, with more limited timeframes of realistic usability, moderate bundling utilization, adaptable bundle sizes, and conceivably more cognizant client conduct might add to the waste decrease. Supply chains for the most part can be carried into association with practical creation and utilization by the parts of wellbeing, prosperity, local area, makers and buyer conduct, decreased waste and contamination outflow. Nonetheless, it ought to be referenced that, as the job of short production network in present day exchange is extremely restricted, these viewpoints play a less significant part in huge scope squander decrease. Diminished

fossil fuel byproducts from short vehicle distances is a significant truth for surveying the natural effect of SSCs. Besides, food goes through less handling ventures, with less or zero bundling, and the little measured makers are probably going to utilize broad creation techniques(Kiss et al., 2019).

Fair Trade and Ethical Sourcing:

Fair exchange and moral exchange have customarily had very various points, extension and modalities, the previous chiefly centered around terms of exchange with limited scope makers and the last option on working circumstances in standard creation(S. Smith & Barrientos, 2005). Globalization of supply chains brings benefits, yet additionally gambles with respect to social and natural maintainability, especially when unrefined components or items start from nations with administrative worries. Policymakers, customers and organizations are looking for better approaches to address maintainability gambles in these globalized supply chains. One methodology taken by organizations to resolve these issues is named 'capable obtaining(van den Brink, Kleijn, Tukker, & Huisman, 2019). The significant elements in growing more supportable stockpile chains are recognized as the kind of store network included and the singular business disposition to expanding liability regarding item quality into social and natural execution inside their own stockpile chains. Relational trust and working to principles are both vital to assemble more maintainable nearby and many rationed food supply chains, yet lacking to change standard agribusiness and unrefined substance supplies to the made and product food markets. Participation among food producers, retailers, NGOs, legislative and farmer's associations is essential to increase expectations for some stock chains and to empower ranchers to embrace more sustainable agricultural.

Sustainable Food Processing

Energy-efficient Processing:

Energy usage in food industry contains a blend of energy types for different warm cycles as cleaning, drying, cooking or burning and electrical energy for siphons, handling, transports or light as well as cooling structures(Arya, Kaimal, Chib, Sonawane, & Show, 2019). Purchaser interest as well as regulative strain to additionally foster food dealing with towards better natural execution as well as the money related need to reduce waste or results energized the mission for novel food taking care of strategies(Verma, 2015). Applying novel, elective taking care of techniques requiring lower energy input or less resources than customary procedures as well as additional creating utilization of raw substance or results are critical issues for sound energy, water and waste organization in blend in with life cycle assessment. Introducing new methods, for instance, crisp decontamination by non-warm techniques or low-energy pretreatments prior to drying can allow extraordinary opportunities to keep further creating energy viability of food taking care of. (Toepfl, Mathys, Heinz, & Knorr, 2006). Energy efficiency improvement and waste power recovery in the food business have been a fixation to grow the sensibility of food taking care of in the past numerous years. Replacement of customary energy-serious food processes with novel advancements, for instance, novel thermodynamic cycles and non-warm and novel warming cycles gives another possibility to diminish energy usage, decline creation expenses, and work on the practicality of food creation(Wang, 2014).

Reduced Food Waste:

The Food and Agriculture Affiliation FAO of the Bound together Nations surveyed, 33% of the food conveyed by and large i.e.1.3 billion tons is either lost or wasted all through the food stock organization from fundamental creation to positive use. There are a couple of notable treatment systems for food waste that have been extensively applied in non-modern countries including animal dealing with, preparing the dirt, anaerobic handling, incineration, and landfills. The typical treatment of food waste in farming countries is dumping or landfills. Around 95% of food waste closes at landfill objections in which food waste is changed over into methane and other nursery gasses that impact natural change. Thusly, diminishing food waste adds to dying down interlinked legitimacy challenges including food waste and sterilization, ecological change and stress to ordinary resources(Nordin, Kaida, Othman, Akhir, & Hara, 2020).

Sustainable Consumption and Consumer Awareness

The need acceptable weight control plans, with uninformed, close by and periodic agro-normal food manifestations as well as short distance creation usage nets for fair trade. Social heritage, food quality and culinary capacities are other key points choosing viable dietary models and food security. Food guidance about reasonable food choices stays crucial everywhere. It consequently appears incredibly basic to essentially change our food procedure and to propel fair, socially appropriated, biodiversity-based, ecofriendly, sensible eating schedule (Burlingame & Dernini, 2010). Purchaser interest and usage, at whatever point moved to a possible model, on a basic level, should influence producers to satisfy that need with pragmatic creation processes, more imperative choice of green things, and different use decisions, for instance, organizations instead of things. Creatures creation colossally influences ecological change releases, resource use, regular environmental factors mishap, and the availability of staples for customers in non-modern countries. No matter what this, full scale publicists stand apart to earth legitimate weight control plans. Notwithstanding the way that researchers in prosperity studies have recognized the need to standard plant-based eats less carbs, they downplay the socio-social ramifications related with meat and vegetable usage(Beverland, 2014). Simultaneously, expanded decision and extended utilization choices ought to drive down relative costs, make green labor and products more reasonable and open, and make a shut cycle prompting practical utilization and creation Sustainable consumption and production framework(Macdiarmid, Douglas, & Campbell, 2016).

Policy and Institutional Support

Government Regulations and Incentives:

Worries about the connection between unfamiliar enterprises and natural issues in non-industrial nations. Unfamiliar enterprises have the powerful abilities to work on the climate of agricultural nations through reception of Green Production network The board (Asif, Lau, Nakandala, Fan, & Hurriyet, 2020). Practices and teaming up with state run administrations and homegrown firms to additionally lessen the natural impression. Social effects happening in emerging nations ought to be respected for what concerns, for example work market, common freedoms, relocation, neediness wellbeing frameworks, food security, orientation equity, and so on. Social contemplations like issues of disparity, comprehensiveness, work relations, interest in human resources and networks, as well as basic liberties issues should be considered additionally with regards to the Feasible Money strategy (Mancini, Valente, Barbero Vignola, Sanyé Mengual, & Sala, 2023).

Most homestead machines are driven by petroleum products, which add to ozone harming substance emanations and, thusly, speed up environmental change. Such natural harm can be relieved by the advancement of inexhaustible assets, for example, sun based, wind, biomass, flowing, geo-warm, limited scope hydro, biofuels and wave-produced power. Maintainable horticulture likewise relies upon recharging the dirt while limiting the utilization of non-sustainable assets, for example, gaseous petrol, which is utilized in changing over barometrical nitrogen into manufactured manure, and mineral metals, for example phosphate or petroleum derivative utilized in diesel generators for water siphoning for water system(Bianco, 2016).

There is a requirement for advancing utilization of environmentally friendly power frameworks for maintainable farming, for example sun powered photovoltaic water siphons and power, nursery innovations, sun oriented dryers for post-gather handling, and sun based boiling water warmers. In far off rural terrains, the underground sub sunlight based photovoltaic water siphon is monetarily suitable and furthermore a harmless to the ecosystem choice as contrasted and a diesel generator set. Clean improvement furnishes industrialized nations with an impetus to put resources into outflow decrease projects in non-industrial nations to accomplish a decrease in CO₂ emanations at the most minimal expense. The component of clean improvement is talked about in short for the utilization of inexhaustible frameworks for manageable farming turn of events (Chel & Kaushik, 2011).

International Agreements and Initiatives:

After almost seventeen years of stop, 197 Gatherings to the UN Structure Show on Environmental Change UNFCCC finished up another peaceful accord at the 21st Meeting of the Gatherings to the UNFCCC COP21 in Paris on 12 December 2015. The Settlement plans to reinforce the worldwide reaction to the danger of environmental change with regards to maintainable turn of events and endeavors to annihilate destitution(Segger, 2016). The Sustainable Development Goals SDGs and the United Nations Framework Convention on Climate Change UNFCCC Paris Agreement seek to change the manner by which advancement issues and environmental change are tended to. Unexpectedly, there is an understanding by the worldwide local area on need regions for improvement with a noteworthy plan and a worldwide obligation to arrive at specific targets and objectives among now and 2030. to accomplish financial additions if the climate, and dangers, for example, environmental change, are disregarded; and that advancing collaborations and relieving or killing compromises among SDGs is fundamental for accomplishing this equilibrium and for accomplishing the temperature focuses of the Paris Arrangement(Gomez-Echeverri, 2018).

Future Trends and Challenges

According to analysis, a 25%–70% increase above present levels of creation might be sufficient to meet harvest demands in 2050. To restore and maintain biological system capacity, horticultural supplement mishaps and ozone-depleting agent emissions should be drastically reduced at the same time.

(Hunter, Smith, Schipanski, Atwood, & Mortensen, 2017). Administration, establishment, and financial issues will continue to provide serious challenges for strategists and decision-makers(Gomez-Echeverri, 2018). There are a few well known treatment techniques for food squander that have been broadly applied in non-industrial nations including creature taking care of, fertilizing the soil, anaerobic processing, burning, and landfills. The normal treatment of food squander in emerging nations is unloading or landfills. Around 95% of food squander closes at landfill destinations in which food waste is changed over into methane and other nursery gasses that influence environmental change. Accordingly, decreasing food squander adds to lessening interlinked supportability challenges including food waste and sanitation, environmental change and stress to regular assets.(Nordin et al., 2020).

Nanotechnology has the planned to work on the horticulture and food industry with novel Nano tools for the controlling of fast sickness symptomatic, upgrading the limit of plants to assimilate supplements among others. The critical interests of involving nanotechnology in farming incorporates explicit applications like Nano composts and Nano pesticides to trail items and supplements levels to expand the efficiency without cleaning of soils, waters, and security against a few bug bother and microbial plant diseases(Prasad, Bhattacharyya, & Nguyen, 2017). Organic control is a critical part of a 'frameworks way to deal with' incorporated bug the board, to balance insect poison safe vermin, withdrawal of synthetics and limit the utilization of pesticides. Current examinations show that hereditarily changed bug safe Bt harvests might affect the action or capability of hunters or parasitoids utilized in natural control(Bale, Van Lenteren, & Bigler, 2008).

Conclusion

Sustainability is and will be a significant issue for the present and people in the future. The ongoing supposition that regular assets are endless and that the regenerative limit of the climate can make up for all human activity is as of now not satisfactory. Developing contest for land, water, and energy, notwithstanding the overexploitation of fisheries, will influence our capacity to create food, as will the critical prerequisite to decrease the effect of the food framework on the climate. The impacts of environmental change are a further danger. Yet, the world can deliver more food and can guarantee that it is utilized all the more productively and evenhandedly. It is normal that the food creation will develop by 66% in 2050 to get satisfactory nourishment for an extra of two billion individuals with the advanced horticultural framework professed to be inefficient and entailing ethical concerns, as well as the risk of reduction in crops yields due to the impact of climate change here is a huge interest to lay out an economical way to deal with supply chains in horticulture, especially inside creation, in view of Roundabout Economy standards and the use of imaginative advances concerning productive strategic policies. In contrast to the straight economy idea of 'purpose and arrange', a round approach to resources offers the potential for a multitude of socio-economic and environmental benefits. Supply chains by nature are complex and require oversight across each of its stages, non-more so than food supply networks, which extends from the farmers, through to consumers, and has an increased emphasis placed on the movement of its produce, given its perishable nature.

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