

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 12; December 2025; Page No. 233-242

Received: 13-09-2025
Accepted: 17-10-2025

Indexed Journal
Peer Reviewed Journal

Diverse model and approaches towards sustainable development goal 2.4 for a shared future

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DOI: <https://www.doi.org/10.33545/26180723.2025.v8.i12d.2762>

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Abstract

The Sustainable Development Goal 2 endeavours to ensure world free of hunger by 2030. Agricultural sector of India plays a vital role in providing food and livelihood security for millions of rural households. However, there is a daunting challenge of doubling the world's food grain production by 2030 due to decrease in per capita arable land area, renewable resources, and the projected climate change. Therefore, it is crucial to identify sustainable processes, practices, and policies for managing natural resources to address this issue. Sustainable Development Goal (SDG) 2.4 is about sustainable food production systems and implement resilient agricultural practices that increase productivity and production, particularly focusing on small-scale food producers. In navigating the complexities tied to this goal, a plethora of diverse models and approaches has emerged, envisioning a shared and sustainable future. This chapter delves into various practices that address specific issues related to food security, nutritional sufficiency, and economic stability for all stakeholders. Noteworthy models such as the soil health model, biodiversity conservation model, and farm-to-fork model are explained. Additionally, the discourse explores technological approaches encompassing precision farming, climate-smart agriculture, biodynamic farming, organic farming, conservation agriculture, integrated farming, as well as integrated nutrient management. Collectively, these strategies pave the way for a resilient and sustainable global agricultural landscape.

Keywords: Sustainable development, model, approach, shared future

Introduction

Sustainability is a convoluted word, one that invokes images of humans living harmoniously with nature; or a system that benefits people, planet and profit (Henderson and Michel Loreau, 2023) ^[45]. The most comprehensive definition of sustainability refers to practices that allow the current population to meet their basic needs, without jeopardizing the needs of future generations (Henderson and Loreau, 2023) ^[45]. The aspect of sustainable development has become ubiquitous in the last 30 years (Salvia *et al.*, 2019), however achieve such a goal, or whether it is even possible, remains a major unknown.

The United Nations is dedicated to bringing countries together to solve international problems and to shape a better future (Henderson and Michel Loreau, 2023) ^[45]. One of the greatest challenges facing society today is meeting the population's basic needs, while protecting the environment, hence the 17 UN Sustainable Development Goals can overcome current and future sustainability challenges. SDG 2 'Zero Hunger' has a specific objective to support sustainable agriculture and enhance food security at global level. SDG Target 2.4 has a clear aim to introduce latest proven sustainable food production systems and improved agricultural practices can be implemented by 2030 (Liu, 2023) ^[57].

In an age of frequent climate change, the agricultural system

must become more prolific to keep pace with exponential population growth, increasing global food demand & changing diets ensuring access to nutritious food (McGinnis and Menachem, 2008; Saiz-Rubio and Rovira-Más, 2020; WHO, 2020) ^[61, 83, 102]. The present population of 7.5 billion (of which about 900 million are still undernourished) is expected to reach 8.5 billion in 2030, 9.7 billion in 2050 and 10.4 billion in 2030 (Alexandratos and Bruinsma, 2012; UN, 2017, Umesha *et al.*, 2018) ^[2, 99, 98]. Cereal production needs to rise about 3 billion tonnes (Muhie, 2022) ^[64] and pulse production must climb by 39 metric tons (Aug 7, 2016, The Times of India) to keep stride. According to 'The economic times' 2019' food grain production in an agricultural economy like India was likely to become 291.95 million tonnes (Arora *et al.*, 2022) ^[9]. Achieving above goal with depleting energy resources, reduced fresh water supply, depleting soil quality, extreme weather patterns, climate change, is virtually impossible using conventional agriculture. Increasing per capita food consumption, will pose further pressure on natural resources (i.e., water, soil, energy) and exacerbate human impact on the environment (i.e., agrochemicals, greenhouse gas emissions (GHGs), biodiversity loss) (Pretty, 2008; Godfray *et al.*, 2010; FAO, 2011a, b; Foley *et al.*, 2011; Gomiero *et al.*, 2011; Alexandratos and Bruinsma, 2012; Gomiero, 2016; Campbell *et al.*, 2017) ^[74, 40, 30, 31, 35, 41, 2, 42, 21]. Restructure of

relevant policies are required as one of the key ways to achieve sustainable agriculture in order to have a resilient global food system and control and maintain the environment (Rukhsana and Alam, 2022) ^[81].

Policy Orientation for Sustainable Development Goal 2.4

The Sustainable Development Goals Report 2023: Special edition serves as a compelling rallying cry, offering an honest evaluation of SDGs based on the most recent data and projections. However, the report cautions that the impacts of the climate crisis, a fragile global economy and lingering aftermath of the COVID-19 pandemic have exposed vulnerabilities and impeded progress towards the Goals. It highlights that while stagnation is widespread, it is world’s poorest and most marginalized who bear the brunt of these unpredicted global challenges. Urgent action is imperative, as the report identifies critical areas requiring intervention to rescue the SDGs and drive sustainable advancements for both humanity and the planet by 2030 (Source: The Sustainable Development Goals Report 2023) ^[97]

Sustainable Development Goal 2.4 strive to establish sustainable food production systems and adopt resilient agricultural practices designed to boost productivity and yields, preserving ecosystems, bolster resilience against climate change, extreme weather events, droughts, floods and other calamities while progressively enhancing the quality of land and soil.

In sustainable agriculture, several models and approaches focus on different aspects of the food production system, from soil health to the consumer's plate. Here are some key

models and paradigms related to stable production, soil management, the farm-to-fork approach, and other aspects of sustainable agriculture.

1. Soil Health Models

1.1 No-Till Farming

No-Till Farming is a progressive agricultural practice aimed at minimizing soil disturbance during planting and harvesting processes, thereby safeguarding soil structure and health while mitigating erosion (Fig. 1). This method not only promotes sustainability but also offers significant economic advantages. By requiring less labour, energy, and machinery compared to conventional tillage systems, no-till farming reduces production costs. Moreover, its environmental benefits are substantial, with decreased erosion and runoff resulting in improved water quality and ecosystem health (Table 1). The adoption of no-till techniques contributes to a more sustainable and ecologically balanced approach to agriculture, aligning with the urgent need for environmentally conscious practices in modern farming. (Uri, 2000) ^[100].

Table 1: CO₂ emissions following different tillage methods

Tillage Method	Cumulative CO ₂ loss over 19 days following tillage (t/ha)
Mouldboard Plow	9.13
Disk Harrow	3.88
Chisel Plow	3.65
No till	1.84

Source: Pieri *et al.*, 2002

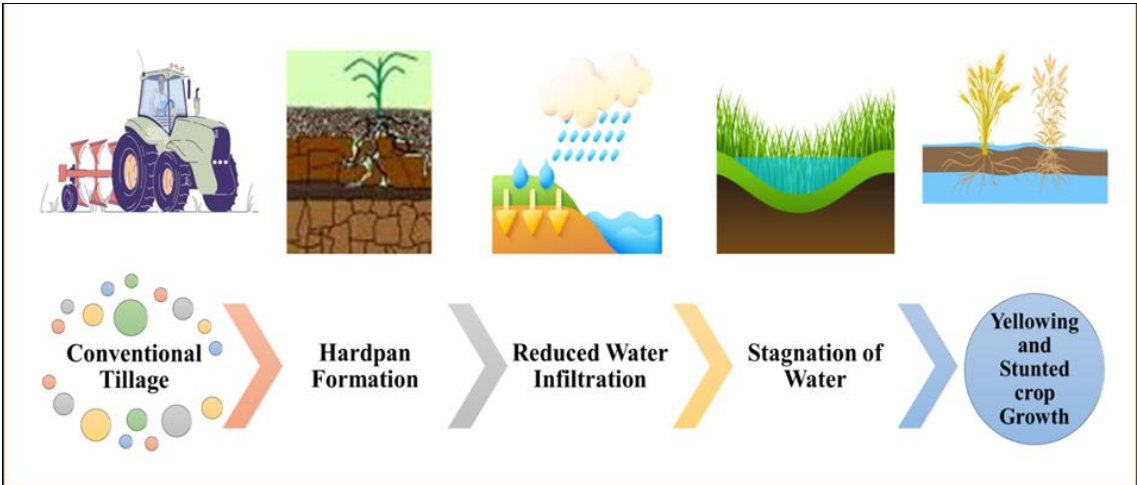


Fig 1: Conventional tillage effects soil system and crop yield

1.2 Conservation Agriculture

The concept of Conservation Agriculture (CA) aims to maintain permanent soil cover, diversify crop species, and minimize mechanical soil disturbance. CA is practiced on about 125 million hectares of land worldwide, covering approximately 9-10% of the global arable land surface. Moreover, FAO reports that CA accounts for 60% of arable cropland in South America, Australia, and New Zealand, 15% in the United States, 3% in Russia and Ukraine, about 1% in Asia, 0.5% in Europe, and 0.3% in Africa. According

to the Food and Agriculture Organization (FAO), Conservation Agriculture (CA) offers a multitude of environmental advantages including soil and water conservation (Fig. 2), carbon sequestration, flood mitigation, and diminished pollution. It has been posited that CA proves to be less expensive and yields greater economic, environmental, and social benefits when executed effectively (Kassam *et al.*, 2014; Friedrich and Kassam, 2012; Lal, 2015) ^[50, 36, 56].



Fig 2: Ecosystem specific effect of crop residue management on soil and environment quality (Source: Lal, 2008) ^[55]

2. Biodiversity Conservation Models

2.1 Integrated farming

An "integrated farming system" (IFS) is an approach to farming that is more integrated than monoculture farming (Choudhary, 2013) ^[24]. IFS combines livestock and crop production, or fish and livestock production (Patra, 2016; Soni *et al.*, 2014) ^[70, 93]. This system creates a network of interconnected businesses, in which waste from one component is repurposed as input for another, reducing costs and improving productivity and/or revenue (Hathaway, 2016; Fiebrig *et al.*, 2020) ^[44, 33]. This approach not only reduces waste but also increases overall production for the entire farming system (Soni *et al.*, 2014; Fiebrig *et al.*, 2020; Pereira *et al.*, 2012) ^[93, 33, 71].

The aim of integrated farming is to improve biological diversity by reducing competition for water, nutrients, and space, and implementing ecologically friendly practices (Kidd *et al.*, 2015; Scavo and Mauromicale 2020) ^[51, 87]. It simulates nature's idea of producing food by combining plants, animals, birds, fish, and other aquatic flora and fauna with crops (Patra, 2016) ^[70]. The benefits of using an integrated farming system include optimizing crop production and resource utilization through changes in farming practices, recycling farm waste for productive purposes within the integrated system, and other agricultural allied enterprises such as dairy, poultry, fishery, sericulture, suitable for the given agro-climatic and socio-economic conditions. (Behera *et al.*, 2012; Rana *et al.*, 2013 and Shah *et al.*, 2019) ^[14, 77, 91]. To achieve this, IFS uses mixed cropping, crop rotation, crop combination, intercropping,

and multi-story architecture to use available space and enhance interaction between biotic and abiotic components efficiently (Nozdrovická *et al.*, 2020) ^[67]. By connecting subsystems, IFS components work together to improve farm productivity (Bonaudo *et al.*, 2014) ^[19]. Sustainable farming system has attracted a significant number of small and vulnerable family farmers in resource-poor Asian and African countries. The goal of this system is to diversify farm produce, increase cash income, improve food quality and quantity, and make use of underutilized resources (Altieri *et al.*, 2017 and Conway, 2013) ^[7, 26]. It typically takes three to four years to build a well-integrated farm with good market ties that can provide food and nutrition security for a family's livelihood. Implementing IFS requires appropriate technology for long-term farming and food security (Ansar, 2018 and Keding *et al.*, 2013) ^[8, 1], but there are obstacles to its adoption, including farmers' lack of comprehension, their limited ability to use agricultural technology, and inadequate financial assistance. Government support is necessary to generate chances to raise farm scale in line with farmers' incomes (Behera *et al.*, 2012, Rana *et al.*, 2013, Shah *et al.*, 2019; Gomiero, 2016, Nguyen *et al.*, 2016 and Ruppert *et al.*, 2019) ^[14, 77, 91, 42, 66, 82].

2.2 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) stands as a cost-effective and environmentally friendly approach to pest control, aiming to avert pest issues without resorting to unnecessary pesticide application (Kamaraj *et al.*, 2018) ^[48] (Fig. 3). This method is designed to strike a balance

between economic viability, environmental safety, and social acceptability, thereby facilitating sustainable intensification—increasing agricultural output while minimizing adverse environmental impacts and enhancing contributions to natural capital and environmental services (Pretty and Pervez, 2015; Fitt and Wilson, 2012; Luna and House, 2020) [73, 34, 59]. By integrating various pest management strategies including biological, cultural, mechanical, physical, and chemical methods, IPM not only reduces economic, health, and environmental risks but also curtails pesticide usage by up to 50% (Romeh, 2018) [80]. Fundamental to IPM are the principles of scouting and thresholds, ensuring that pesticide application is employed only when absolutely necessary rather than as a routine practice. Despite its numerous benefits, IPM remains underutilized in sustainable agriculture; however, with the development of a revised model for the twenty-first century, IPM's adoption is expected to increase (Gigon *et al.*, 2016; Goda *et al.*, 2015) [38, 39]. This updated model embraces all

facets of sustainable crop production, promoting more accessible IPM-based agricultural practices that align with contemporary global food production trends, as well as environmental and social considerations (Chappell *et al.*, 2019; Kogan and Hilton, 2009) [22, 53]. IPM systems act as the primary line of defence against pests, effectively managing crops, lawns, or interior spaces with minimal human and environmental impact (Reddy, 2017; Romeh, 2018) [78, 80]. In IPM, pesticides such as neem formulations and plant-based bio-pesticides are reserved as a last resort when pest populations surpass economic threshold levels (Baker *et al.*, 2020; Saxena *et al.*, 2018) [11, 86]. By implementing practical and cost-effective agricultural measures that minimize ecosystem disruption, IPM facilitates pest population control below economic threshold levels, thus ensuring sustainable agricultural productivity (Barzman *et al.*, 2015; Birch *et al.*, 2011; Harrison *et al.*, 2019) [13, 18, 43].

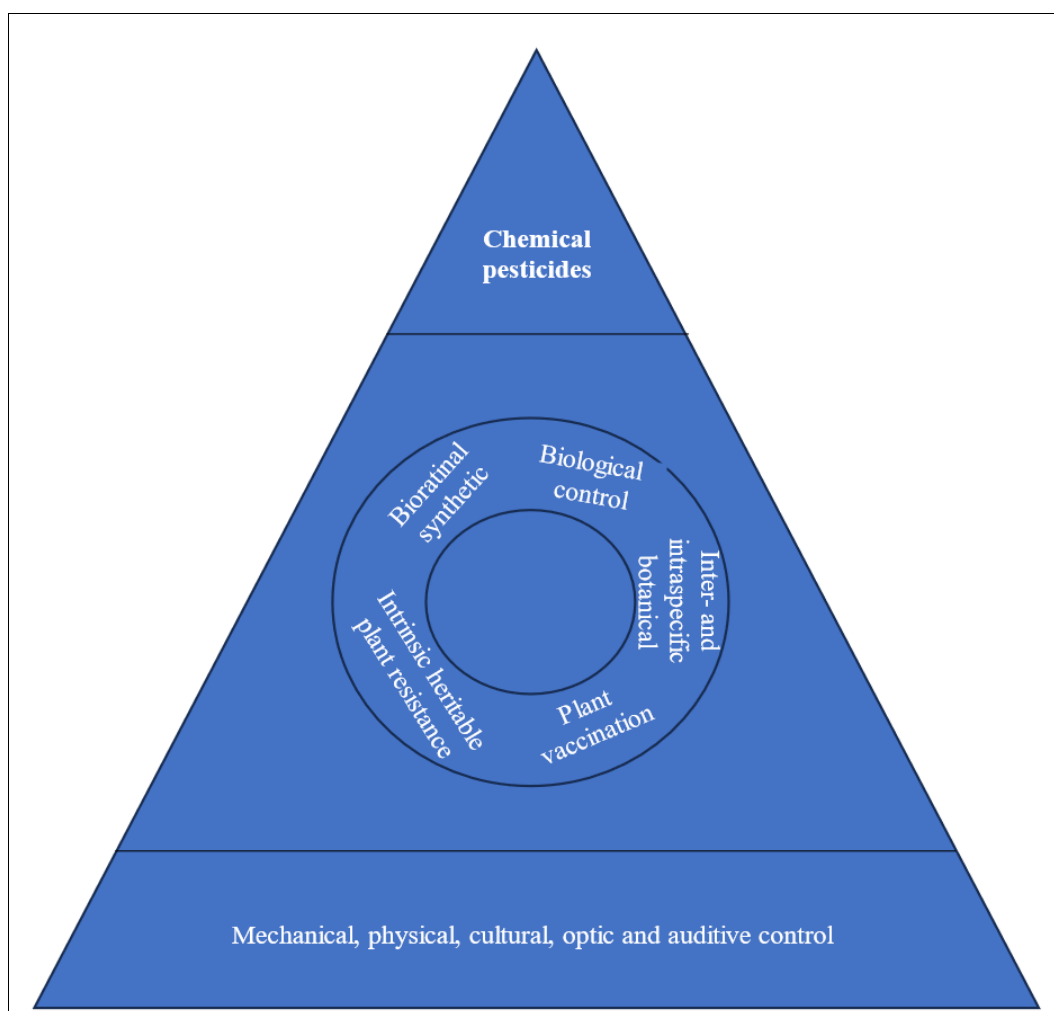


Fig 3: The foundational level of the IPM pyramid involves abiotic strategies implemented before or immediately after planting, extending through to harvest. Next, a circular tier encompasses crucial ecological components that underpin ecology-based IPM practices. At the apex of the pyramid are chemical pesticides, which should be used sparingly and only when lower-tier IPM methods do not effectively manage pest populations below the economic threshold (Stenberg, 2017) [94]

2.3 Biodynamic agriculture

Biodynamic agriculture amalgamates organic and metaphysical principles derived from Rudolf Steiner's teachings. This method fosters ecological harmony by

leveraging natural energies and rhythms, such as solar and lunar cycles, in agricultural practices. While closely akin to organic farming, biodynamic agriculture distinguishes itself through its holistic approach, which interconnects all living

systems and eschews synthetic inputs (Muhie, 2022) ^[64].

The main objective of biodynamic agriculture is to build a sustainable agricultural production with the combination of natural and ecological production gained since ancient times with the celestial impacts of the sun, stars, planets, and moon (Seid Hussen Muhie, 2022) ^[89]. In the same way, developing standards for natural sciences employed in manufacturing and observing the impact of spiritual realities (Karadaug *et al.*, 2019). The knowledge gained during the production stages can be applied to a variety of areas, including education and social life. Within the framework of “anthroposophical” approach, characterized as “spiritual development path,” create value nature, people, and the environment, as well as protecting the balance and cleanliness of nature (Muhie, 2022) ^[64].

Biodynamic agriculture prioritizes ecological and ethical considerations, contrasting with traditional farming practices that degrade soil quality over time. It optimizes land's potential while restoring ecological balance and organic harmony, yielding sustainable, quality products. The increasing demand for healthier foods has boosted interest in biodynamic agriculture. Despite early scepticism, it has gained scientific recognition over the past two decades as a viable long-term alternative to conventional farming. Rooted in early 20th century principles, it aims to enhance soil, animal, food, and human well-being, considering the farm as a self-sustaining ecosystem influenced by celestial cycles. Biodynamic farming contributes to agriculture's sustainability by improving soil quality, product quantity, nutritional value, and pest control, making it a potential path to integrated and sustainable agriculture in the future.

3. Farm-to-Fork Models

Farm to Fork (F2F) aims at resolving the issue of food sustainability and ensure support to the producers, i.e., the farmers and the fishermen. It combines both regulatory and nonregulatory initiatives to attain the objectives of making the entire food chain from production to consumption more sustainable and neutral in its impact on the environment. F2F includes ambitious and concrete targets on pesticides, fertilizers, nutrient losses, antimicrobial resistance, and organic farming to be achieved by 2030 and legislation carried out across the globe in preventing food loss and waste (Kiran *et al.*, 2023) ^[52]. The Farm to Fork strategy revealed that research and innovation are key drivers in accelerating the transition to sustainable, healthy and inclusive food system from primary production to consumption (Riccaboni *et al.*, 2021) ^[79].

3.1 Organic Farming

Organic farming is a comprehensive approach to food production that aims to enhance the well-being of agroecosystems, biodiversity, organic cycles, and soil biological activity (FAO/WHO 2011) ^[103, 102]. According to Bhat *et al.* (2021) ^[17], there are currently over 600,000 farmers worldwide who cultivate 31 million hectares of agricultural land using organic farming practices. In addition, more than 62 million hectares have been certified for organic farming. Important component of organic farming are as follows (Umesha *et al.*, 2018) ^[98]:

1. Soil and crop management
2. Agriculture waste recycling

3. Biological weed management
4. Industrial and domestic waste recycling
5. Energy reuse
6. Food quality improvement
7. Eco-agriculture
8. Integrated intensive farming system.

3.2 Integrated nutrient management

Integrated nutrient management (INM) is a sustainable agricultural strategy that promotes safe disposal of crop residues and production of high-quality compost by utilizing a balanced combination of organic and inorganic fertilizers. This approach ensures soil fertility and provides plants with optimal levels of nutrients throughout their life cycle, resulting in sustained yields (Bhardwaj *et al.*, 2021 and Selim, 2020). ^[16, 90] INM also aims to protect the environment for future generations by maximizing fertilizer and organic resource utilization efficiency (Sanginga and Woome, 2009) ^[85].

To achieve long-term food security, a balance between crop productivity and environmental sustainability must be struck, and INM offers a solution. INM is composed of four major components: A) consideration of all nutrient sources for developing nutrient input programs (Selim, 2020, Wu *et al.*, 2015) ^[90, 104], B) analysis of soil nutrient content and its temporal and spatial availability, C) reduction of nutrient losses, particularly in intensive agriculture (Chen *et al.*, 2011 and Wu *et al.*, 2015) ^[23, 104] taking into account all elements affecting the plant/nutrient connection to produce high yield production (Prasad *et al.*, 2002) ^[72].

Rather than focusing on a single crop, INM emphasizes maximizing nutritional resource usage across a cropping system or rotation, encouraging farmers to think long-term and consider environmental consequences (Bhardwaj *et al.*, 2021 and Selim, 2020) ^[16, 90]. INM helps maintain economic yield while minimizing impacts on soil fertility and pollution, as well as promoting environmentally friendly techniques like organic farming. This approach ensures the production of healthy, contaminant-free food while ensuring satisfactory economic returns. Overall, INM is an effective strategy for promoting sustainable agriculture and conserving soil productivity for future generations.

3.3 Precision Agriculture

Precision agriculture revolutionizes field-level management practices to foster sustainable food production system. It aims to boost farm profits through several means like, (1) variable rate application of nutrients, agrochemicals and water to enhance the use efficiency of resources (2) mitigation of crop yield losses during harvesting, (3) Reduction of environmental risks including reduced greenhouse gas emission and nutrient leaching, and (4) optimizing footprints of the farming inputs (e.g., carbon sequestration and soil organic matter). Potential of precision agriculture technologies in simultaneously boosting farm profits and safeguarding the environment hinges is in fact based on the site-specific application of agricultural inputs (Zaman, 2023) ^[106].

Precision agriculture (PA) has been developing since the 1990s, and it allows site-specific management (SSM) to be computerized in intensive agriculture owing to information technology (Ramírez and Maiti, 2016) ^[76]. Variable rate

application (VRA), yield monitors, and remote sensing (Table 2) represent agricultural production techniques that leverage information technology to tailor input utilization for achieving specific objectives or measuring corresponding outcomes (Bongiovanni and Lowenberg-Deboer, 2004, Patil Shirish and Bhalerao 2013, Schrijver, 2016 and Salam, 2020) [20, 69, 88, 84]. Availability of GPS and GNSS made precision agriculture a reality. Furthermore, precision agriculture makes extensive use of data and information to increase the efficiency of agricultural resources, yields, and crop quality (Mulla, 2013). [65] Farmers that employ precision agriculture technology are said to “use less to grow more” (El Bilali *et al.*, 2019 and Coomes *et al.*, 2019) [28, 27]. Precision agriculture research

aims to develop a decision support system (DSS) for whole-farm management that maximizes input returns while conserving resources (Ahmad *et al.*, 2018 and Al-Mastawi *et al.*, 2020) [1, 5].

Although PA has some limitations, such as high initial capital costs and demanding work, it is beneficial to the preservation of a healthier ecosystem. Increased yields, reduced fertilizer application through precise placement, minimized pesticide usage through efficient application, fuel conservation via reduced overlap and enhanced monitoring, and water conservation through improved detection of irrigation needs are the advantages of precision agriculture technology adoption.

Table 2: Several recently used vegetation indices for remote sensing applications in Agriculture

Application	Indices	Reference
Water Stress	Optical imaging-derived metrics such as the normalized difference vegetation index (NDVI), Degrees above non-stressed canopy (DANS) and the soil adjusted vegetation index (SAVI) offer valuable insights into assessing water stress and soil moisture levels across various crops.	Sishodia <i>et al.</i> , 2020 [92], Ballester <i>et al.</i> , 2018 [12]
Estimation of irrigation water demand	The crop water stress index (CWSI) derived from thermal remote sensing.	Sishodia <i>et al.</i> , 2020 [92]
N-management	Normalized difference vegetation index (NDVI), Normalized difference red edge (NDRE). Commercially available remote sensors that use crop reflectance data to determine and apply spatially variable fertilizer rates in real-time include Green Seeker, Yara N-sensor, and Crop Circle. These sensors can be hand-held or tractor-mounted.	Sishodia <i>et al.</i> , 2020 [92] Ali <i>et al.</i> , 2017 [4]
Irrigation management	Red edge normalized difference vegetation index (RENDVI)	Sishodia <i>et al.</i> , 2020 [92]
LAI estimation	Red-edge vegetation indices have demonstrated potential in estimating LAI across various crops. A study by Ali <i>et al.</i> (2020) utilized the red-edge position (REP) derived from hyperspectral images to accurately predict the LAI ($R^2 = 0.93$) and chlorophyll content ($R^2 = 0.90$) in Kinnow mandarins cultivated in Pakistan	Ali <i>et al.</i> , 2020 [3]
Disease detection	Compared to commonly used vegetation indices like NDVI, creating disease-specific spectral disease indices (SDI) can enhance the accuracy of disease detection and differentiation in real-world field conditions.	Mahlein <i>et al.</i> , 2013 [60], AL-Saddik <i>et al.</i> , 2017 [6]
ET	Degrees above canopy threshold (DACT)	Kullberg <i>et al.</i> , 2017 [54]

3.4 Climate Smart Agriculture

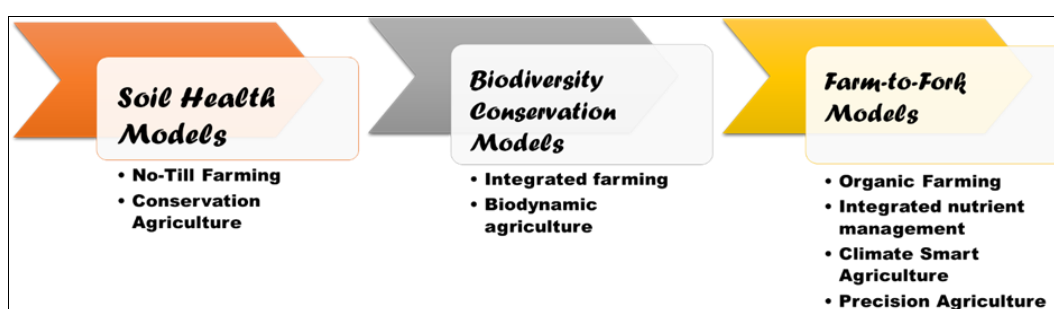
Climate change as an environmental hurdle affect smallholder agriculture across numerous tropical regions. Smallholder agriculture and climate change exhibit an interconnected relationship with visible effects on each other (Cohn *et al.*, 2017) [25] through fluctuations in both high and reduced rainfall patterns and escalating temperatures, alongside recurring droughts (Lobell *et al.*, 2011, Ortiz-Bobea *et al.*, 2021, Qiao *et al.*, 2022) [58, 68, 75]. Climate change could significantly impact agriculture, leading to substantial effects on food and nutrition security (Wheeler and von Braun, 2013, Hertel, 2016, Michler *et al.*, 2019) [101, 46, 63]. Conversely, agricultural activities have the potential to worsen climate change through the release of greenhouse gases (GHGs) from unsustainable farming practices and inputs (Bennetzen *et al.*, 2016, IPCC, 2019) [15, 47].

Embracing suitable climate-smart innovations represents a crucial stride in bolstering food security, fortifying climate resilience, and mitigating greenhouse gas emissions on smallholder farms. These measures are essential for sustaining agricultural livelihoods in a sustainable manner. The Food and Agriculture Organization (FAO) estimates that global crop and livestock production will need to be 60% greater than it was in 2006 (McKenzie *et al.*, 2015) [62]. In developing countries, improved yields and cropping intensity will account for roughly 80% of the required increase, while expansion of cultivable land will contribute only 20% (World Agriculture, 2021). The main objectives for promoting Climate Smart Agriculture (CSA) are enhancing adaptation, reducing greenhouse gas emissions, and sustainably increasing production and profitability, all of which contribute to sustainability (Table 3).

Table 3: Global Case studies and experimental results

Climate smart agriculture towards sustainable development: few global case studies		
Strategy	Outcome towards sustainability	Reference
Adoption of climate-smart varieties, cereal-groundnut intercropping, and organic fertilisers (Ghana, Mali, and Nigeria)	High Land productivity Acceptable food security status Food Security	Tabe-Ojong <i>et al.</i> , 2023 [95]
Implementation of row planting, composting, physical soil and water conservation, management of crop residues, crop rotation, utilization	Enhancing food security, building climate resilience capacity as well as reducing or removing GHG	Teklu <i>et al.</i> ,

of improved crop varieties, and promotion of agroforestry practices in Ethiopia's Upper Blue Nile Highlands.	emissions from smallholder farms to sustainably maintain agricultural livelihoods.	2023 ^[96]
integrated agronomic management (e.g. dense planting, subsoiling tillage, manure amendments, nitrogen fertilizer optimization, and so on) (Northeastern China)	sustainable maize production Higher grain yield nitrogen uses efficiency (partial factor productivity, PFPN), soil organic carbon (SOC) sequestration, while less carbon emission	Feng <i>et al.</i> , 2023 ^[32]
Crop diversification, irrigation, drought-tolerant and early-maturing crop varieties, integrated soil fertility management, and integrated pest management (Ethiopia)	improve crop productivity, increase adaptivity capacity, and mitigate the adverse climate change effects in the study area	Erekalo and Yadda, 2023 ^[29]
Organic farming towards sustainable development: few global case studies		
Organic farming practice often The organic farming may largely exclude the use of chemical fertilizers and growth hormones for crops & feed additives for livestock.	Organic farming contributes towards SDG 2 by ending hunger, achieving food security and improving nutrition	Gamage <i>et al.</i> , 2023 ^[37]
Precision agriculture towards sustainable development: few global case studies		
Application of nanotechnology in precision agriculture	Sustain agricultural production	Zain <i>et al.</i> , 2023 ^[105]
Application of smart technology	Reduces environmental impact and helps towards achieving sustainability ogle	Azlan <i>et al.</i> , 2023 ^[10]



Conclusion

Addressing the nutritional needs of the expanding global population poses a significant challenge to agriculture, amidst evolving dietary preferences and heightened food demand. Substantial escalations in food grain production are imperative to meet this demand, yet hindered by challenges such as diminishing natural resources, climate shifts, and erratic weather conditions. The rise in per capita food consumption intensifies strain on resources, amplifying environmental repercussions. India's agricultural sector plays a pivotal role in ensuring food security for millions, presenting a formidable challenge. Embracing sustainable agricultural methodologies, crucially emphasized by SDG Target 2.4 encompassing biodynamic farming, organic farming, conservation farming, regenerative farming, and other approaches, each emphasizing environmental stewardship and efficacy is essential to navigate the complexities of meeting escalating food demands while mitigating environmental tolls. Achieving agricultural sustainability requires more than just altering production techniques; it necessitates concurrent shifts in dietary habits, responsible consumption, food waste reduction, access to sustainable food options, and environmental education. The successful execution of sustainable agriculture hinges on cohesive collaboration across all sectors of society to ensure that policy objectives translate into tangible changes on the ground.

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