Biological Forum – An International Journal **13(3): 361-374(2021)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Current Status of Indian Agriculture: Problems, Challenges and Solution

Acharya Balkrishna[1,2,3,4], Manisha Phour[1], Manisha Thapliyal[1*] and Vedpriya Arya[1,2]
[1]Patanjali Research Institute, Haridwar, (Uttarakhand), India.
[2]Department of Allied Sciences, University of Patanjali, Patanjali Yogpeeth, Haridwar, (Uttarakhand), India.
[3]Patanjali Organic Research Institute, Haridwar, (Uttarakhand), India.
[4]Bharuwa Agriscience Private Limited, Patanjali Yogpeeth, Haridwar, (Uttarakhand), India.

(Corresponding author: Manisha Thapliyal)*
(Received 11 May 2021, Accepted 07 August, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Food consumption and growing population remain the biggest problems in the developing countries like India. This could only be solved through an increase in agricultural output. While intensive agriculture practices based on the green revolution have contributed to a significant increase in yield and production, they have come at the expense of ecosystem deterioration. It advocates for a novel method that educates producers or small farm holders on how to use their conventional expertise to enhance greater yield production with fewer external inputs. This strategy is referred to as sustainable agriculture, and it is currently the most pressing issue facing the world. This study provides a brief background to the idea of current scenario of Indian agriculture, as well as a critical evaluation of the concept in terms of difficulties and possibilities for overall sustainability.

Keywords: Agriculture Sustainability, Green Revolution, Indian Agriculture, Precision Farming.

INTRODUCTION

Agriculture plays a vital role in the process of socio-economic development. In India, agriculture is the primary source of livelihood for about 58 percent of the population (IBEF, 2021) and approximately 70 percent of the rural households depend on agriculture only. The agriculture industry plays a significant part in the Indian economy, accounting for around 20% of Gross Domestic product (GDP). Around 62 percent of India's population is reliant on it for survival (Gupta & Nagar, (2017). Agriculture is a crucial sector of Indian economy as it contributes about 20.19 percent of GDP (DAC&FW Annual Report, 2020-21). Early in the history, agriculture was done for the domestic purpose only, as the time passes new technologies and developments were made to enhance the crop production and people started earning from agriculture too. But there are several adversities that emerged in the socioeconomic areas along with the environmental hazards (Bhatt *et al.*, 2019).

Agricultural technology is a vital part of food system sustainability. The Green Revolution (GR) exemplifies how scale-independent technology reshaped agricultural productivity. The GR has resulted in higher yields, poverty reduction, infrastructure development, increased food availability, and lower food prices, among other benefits (McCullough *et al.*, 2012). It played a crucial role in guaranteeing agricultural output in countries such as India, as well as easing concerns that we had reached the point of food excess capacity, which occurs when the population exceeds agricultural production. India has just a tiny percentage of the world's agricultural area, the country ranks second in agricultural production worldwide. The most significant disadvantage of green revolution methods is that they are restricted to a small number of particular crops (Armanda *et al.*, 2019; Goswami *et al.*, 2017). The goal of sustainable development via the reduction of negative consequences is becoming more important as the world's population and environmental concerns continue to rise.

There is a lack of cutting-edge technology and contemporary way of farming in Indian agriculture. Advanced farming employing sensors and other scientific instruments for advance techniques and application of artificial intelligence is now taking place on a global scale (Ennouri & Kallel, 2019; Charania & Li, 2020; Talaviya *et al.*, 2020). It is an effective means of saving money, reducing the environmental impact, increasing the quality and yield. Likewise, demand for agricultural products may be boosted by the growth of new industries. As a result, increases in available resources, company growth, or the reinvestment of non-farm earnings into agriculture may result in the creation of more productive linkages between the farm and non-farm sectors. The removal of financial and market restrictions in the rural economy is a key component of rural economic development (Gangopadhyay *et al.*, 2008). In India, the urban population was just 30% in 2010, according to a UNDP assessment, but it is expected to increase to 40% in 2030 and over 50% by 2045. In compared to urban expansion, India's urban population is expected to expand from 3.5 billion to more than 6 billion by 2050. *Areas under cultivation grow at a rate of only 2% each year (Agarwal & Sinha, 2017).

Aim of this paper is to provide a summarized information on the current scenario, challenges farmers are facing in day to day life and suggestive solutions and the goal is to achieve the improved agricultural sector in India. Improved results can be obtained by facilitating labour migration to areas of greater opportunity, highlighting the critical role of urban infrastructure in facilitating rural-urban migration, providing latest technology, high quality planting material etc.

A. Major Issues in Agriculture Sectors in Current Scenario

Inadequate crop rotation: Long term practice of cereal-cereal rotations in India have resulted in nutrient imbalance, increasing pest infestation and soil degradation (Chauhan *et al.,* 2012). Thus, in order to enhance the crop, the pulse-cereal rotation techniques must be implanted. The aim of crop rotation is to maximize crop output by maintaining oil fertility. Importantly, pulses might be an alternative for diversification or intensification of cereal rotations. Pulses have the potential to increase the organic carbon content of soil and disperse nutrients across the soil profile (Ganeshamurthy, 2009; Kamanga *et al.,* 2014).

Inadequate use of manure and fertilizers: Indian soils were used for cultivation without much care for replenishment for centuries. As a result, soils have become depleted and exhausted. Almost all crops have average yields that's among the lowest in global average. This is a significant issue that can be resolved by increasing the use of manures and fertilizers. Manures and fertilizers have the same effect on soils as good nutrition has on the body. For greater output, long-term sustainability and minimising environmental damage, efficient nutrient management will be vital. Research findings from a number of long-term researches demonstrate that an unbalanced or suboptimal fertilizer application has a deep influence on soil fertility and quality (Sharma *et al.,* 2014). On the other hand, organic amendments have an overall cumulative effect over time, but have a greater impact in the long term. Other issues include the lower nutrient input rate and the non-synchronization between nutrient supply and crop need during crucial growth phases (Sacco *et al.,* 2015; Hazra *et al.,* 2016). In places where agricultural practices are heavily reliant on the use of chemical fertilizers, crop yields have risen, but a rise in soil quality issues and environmental pollution has also been found. So, agriculture organic waste such as agricultural residues, animal wastes, or compost have been widely considered as a significant agricultural fertilizer resource in agroecosystems (Mupambwa & Mnkeni, 2018; Ravindran *et al.,*2019; Brunetti *et al.,* 2019). To facilitate widespread adoption of this technology, numerous factors must be considered, including the type and dosage of organic amendments, the appropriate ratio of organic amendments to chemical fertilizer (Paramesh *et al.,* 2020), the timing of nitrogen application (Shen *et al.,* 2018), and other factors such as the mixing of organic amendments with different soil organisms such as phosphate-solubilizing bacteria, native free-living nematodes, and epigeal fungi.

Poor quality of seeds: Seeds are a vital and fundamental ingredient for increased agricultural productivity and ongoing farming expansion. It is equally crucial to distribute and production of quality seeds. Consequently, the fraction of farmers, particularly the small holders, poor and rural farmers, do not have access to excellent quality seeds largely due to sky-high price of those seeds (Murphy, 2010). NSC (National Seeds Corporation, 1969) and SFCI (State Farmers Corporation of India, 1963) were formed by the Indian government in order to address this issue. According to the annual report of Department of Agriculture, Cooperation & Farmers' Welfare 2020-21, 15.42 lakh quintals of seeds have been produced/procured by NSC during 2019-20 and the total number of quintals of seed distributed by NSC in 2019-20 is 15.85 lakh. In order to increase the delivery of improved seeds to farms thirteen State Seed Corporations (SSCs) were also set up. Under the plan, funds are supplied to implementers to aid with operating funds (Cost of Seeds), seed maintenance costs, and pricing differentials for unopened seed supply. Seed and Planting Material Sub-Mission (SMSP) is currently in progress with the intention of expanding the seed sector and improving crop production and multiplication, while also implementing a comprehensive system for protecting plant varieties, farm owners, and plant breeders, with the goal of encouraging the implementation of novel plant varieties.

Excessive use of pesticides: Pest damage is a grave problem for farmers and pesticides is often important for the conservation and protection of crops. According to the statistical database of Directorate of Plant Protection, Quarantine, Department of Agriculture, Cooperation & Farmers Welfare 2021, an extensive detail of the total consumption of chemical pesticide is summarized in Fig. 1.

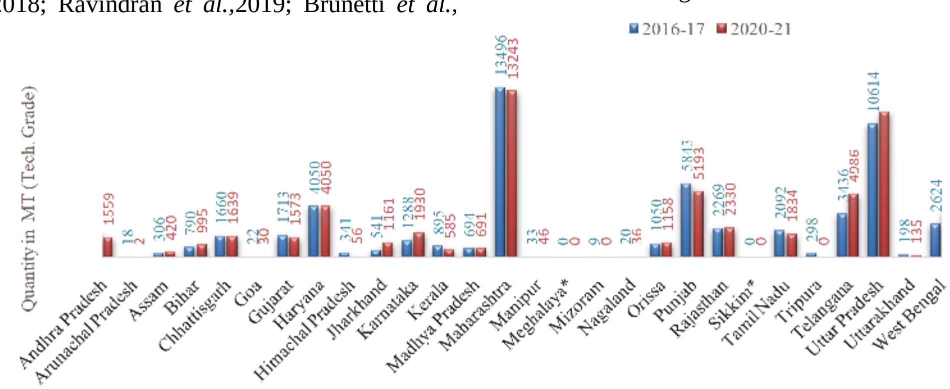

Fig. 1. Chemical pesticides consumption in Indian States.

Among all states, Meghalaya and Sikkim are found to be the complete organic states, also Sikkim is World's first fully organic state. If we talk about the absolute differences of pesticide consumption since 2016 to 21, Arunachal Pradesh shows the decline rate by -89.17% and on the other hand Jharkhand raises the consumption by 114.42%.

Agricultural marketing: Agricultural marketing in rural areas is still in a state of disarray. Without viable marketing channels, farmers are forced to rely on local merchants and intermediaries to dispose of their agricultural product, which is sold at a loss. In the majority of instances, these farmers are compelled by socioeconomic circumstances to engage in distress sales of their product (Chakraborty, 2018). The needy farmers obliged to sell his product at whatever value is given to him in order to fulfill his financial obligations and pay his debt. To a certain extent, the current financing programmes for farmers are still in the early stages of development, and the majority of small farmers continue on turn to local greedy money lenders and demand exorbitant interest rates. Farmers should profit from their efforts, but instead there are vultures who make it all go to waste. Despite claims that technology has advanced, it has only reached metropolitan regions thus far. There are many gaps in the current law, and without an organised and controlled marketing structure for selling agricultural products, food prices would rise and people will have to struggle to feed themselves. In order to get a fair and reasonable payment for their labour, farmers must endure many difficulties and face multiple obstacles to be paid properly.

Farm-to-market connectivity-lowering transaction costs: Along with increased linkages to factor markets, increased linkages to agricultural output markets are also required for commercialization. New agricultural innovation and technology are needed to improve the capacity, production and reliability which are important in response of agricultural marketing (Narayanan, 2014; Swinnen & Maertens, 2007). Traditional spot markets account for most of the agro-industry in India. These primarily unorganised markets with limited infrastructure are unable to meet changing demand's quality requirements and specifications, emphasizing the seriousness of the organized and critical role of online market place for agriculture goods (McCullough *et al.*, 2008). In India, the retail food sector is huge and disorganised, whereas the proportion of organized retail is negligible. It is predicted that organized retail has a small market share today, projections show that it will more than double by 2022. Food and grocery organised retail has a wide range of products. Together with traditional retailers such as Big bazar, big basket, Jio mart, pantry in agriculture sector is gaining momentum. The farm-retail connection is necessary for food retail development to occur. The connection between farms and retail is crucial for agricultural revenue development, job creation in rural and urban regions, and waste reduction. This will impact the economy, agricultural production, healthcare, and food security.

Agricultural transaction costs: Limited scale economies, low negotiating effort and inadequate market connection all decrease transaction costs for small and marginal producers. There are no consistent trade connections across agricultural markets and the prices are not simply fixed. The expenses for transactions depend on household, farm, place and crop (Pingali *et al.*, 2005). Socialization in society, such as caste and class, may influence access to land, finance and markets (Kumar, 2013). Heterogeneous costs for transactions may lead to the charge and payment of various services and products on the market (Thorat, 2009). Specific variables in agriculture and geography can influence market access and costs of participation decreased economies of scale (Poulton *et al.,* 2010). Geographic constraints, market proximity, and limited connections prevent small holders from selling directly in the markets. The Committee recommended changes that allowed the trading in market places, farmer and manufacturer agreements and bulk purchases straight through the manufacturer and producers, circumventing the APMCs. Changes happened in the twenty-first century in the distribution channel setups, and they caused commercial agriculture advancements.

Vertical coordination in value chains-the risks and challenges: A vertical coordination or exchange is a method of trade in which the production of high-quality agricultural commodities is guaranteed by bypassing current distribution channels and going directly to the farmers and customers. To maintain better and effective criteria while lowering the cost, vertical coordination plans and manages operations and communication processes (Buvik & John, 2000). Small holder farmers and distribution channels are often too inflexible to accommodate changes in agricultural needs, which results in the emergence of new market-oriented farming industries. Vertical coordination deals establish the conditions of sale based on pricing, availability, and excellence before instability is reduced. Vertical coordination mechanisms, such as contract farming, have been used extensively in developing nations to combat shifting consumer needs and industry inconsistencies (Barrett *et al.,* 2012). Contract farming requires directly distributing foods from producers to merchants and exporters under specified deliverables, quantities, grade, and variation (Singh, 2011). There are intensive agriculture techniques used in India in the agricultural contract agricultural sector. As a consequence, linking small farms to commodity networks has been hindered due to the absence of smallholders and the associated expense of establishing supply chains.

Soil degradation: Soil degradation is projected to occur over more than hundred million hectares of land in India. It includes 94 million hectares due to water erosion, 16 million hectares due to acidity, 14 million hectares due to floods, 9 million hectares due to wind erosion, 6 million hectares due to salt, and 7 million hectares due to different environmental factors. It is alarming because India accounts for 18 percent of the overall of the earth's population but having only 2.4% of the world's total land area. Agricultural output, forestry, and aquaculture account for 17% of the country's GDP and occupy roughly half of the actual employment. Overburden clearance from mining sites causes substantial losses of flora and very fertile soils to the surrounding areas. The degradation of soil is naturally occurring as well as induced by human activities (Bhattacharyya *et al.*, 2015). This list includes many natural disasters including seismic activity, typhoons, storms, hurricanes, falling trees, rockfalls, volcanic activities, storms, thunderstorms, and bush fires (Brausmann & Bretschger, 2018). Man-made induce soil degradation is brought on by land clearing and deforestation, inadequate agricultural practices, poor chemical waste disposal, grazing, mineral extraction, rapid urbanization, and commercial growth. There are a number of sociopolitical causes for soil erosion in India, including a rapid urbanization, decreasing per individual land area, farm leasing, illiteracy, and rising population. In conclusion, main contributors to soil deterioration in varied agro-climatic regions, including climate change, farming techniques, and fertilizers (Bateman, 2019).

Post-harvest losses: In terms of food production, India is in second place next to China, and its food processing sector is estimated to be worth around $70 billion (Lathamani, 2021). This year's total food grain production was about one-and-a-half times the combined amount of fresh vegetables. Postharvest losses in fresh foods and commodities, such as dairy products and eggs, are estimated to be between 10 and 25 percent in most cases. It was estimated that between 30 and 40% of the projected losses in fruits and vegetables would occur (Hegazy, 2013). These figures are undesirable and have a negative effect on the Indian economy. Crop loss after harvest starts to accumulate rapidly in the production chain. Following post-harvest, there are four major stages in this production chain: harvesting and production; processing and product management; and market place connections. Efficiency is always an issue for crops. Efficiency is always an issue for crops. Incidence of post-harvest loss is considerable in the first two periods, with severe effects for small holders' farmers earnings (Ganesh *et al.*, 2018). However, there has been minimal attention paid to value chain efficiency or examining the causes behind PHL trailing output. This exhibit illustrates many important post-harvest value chain inefficiencies that together lead to post harvest losses. There are several causes behind the Post-harvest losses, summarized details are mentioned in Fig. 2.

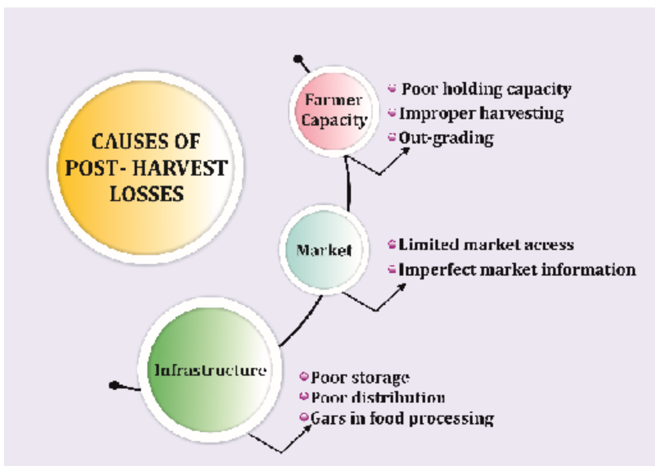

Fig. 2. Causes of post- harvest losses.

B. Current Challenges in Agriculture Sector

Productivity has to be the motor behind agricultural development, since almost all cultivated area is farmed. Because of limited water resources, new supplies of water are needed to meet the growing demands of industry and urbanization (Boretti & Rosa, 2019). NITI Ayog has also taken initiatives by Poverty Alleviation Programme, according to this productivity to be increased, several other options will have to be considered, including the introduction of higher yielding verities, a wider range of high-value crops, and the creation of value chains to decrease marketing costs. It is a method to improve rural poverty via an inclusive approach, both agricultural and non-farm employment-based approach. All farmers including small land holders must also benefit from rural development, particularly the landless, the destitute, women, reserved castes and tribes. Also, India's large majority of the poor live in regions that don't get enough rain, or on the Indo-Gangetic Plain, where there is enough rain. Currently raised population and high food demands is a major challenge of agriculture sector.

Post-Green Revolution Challenges for Indian Agriculture: The aim of Green revolution was to achieve the self-sufficiency in food grains and it was successfully contributed to a high-yielded variety of seeds, irrigation, increased used of fertilizers, and incorporated the modern farming methods. However, a significant decrease in soil quality and environmental robustness has resulted as a result of the outward manifestations of agriculture as shown in Fig. 3. (Goswami, 2017).

(i) Green Revolution Technologies will be taken to the Next Level: Due to the fact that the development of GR technologies was not resource neutral, there was significant region a line quality and a lack of regional diversity. The advantages of agricultural productivity increase and development were not felt by rainfed regions that were less fortunate. Food self-sufficiency was achieved as a result of parity in food sources, however this came at the expense of insufficient micronutrient availability a cross the food system.

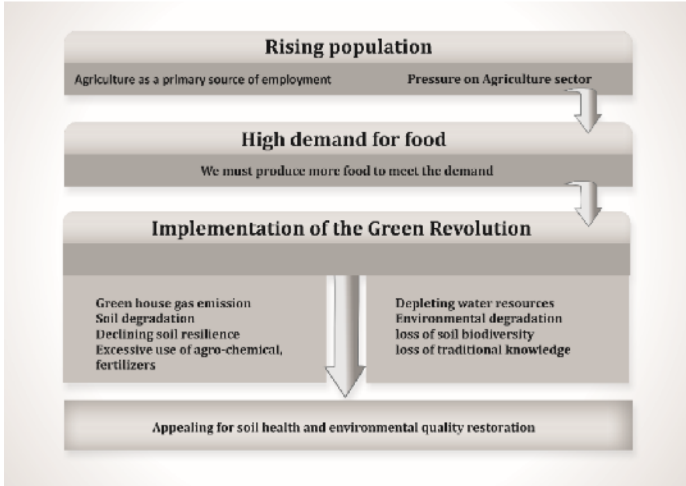

Fig. 3. Post-green revolution challenges.

Monocropping emerged in India's irrigated fields as a result of increasing disparities in production incentives (Abraham & Pingali, 2021; Pingali, 2012). The environmental effect of GR-related activities was also different. Chemical run off, soil deterioration, and water depletion were all caused by increased environmental contamination as a consequence of the misuse of agricultural inputs (Pingali, 2012). India has one of the greatest rates of water depletion in the world (Aeschbach-Hertig & Gleeson, 2012). According to Shiao (2015), 54 percent of India's total land area is under significant water stress, with the majority of the stress occurring in the northwestern areas and eastern coastal regions, where GR technologies have been most effective. Eastern India, where water stress is minimal, is more adversely impacted by a lack of farm-level irrigation than other parts of the country.

Human and natural soil deterioration due to deforestation, pollution, bad agricultural practices, overgrazing, wind and river erosion, and other factors account for about 64 percent of all land degradation in India, according to the World Bank (Mythili & Goedecke, 2016). The northern, western, and southern areas are the most severely impacted by land degradation, and they also suffer from severe water scarcity and scarcity. The use of GR technologies came at a cost to the environment, and as India tries to increase output and diversify its economy, it is essential to take measures to reduce negative externalities. In order to reduce environmental stress while also maintaining agricultural output sustainability in eastern India, technology and sound management practices will need to be used.

(i) Climate Change, Degradation of the Environment, and Production Risks: Climate change is being exacerbated by increased emissions, which has a major effect on agricultural production. Agriculture has a significant impact on climate change. It produces greenhouse gases (GHGs) that are both CO_2 and non-CO_2-based, such as methane (CH4) and nitrous oxide (N_2O), which contribute to global temperature rise. Agriculture in India accounts for 18 percent of the country's overall greenhouse gas emissions. Anaerobic and enteric fermentation are responsible for the production of 36.9 percent and 38.9 percent of all greenhouse gases, respectively, in rice and cow agriculture, respectively (Vetter *et al.,* 2017). All of these factors are acting in concert to affect production conditions and agricultural hazards in the agriculture sector. Additionally, legislation giving input subsidies to enhance and encourage adoption has been implemented. The overuse of technology has resulted from the usage of technology that has been continuously subsidised. Electricity for water usage increased the energy demand of the agricultural sector, while fertilizer subsidies increased the agricultural industry's greenhouse gas emissions, particularly N_2O. (Vetter *et al.,* 2017). Increased urea subsidies have resulted in increased usage of nitrogenous fertilizers, which has resulted in decreased efficiency and soil health (Prasad, 2009). Over-irrigation is a result of power subsidies, which lowers groundwater levels (Bhanja *et al.,* 2017; Jacoby, 2017; Fishman *et al.,* 2015). Excessive tillage, heavy use of inorganic fertilizers, inadequate irrigation, pesticide misuse, low carbon inputs, and crop cycle planning are all factors that contribute to soil deterioration (Bhattacharyya *et al.,* 2015). Different agro-ecological zones will be affected differently by changes in temperature, as well as degradation of land and water resources. Because of the increasing agro-climatic risks in marginal regions, water shortages will have a significant effect on agricultural production. Groundwater levels being depleted, coupled with water pollution due to runoff and soil degradation as a result of over fertilisation, may have a negative impact on agricultural output in high-productive regions. High-value agriculture may also need the use of more resources, such as water, fertilizer, and feed, as well as the production of more greenhouse gases. Technology efforts work hand in hand with the reduction of externalities while simultaneously boosting production. Despite the fact that technological interventions have an associated energy cost, as agriculture becomes more commercialised, emissions are expected to rise. It is critical to maximize the use of existing water and land resources, as well as chemical and fuel inputs, while also coping with climate change in order to reduce the impact on agriculture as much as possible.

Covid-19 Crisis and its effect on the Indian agriculture sector: In this scenario, both consumers' purchasing limits have been lowered due to a drop-in salaries and employment, while retailers have stocked more nourishment, thus influencing food accessibility and food cost. Due to transportation constraints, the harvest was not delivered to the final destination, resulting in produce shortages and price increases. In the chain of production, automation has gained more importance when it comes to harvesting, and manufacturing products. Following the onset of the COVID-19 pandemic, several initiatives were launched in the Agriculture sector in India. Various agricultural policies were implemented by the government to assist the needy. The following list includes only a few examples: The state-run procurement activities made certain that farmers purchased the most expensive seeds and pulses at the lowest price designated by the government (OCED, 2018). From April'2021, the industries and agriculturists will be ableto resume operations as long as they are outside of the virus hotspots. As per the Pradhan Mantri Garib Kalyan Yojana/Package, the government declared that 1 kg of pulses and 5 kg of rice and wheat will be provided to 800 million underprivileged people every month between April and June, while another 80 million people will be able to cook for free during this time so that they can keep themselves alive (GOI, 2020).

Fertilizer production and sales make the world's top fertilizer supplier. Manures and fertilizers are highly tradeable globally because of Lockdown. Additionally, spring season crops such as barley, sunflower, maize, and open field foods/vegetables have been severely impacted by this pandemic too. Labour migration has resulted in a rise in transmission rate, which in turn has led to acute scarcities in the agricultural sector, which are the major determinants for the crop harvest. Due to the high transmission rate of COVID-19, the agricultural sector has been affected by difficulties in finding healthy workers and labour shortages (Aday & Aday, 2020). In 2020, the Farmers' Produce Trade and Commerce (Promotion and Facilitation) Act will come into effect in the United States.

According to the government, farm bills will help to increase farmers' incomes. In such a country, farmers are not well-educated and are thus unaware of the laws. Consequently, they can not market their yield without a pan card. Farmer fear of the Crop MSP is met by centralization and hands-on control of large corporations. The presumption is that these bills will weaken agriculture. The farmers believe that all larger corporations may declare the price of their crops and gain additional profit from it, bringing about the decline off farmers. In the event of a pandemic, travel restrictions could lead to a significant reduction in food arrivals. The state government has confirmed that Bills are being developed in order to provide a framework for all farmers to buy and sell their harvests outside Mandis. On the contrary, the farmers are worried about their business and concerned that they will lose a significant amount of money if they operate outside of the Mandis under the minimum support price scheme. Farmers are also fearful of the trade fee. If empowered authorities fail to make judicious decisions, farms will be vulnerable to big corporations, without anyone offering them a chance to be heard. In the farmers' opinion, having the land transferred to large corporate and trader interests will lead to even greater problems (Kaur *et al.*, 2021). During COVID-19, a fear of the spread of corona virus was created and resulted in a large number of fatalities for the farmers' protests. a sizable percentage of protesting farmers belong to the elderly age demographic, who can be more easily affected by the virus.

C. Domains of Agriculture Sector with the Highest Priority

Alternative marketing platforms: Working group on agricultural marketing of the planning commission (2011) said that the main difficulties for markets were the large number of intermediaries, insufficient infrastructure for storage and grading, and underperforming market personnel. State-by-state variations in agricultural markets are due to the fact that market reforms and governance are the responsibility of individual states rather than the federal government. In fact, the computerised gateway for agricultural marketing has been in operation for quite some time (Narayanamoorthy & Alli, 2018). The National Agriculture Market (eNAM) platform, which was established in 2016, was developed with the aim of connecting all Agricultural Produce & Livestock Market Committees (APMCs). On the platform, 9 percent of the APMCs are connected to one another. It is the goal of the electronic portal to assist in price discovery and grading standards in India, in order to guarantee a uniform and transparent transaction. The bids have been finished, and the product has been weighed and stored in preparation for pickup. The money is given to the farmer via electronic means.

Despite the fact that a unified market is needed for price discovery in theory, standardising practises and lowering transaction costs have been sluggish to gain traction in practise. The infrastructure and mechanisms of the market are inadequate, a shortage of testing equipment and experts for the determination of grades and standards, poor internet connection, limited stakeholder involvement, and the misreporting of physical auctions as online auctions are all issues that must be addressed (Nirmal, 2017). In contrast to non-eMarkets, higher market bids in auctions, decreased collusion among merchants and cartels, improved transparency in transactions, and reduced payment delays are all benefits of using eMarkets instead of traditional markets (Reddy, 2017). The efficient operation of internet marketing platforms promotes greater involvement from the private sector, and unproductive potential sectors that lack vertical coordination may significantly benefit from the implementation of these models.

The importance of warehouse systems in agricultural marketing cannot be overstated, particularly in the face of significant commodity price volatility. Farmers sell their product even when the market price is low. Thanks to the warehouse receipt system implemented by WDRA in 2010, now farmers may keep their goods in warehouses while prices are low and sell it when prices rise. They utilise a warehouse receipt as a derivative that may be sold or collateralized in order to meet their urgent financial requirements. Wine storage has a number of advantages, including reduced costs, greater price realisation, and the opportunity to purchase and sell without the need for a transfer. Public warehouses include the Food Corporation of India, the Central Warehousing Corporation, the State Warehousing Corporation, and the Department of State Civil Supplies.

Other market places have a higher level of involvement from the private sector. At this point in time, ReMS has used both private and public warehouse platforms, with both public and private warehouse systems managing the receipts of storage space. ICABD, one of the world's biggest non-state wheat purchasers, purchases and sells wheat and soybean futures contracts on futures markets (Rajib, 2015). Participants from the private sector also provide critical market information. Among other things, the NCDEX collaborates with state procurement organisations such as NAFED and SFAC to offer grading and testing services prior to each transaction. The development of infrastructure that is suitable for smallholder participation in these platforms is essential for long-term sustainability. Warehouses and collection sites located in low-potential regions are a hindrance to the access of producers. In most cases, the crops produced will not be of acceptable quality or grade standards. Smallholder involvement in these platforms is discouraged by the high fixed costs associated with grading, weighing, and storage insurance.

Marketing is restricted to a certain crop type, a specific region, and a specific set of hazards associated with production. When irrigation and market access are abundant, it is feasible to grow high-value crops in a sustainable manner. When it comes to vertical coordination, there is a high degree of favourability. APMCs continue to play an important role in these regions, due to the reduced production risks and larger geographic benefits that exist in these places. Another advantage of these alternative markets is that they may assist in reducing the possible issues associated with APMCs, such as the presence of middlemen, the lack of grades or standards, and the inability to achieve optimal price discovery and realization. The need to address problems such as economies of scale, access to finance for both producers and value chain players, and the efficient regulation of value chains and markets, on the other hand, is critical. Farm-market integration necessitates the establishment of effective institutions and policies (Pingali *et al.*, 2019).

Institutions and policies-future food systems and value chains: Two critical issues to examine are value chains and the development of food systems. It is essential to connect smallholders to markets in order to facilitate industrialization, improve family incomes, and provide an incentive for agricultural and livestock diversification (Abraham & Pingali, 2020). Food loss and waste are reduced as a result of a well-functioning production chain, resulting in increased access to and availability of food for everyone. With shifting customer demand comes the development of new promotional channels and platforms to suit the changing needs of the marketplace. The support of policymakers, interventions such as aggregation models, infrastructure development, and reform of existing marketing practises that have resulted in increased transaction costs in the market, on the other hand, will be required by small producers in order to connect to markets through these channels (Planning Commission, 2011). It is necessary to take these steps in order to ensure the long-term sustainability of value chains as well as the enhancement of welfare.

(i) Vertical coordination and linkages to alternative marketing platforms: To solve the many difficulties of the value chain in small farm-based economies, aggregation models and vertical coordination (VC) mechanisms, such as contract farming, must be used in conjunction with one another. In a mainly smallholder-based agriculture industry, the consolidation of farms, as well as strong laws to allow and enforce contracts, are needed for VC to be successful. Accumulation models have the ability to solve problems of scale that may arise when trying to get access to factor markets such as finance. Recently, the Indian government passed the Model Agriculture Produce and Livestock Contract Farming and Services (Promotion and Facilitation) Act, which will make it more convenient for farmers to enter into contracts with buyers in the country. Farming under contract has historically been a more informal approach, with most agreements being reached informally and agreements being violated on a regular basis (Dileep *et al.*, 2002; Singh, 2000; Swain, 2011). To guarantee that both producers and purchasers comply to the terms of the contract, a new law promotes the creation of legally enforceable contracts as well as the implementation of dispute resolution procedures

(ii) Infrastructure and market reforms: In order to improve market access in small farm-based economies, vertical coordination and alternative markets are essential platforms and tactics. However, efficient access to agricultural spot markets is also needed in order to achieve this. Markets for agricultural products are diversified, with a significant number of middlemen active in the industry. When agricultural markets are scarce, however, these intermediaries perform critical aggregation and standardisation functions, particularly in the absence of recognised grades and standards. Infrastructure upgrades, such as increased road connections to allow for easier movement of products, cold chains and storage facilities to minimise waste, as well as appropriate communication routes for the transmission of pricing and quality information, would be necessary for greater market access (Warner& Kahan, 2008). Moreover, these modifications would enhance the performance of alternative marketing platforms, especially eMarkets and warehousing services. The importance of public sector investment in the creation of public goods in this industry cannot be over emphasized. In order to attract private sector investment across the value chain, effective infrastructure development is also needed (Bohun, 2001). It has not been possible to build backend infrastructure in organised retail despite legislative mandates to do so owing to policy ambiguity surrounding foreign direct investment (FDI) in organised retail. To accomplish objective grade-based pricing determination, it is necessary to introduce grades and standards, as well as infrastructure and techniques for evaluating them at markets. Institutions that enforce adopted legislation, as well as infrastructure that increases physical market access, are all necessary for long-term value chains to function efficiently and effectively

The new venture of technology and processes in achieving long-term agriculture sustainability: The most significant technical challenge in agriculture is to enhance output via intensification while simultaneously reducing negative externalities such as reduced biodiversity, greenhouse gas emissions, and land and water degradation (FAO, 2016; Matson *et al.*,1997; Pretty *et al.,* 2011). Increased access to technology, given that small and marginal farms account for the vast bulk of agricultural output, is essential for economic development, poverty eradication and food security. It is also important for gender empowerment and sustainable development (Byerlee *et al.,* 2009; Pingali, 2010). Smallholders' ability to handle climate risks, especially during severe occurrences, is, on the other hand, restricted, and this may cause them to become trapped in chronic poverty (Carter & Barrett, 2006; Fafchamps, 2003; Kebede, 1992). As a consequence, three things must be given top priority in technology: To begin, technology must be made available to small and marginal producers, who are often limited in their ability to access resources. Another goal is to increase productivity in order to meet the needs of an expanding population while also taking into consideration land and water resource limitations. The third point is that technology should make resource utilisation and control of agricultural externalities more efficient and effective in order to prevent aggravating climate change. This section's goal is to investigate the impact of plant process improvements in improving crop and agricultural strategies as well as technologies that increase productivity in Indian agriculture.

(iii) Plant and crop technologies and yield gaps: In India, there are a total of 20 AEZs (agro-ecological zones). In each, there are distinct physiographic characteristics (such as precipitation and temperature) and soil types, which all influence the kinds of agricultural production that may be carried out within the area (Ahmad *et al.,* 2017). Climate change is having a significant effect on agriculture. Lower yields, higher pest and disease risks, and reduced feed and pasture quality and quantity are all consequences of rising temperatures in agriculture. Farm output, as well as food production, will be impacted as a result of these modifications (Rojas-Downing *et al.,* 2017). Heat stress has a negative effect on animal health, increases parasites and pathogens, and raises the danger of my cotoxin contamination in grains and pulses, among other things (Paterson & Lima, 2011). As goods travel from farm to plate, there is growing concern about the food supply chains. Yield gaps will be the main problem and objective for technology interventions in the future, and climate change will be the primary issue and goal as well. Conventional plant breeding will continue to be important for increasing yields in coarse grains and pulses, but recent genetic engineering findings have opened the door to the possibility of creating plants that minimise environmental effects while still increasing productivity. GMOs have the potential to be more accurate, productive, and time-efficient than conventional plant breeding (CPB), and they have been discovered in biofuels, food, livestock, fisheries, and forestry, among other applications. When comparing GM biotechnology to CPB, the most significant distinction is that biotechnology is trans-species and makes use of gene modification, DNA typing, and cloning to achieve its goals (Rao *et al.,* 2018). Insecticide, pesticide, and herbicide tolerance or resistance was found in first-generation genetically modified crops. This includes genetically modified maize, genetically modified cotton, Pat maize, and genetically modified soybeans. There was just one first-generation genetically modified organism (GMO) introduced in India: Bt cotton. GMOs of the second generation have increased tolerance to environmental stress (drought, flood salinity), as well as significant changes in nutrient content (protein, amino acids, fatty acid content, starch content, vitamins minerals, and enzymes), allowing for the development of more resilient and nutritious crops in a variety of environments (González *et al.,* 2020). However, second-generation genetically modified organisms (GMOs) are not allowed in the Indian agriculture industry. Large grains, such as millets and sorghum, and crops that grow well in subtropical and semi-arid climates would benefit from technological advancements, according to the researchers. Increased yields of coarse grains and pulses, which are advantageous in areas of eastern India where they have a competitive edge in growing, would result in a greater per capita availability of these commodities and an increase in income growth as a consequence of research and development via CPB.

(iv) For Sustainable Intensification, Information, Management Practices, Production, and Consumption Efficiency are Required: Growth and progress in agriculture rely on easy access to the required information. In order for farms to make educated choices about planting, harvesting, and selling, information systems are becoming more essential as they become more engaged in the market (Aker *et al.,* 2016; Ogutu *et al.,* 2014). Several studies have shown that information and communication technologies (ICTs) have a considerable potential for decreasing information asymmetries and improving the efficiency of manufacturing and marketing operations. The management of resources, especially inputs, is essential to the accomplishment of long-term intensification objectives in agricultural production. The combination of technical methods to improve production with resource management practises is necessary to minimise externalities such as greenhouse gas emissions and misuse of natural resources, which are both harmful to the environment. It is discussed in this part how important it is to improve public access to information, the role that technology plays in making this possible, and the relationship between information access and sound management practises. Information on markets and prices, meteorological information, information based on technical extension services, or a mix of these information and services are the most important kinds of information and services that farmers need (Aker *et al.,* 2016). Indications are that information and communication technology (ICTs) may play a role in the early adoption of technologies such as genetically modified crops and farming techniques like zero-tillage (Fischer *et al.,* 2009). A number of studies have also revealed that information and communication technologies (ICTs) assist in the acquisition of information about seed varieties, weather-related information, and diseases (Mittal & Mehar, 2012), as well as in the realisation of higher prices and the reduction of wastage (Mittal & Mehar, 2012), among other things (Aker & Fafchamps, 2015; Muto& Yamano, 2009). Information and communication technologies (ICTs) often make use of platforms that gather information. Information on the weather, extension, and the stock market would all be combined on these platforms. In order to achieve more sustainable intensification, new technologies must be used in conjunction with improved resource management practises. CA technologies, are resource-saving agricultural practises that help conserve resources while simultaneously producing a profit, it also reduces the production cost, increase the yield and crop diversification, save water, improve efficient use of resources and exploit the environment (Bhan & Behera, 2014). Agricultural practises that are climate-smart are defined as those that are "more productive, more resilient, and that may be utilised to assist achieve national food security and development goals" (Lipper *et al.,* 2014). Carbon sequestration, soil protection, and watershed management are all important for achieving sustainable intensification in agricultural production (Pretty *et al.,* 2011).

Precision farming: Precision Farming or Precision Agriculture (PA) is a technology-based farm management system, which requires the succour of Global Positioning System, geo-referenced maps to identify, analyse and manage the different parameters within field for optimum productivity, sustainability and profitability (Fig. 4). PA is a solution to all the solution to the countless challenges faced by the agriculture sector as well as, it could answer all the problems and emerge as a powerful tool for food sufficiency in developing countries (Roy, 2020). Precision farming is a kind of agriculture that entails the exact use of inputs in order to obtain greater average yields than are possible with conventional farming methods. This means that the system incorporates critical elements of information, technology, and management to optimise production in order to increase production efficiency while also improving product quality and crop chemical use efficiency while also conserving energy and protecting the environment (Shibusawa, 2002).

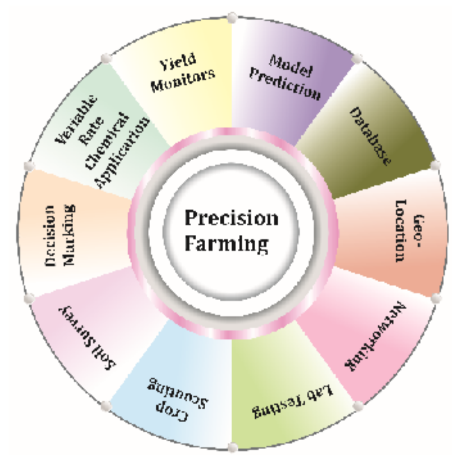

Fig. 4. A brief overview of precision farming approaches.

Precision farming, in particular for small farmers in underdeveloped nations, offers the potential of substantial output increase with little reliance on external inputs. The global food system is now confronted with tremendous challenges, which are expected to worsen substantially over the next 40 years. Much may be accomplished quickly with today's technology and knowledge, as well as with adequate desire and investment. Reduced total productivity, decreasing and degrading natural resources, stagnant agricultural incomes, a lack of ecoregional approaches, shrinking and fragmenting agricultural holdings, trade liberalisati on in agriculture, a scarcity of non-farmer jobs, and global climate variation were the primary concerns of the agricultural development community. As a result, the use of new technology is considered to be one of the most important factors in increasing future agricultural production. Rather than managing a whole field in accordance with a hypothetical average condition, which cannot exist in any field, the precision farming method recognises site-specific differences within fields and adapts management activities to these needs. Farmers are usually aware of the fact that the rates of their fields vary depending on where they are located in the nation (Hakkim, 2016).

(i) Use of resource-efficient agricultural techniques: Various agro techniques have been well established with the aim of increasing resource efficacy and decreasing greenhouse gas emissions while also improving soil quality. Listed below are some resource-efficient emerging farming practices:

— Rice intensification was implemented in south India for the first time in 2008 with the goal of enhancing the robustness of rice production. Rice fields needs frequent irrigation and cultivated in huge area across India. Because of the current water shortage scenario, conserving irrigation water has become even more important than before. There have recently been several key strategies introduced, including aerobic rice production, and the framework for rice intensification, which allows rice to be grown under non-puddled environments, which have been shown to reduce rice irrigation needs and greenhouse gas emissions without affecting crop production (Senthilkumar *et al.*, 2008). Rice intensification is one of many new agricultural techniques that have lately gained popularity among farmers all around the world. Treating the field with fertilizers and pesticides leads to enhanced soil fertility, which results in improved agricultural yields (Mishra *et al.*, 2013). Standard requirements being used in SRI help in lowering seeds requirements, increasing efficient tiller numbers, stronger roots, reduced reliance on inorganic fertilizer and water supply, and producing a disproportionately higher agricultural output even in droughts (Balamatti & Uphoff, 2017). Published trials on rice intensification revealed that it was enthusiastically embraced by farmers who were dealing with water shortages and resource constraints, particularly small and marginal farmers (SLHs) (Balamatti & Uphoff, 2017).

— Tillage affect severy aspect of the soil ecosystem (Neelam *et al.*, 2010). It is considered to be the main driver of soil health decline (Luo *et al.*, 2010). Thus, to minimise or prevent tillage and to preserve waste on-site for sustainable agricultural and enhancement of soil health, a number of methods have been suggested. The methods used are characterized by three guiding concepts; minimum soil impact, waste holding, or mulching, as well as crop rotation to help maintains oil health (Paul *et al.*, 2013). Although rice-wheat cultivation is extensively practised in the northern-India, no tillage is commonly acknowledged and implemented as the first fundamental of agricultural practices in this region (Bhan & Behera, 2014). The fundamental rationale for this approval is the immediate economic advantages for producers using zero tillage technology. Conservation agricultural systems are presently being used on more than 1.5 million hectares of land in India (Jat *et al.*, 2012). Changes in tillage practises from traditional to conservation have been shown to decrease greenhouse gas emissions, water consumption for irrigated agriculture, which is important for enhanced nutritional use and sustainability. Furthermore, the decrease of carbon dioxide emission and underground aquifers was observed from wheat cultivation in India (Singh *et al.*, 2016). Despite this, the feasibility of waste holding is sometimes challenged by other methods, which is concerning for the sustainable agriculture.

— Energy protection and smart agriculture as well as the implementation of novel advance methods are required to sustain India's exploding population. If applied properly, nanotechnology, with its innovative and sophisticated methods, may provide a quick and effective solution for these problems. In terms of offering effective answers to the many issues that face agricultural production, it presents tremendous possibilities. Nano-fertilizer or Nanobio-fertilizers, nanosensing technologies, nano-pesticides, and nano-formulations can be used as carrier for biological control of diseases and weeds. It contributes to make agriculture more productive and efficient, which would in turn helps to satisfy the growing need for food while also ensuring the long-term viability of the ecosystem (Nair *et al.*, 2010). According to Benoit and colleagues (2013), several soil physico-chemical characteristics, such as soil type, soil organic matter, pH, and nutrient availability, significantly influence the absorption, mobility, and movement of minerals in the soil. Various agricultural crops have shown improved seed germination, development, and vigour index as a result of the application of nanotechnology, according to research (Singh *et al.*, 2016). Furthermore, research on the association of nanotechnology with crops, microbes, and soil have been conducted (Mohanty *et al.*, 2014); nevertheless, the effect of nanotechnology on soil microbial communities is currently under investigation by the scientific community. As a result, in order to expand the scope of nanotechnology applications, it is necessary to do significant research on the distribution, movement, accessibility, and resultant cytotoxicity of nanomaterials under a variety of soil environments (Benoit *et al.*, 2013).

Agricultural input: Recently, agricultural inputs form the backbone of Indian agriculture, and the agricultural inputs of India largely depend on production and productivity. Agriculture is strongly determined by the volume and type of inputs used. Since the Green Revolution, new farming techniques and inputs have helped to increase agricultural production in India. Due to population growth and the limited supply of resources, such as land and water, agricultural production now depends heavily on yields, and focus has turned to science and technology to boost productivity (Gandhi & Johnson, 2019). These discoveries and developments include:

— Better genetics/ high yielding variety seeds better fertilizer nutrients

— Better water supply through water-sourcing technology

— Management pesticides reduce pest problems

— Better physical and time efficiency.

Both public and private sectors have contributed to these efforts. Due to the necessity and demand for these inputs, the seed, fertilizer, irrigation equipment, agrochemical, and farm machinery industries have all grown significantly. They are now significantly improving agriculture. An increasing demand for modern inputs is seen in farmers' desire to raise their production and profits. According to a report the certified seed use has grown six-and-a-half times from 45.0 to 320.4 lakh quintals. 3.8-fold increase in fertilizer use from 60.6 lakh tonnes to 273.75 lakh tonnes. Groundwater irrigation has increased 2.5 times (from 19.34 to 43.12 million hectares). The farm machinery industry has seen a sevenfold increase due to the increase in tractors to 880,402. Only the pesticide business increased, increasing from 50,000 tonnes in the early 1980s to 72,100 tonnes in the early 1990s and increasing to 58,200 tonnes by 2017 (Gandhi).

CONCLUSION AND FUTURE SCOPE

The major problems confronting Agricultural sector at the moment are a knowledge gap and an infrastructural gap, particularly in rural regions. Issues related to water, commerce, and transport networks add considerable expense to producers' livelihoods. An even worse problem is lack of procurement systems. There seem to be a lot of programmes targeted at developing agriculture. Non-efficient transport methods cannot lead to an increase production, decreased cost, or higher price collection at the ground level. Furthermore, ineffective state govt. support exacerbates these issues. Thus, corporate agriculture may be a solution to the Indian agricultural sector, but it requires a deep thought and innovative legislation so that neither the corporations nor the producers or farmer suffer. Food supply depends on agricultural output. Agricultural development in India necessitates the development of highly creative concepts for the improvement of this area. Furthermore, farming is a physically demanding and back-breaking occupation in the absence of automation. A direct consequence of this has been the abandonment of farming by the majority of farmer's children in favour of other careers. Farmers get more income when they sell their property to developers, shopping complexes, and manufacturing plants. This has increased the strain on agriculture, necessitating the development of technology to improve productivity in order for India's dwindling farmland to continue to feed its billion-plus population in the years to come. India, while being one of the world's largest producers of agricultural commodities, has very poor farmers' income.

Conventional farming has accelerated agricultural production, but at the cost of severe ecological damage. People regard organic production as being more sustainable because of its reduced use of external inputs and its smaller environmental impact. According to a new study published recently, smart agriculture has the potential to close the yield gap among both conventional and organic agriculture due to its inherently more diverse biological production systems. Sources mostly employed experimental design, controlled experiment locations, paired farms, and organic system experiments placed within a conventional framework. Can large-scale advanced organic agriculture emulate plot-scale organic yields and environmental benefits? The claims made above are correct. So extensive conclusions should be made with care, and an impartial system comparison is needed.

Acknowledgments. Authors are highly express their sense of gratitude to Swami Ramdev ji for their immense support and guidance. We are also pleased to thank Mr. Sunil Kumar for designing the graphics of this paper.

Conflict of interest. There is no conflict of interest among the authors.

REFERENCES

Abraham, M., & Pingali, P. (2020). Transforming smallholder agriculture to achieve the SDGs. In The role of smallholder farms in food and nutrition security (pp. 173-209). Springer, Cham.

Abraham, M., & Pingali, P. (2021). Shortage of pulses in India: Understanding how markets incentivize supply response. *Journal of Agribusiness in Developing and Emerging Economies*.

Aday, S., & Aday, M. S. (2020). Impact of COVID-19 on the food supply chain. *Food Quality and Safety, 4*(4): 167-180.

Aeschbach-Hertig, W., & Gleeson, T. (2012). Regional strategies for the accelerating global problem of groundwater depletion. *Nature Geoscience, 5*(12): 853-861.

Agarwal, H. P., & Sinha, R. (2017). Urban farming-A sustainable model for Indian cities. *International Journal on Emerging Technologies, 8*(1): 236-242.

Ahmad, L., Kanth, R. H., Parvaze, S., & Mahdi, S. S. (2017). Agro-climatic and agro-ecological zones of India. In Experimental agrometeorology: A practical manual (pp. 99-118). Springer, Cham.

Aker, J. C., & Fafchamps, M. (2015). Mobile phone coverage and producer markets: Evidence from West Africa. *The World Bank Economic Review, 29(*2): 262-292.

Aker, J. C., Ghosh, I., & Burrell, J. (2016). The promise (and pitfalls) of ICT for agriculture initiatives. *Agricultural Economics, 47(*S1): 35-48.

Armanda, D. T., Guinée, J. B., & Tukker, A. (2019). The second green revolution: Innovative urban agriculture's contribution to food security and sustainability–A review. *Global Food Security, 22:* 13-24.

Balamatti, A., & Uphoff, N. (2017). Experience with the system of rice intensification for sustainable rainfed paddy farming systems in India. *Agroecology and Sustainable Food Systems, 41*(6): 573-587.

Barrett, C. B., Bachke, M. E., Bellemare, M. F., Michelson, H. C., Narayanan, S., & Walker, T. F. (2012). Smallholder participation in contract farming: comparative evidence from five countries. *World development, 40*(4): 715-730.

Bateman, A. M., & Muñoz-Rojas, M. (2019). To whom the burden of soil degradation and management concerns. In Advances in Chemical Pollution. *Environmental Management and Protection, 4*: 1-22). Elsevier.

Benoit, R., Wilkinson, K. J., & Sauvé, S. (2013). Partitioning of silver and chemical speciation of free Ag in soils amended with nanoparticles. *Chemistry Central Journal, 7*(1): 1-7.

Bhan, S., & Behera, U. K. (2014). Conservation agriculture in India–Problems, prospects and policy issues. *International Soil and Water Conservation Research, 2*(4): 1-12.

Bhanja, S. N., Mukherjee, A., Rodell, M., Wada, Y., Chattopadhyay, S., Velicogna, I., Pangaluru, K., & Famiglietti, J. S. (2017). Groundwater rejuvenation in parts of India influenced by water- policy change implementation. *Scientific reports, 7*(1): 1-7.

Bhatt, H., Bhushan, B., & Kumar, N. (2019). IOT: the Current Scenario and Role of Sensors Involved in Smart Agriculture. *International Journal of Recent Technology and Engineering, 8*(4), 12011-12023.

Bhattacharyya, R., Ghosh, B. N., Mishra, P. K., Mandal, B., Rao, C. S., Sarkar, D.,Das, K., Anil, K. S., Lalitha, M., Hati, K. M.,& Franzluebbers, A. J. (2015). Soil degradation in India: Challenges and potential solutions. *Sustainability, 7*(4): 3528-3570.

Bohun, V. (2001). Developing Best Practices for Promoting Private Sector Investment in Infrastructure: Roads.

Boretti, A., & Rosa, L. (2019). Reassessing the projections of the world water development report. *NPJ Clean Water, 2*(1): 1-6.

Brausmann, A., & Bretschger, L. (2018). Economic development on a finite planet with stochastic soil degradation. *European Economic Review*, *108*: 1-19.

Brunetti, G., Traversa, A., De Mastro, F., & Cocozza, C. (2019). Short term effects of synergistic inorganic and organic fertilization on soil properties and yield and quality of plum tomato. *Scientia Horticulturae, 252*: 342-347.

Buvik, A., & John, G. (2000). When does vertical coordination improve industrial purchasing relationships ? *Journal of Marketing*, *64*(4), 52-64.

Byerlee, D., De Janvry, A., & Sadoulet, E. (2009). Agriculture for development: Toward a new paradigm. *Annu. Rev. Resour. Econ.*, *1*(1): 15-31.

Carter, M. R., & Barrett, C. B. (2006). The economics of poverty traps and persistent poverty: An asset-based approach. *The Journal of Development Studies, 42*(2): 178-199.

Chakraborty, D. (2018). IoT & Agricultural Marketing: A Case Study. *International Journal of Research*, *9*(1).

Chandrasekhar, S., & Mehrotra, N. (2016). Doubling farmers' incomes by 2022. *Economic & Political Weekly, 51*(18): 10–13

Charania, I., & Li, X. (2020). Smart farming: Agriculture's shift from a labor intensive to technology native industry. *Internet of Things*, *9*: 100-142.

Chauhan, B. S., Mahajan, G., Sardana, V., Timsina, J., & Jat, M. L. (2012). Productivity and sustainability of the rice–wheat cropping system in the Indo-Gangetic Plains of the Indian subcontinent: problems, opportunities, and strategies. *Advances in Agronomy, 11*: 315- 369.

Department of Agriculture, Cooperation & Farmers' Welfare(DAC&FW). Annual Report (2020-21). https://agricoop.nic.in/en/whatsnew

Department of Food and Public Distribution, Government of India. (2021). Warehousing Development and Regulatory Authority. https://dfpd.gov.in/wdraNew.htm

Dhruvanarayana, V. V., & Babu, R. (1983). Estimation of soil erosion in India. *Journal of Irrigation and Drainage Engineering*, *109*(4): 419-434.

Dileep, B. K., Grover, R. K., & Rai, K. N. (2002). Contract farming in tomato: An economic analysis. *Indian Journal of Agricultural Economics*, *57*(2): 197-210.

Ennouri, K., & Kallel, A. (2019). Remote sensing: an advanced technique for crop condition assessment. *Mathematical Problems in Engineering*, 2019.

Fafchamps, M. (2003). Rural poverty, risk and development (Vol. *144*). Edward Elgar Publishing.

fanfare. The Hindu Business Line.

FAO, F. (2016). The state of food and agriculture: Climate change, agriculture and food security. Rome, Italy.

Fischer, R. A., Byerlee, D. R., & Edmeades, G. O. (2009). Can technology deliver on the yield challenge to 2050 ? (No. 138-2016-2032).

Fishman, R., Devineni, N., & Raman, S. (2015). Can improved agricultural water use efficiency save India's groundwater? *Environmental Research Letters, 10*(8): 084022.

Gandhi, V. P. Indian Agriculture at a Crucial Stage: Change and Transformation for a Brighter Future.

Gandhi, V. P., & Johnson, N. (2019). Decision-oriented information systems for farmers: a study of Kisan Call Centres (KCC), Kisan Knowledge Management System (KKMS), farmers portal, and M-Kisan portal. *Agricultural Situation in India, 76*(6): 29-32.

Ganesh, U., Shankar, M., Banerji, S., Borthakur, S., Thukral, C., & Yadav, S. (2018). Reducing post-harvest losses in India: Key initiatives and opportunities. Intellecap and the Rockefeller Foundation.

Ganeshamurthy, A. N. (2009). Soil changes following long-term cultivation of pulses. *The Journal of Agricultural Science, 147*(6): 699-706.

Gangopadhyay, D., Mukhopadhyay, A. K., & Singh, P. (2008). Rural development: A strategy for poverty alleviation in India. India Science and Technology (Online).

GOI. (2020). Pradhan Mantri Garib Kalyan Package (PMGKP). https://www.india.gov.in/spotlight/pradhan-mantri-garib-kalyan-package-pmgkp

González, F. G., Rigalli, N., Miranda, P. V., Romagnoli, M., Ribichich, K. F., Trucco, F., & Chan, R. L. (2020). An interdisciplinary approach to study the performance of second-generation genetically modified crops in field trials: a case study with soybean and wheat carrying the sunflower HaHB4 transcription factor. *Frontiers in plant science*, *11*, 178.

Goswami, B., Bezbaruah, M. P., & Mandal, R. (Eds.). (2017). Indian agriculture after the green revolution: Changes and Challenges. Routledge.

Gupta,G. & Nagar, M. (2017). Agriculture Sector in India: As a Career. *International Journal on Arts, Management and Humanities 6*(2): 01-06.

Hakkim, V. A., Joseph, E. A., Gokul, A. A., & Mufeedha, K. (2016). Precision farming: the future of Indian agriculture. *Journal of Applied Biology & Biotechnology*, *4*(06): 068-072.

Hazra, K. K., Swain, D. K., Bohra, A., Singh, S. S., Kumar, & N., Nath, C.P. 2016. Organic rice: potential production strategies, challenges and prospects. Organic Agric.

Hegazy, R. (2013). Post-harvest situation and losses in India. High Court of Karnataka-Bengaluru Bench: WP, 24739, 2012.

https://agricoop.nic.in/sites/default/files/Web%20copy%20of%20AR%20%28Eng%29.pdf

India Brand Equity Foundation (IBEF) (2021). Indian agriculture and allied industries industry report. https://www.ibef.org/industry/agriculture-india.aspx

Jacoby, H. G. (2017). "Well-fare" economics of groundwater in South Asia. *The World Bank Research Observer, 32*(1): 1-20.

Jat, M. L., Malik, R. K., Saharawat, Y. S., Gupta, R., Mal, B., & Paroda, R. (2012). Regional dialogue on conservation agricultural in South Asia. *Asia Pacific Association of Agricultural Research Institutions (APAARI).* International Maize and Wheat Improvement Center (CIMMYT), *Indian Council of Agricultural Research (ICAR)*, New Delhi, India, 34.

Kamanga, B. C., Kanyama-Phiri, G. Y., Waddington, S. R., Almekinders, C. J., & Giller, K. E. (2014). The evaluation and adoption of annual legumes by smallholder maize farmers for soil fertility maintenance and food diversity in central Malawi. *Food Security, 6*(1): 45-59.

Kaur, N., Singh, E. H., & Singh, J. (2021). Impact of three farm bills on agriculture during COVID-19 in india. PalArch's *Journal of Archaeology of Egypt/Egyptology*, *18*(5): 176-186.

Kebede, Y. (1992). Risk Taking Behaviour and New

Technologies: The Case of Producers in the Central Highlands of Ethopia. Quarterly journal of international agriculture (Germany).

Kumar, S. M. (2013). Does access to formal agricultural credit depend oncaste? *World Development, 43*: 315-328.

Lathamani, B. (2021). Application of Altman's Z Score Model to assess the Financial stability of select Food Processing Industries listed in BSE, India. I would like to express my gratitude to all authors for their outstanding contributions in general and in particular to the members of technical review committee and session chairpersons for their competent evaluation of a large number submissions. I would like to take this opportunity to place on record my sincere appreciation to members of organizing team for their untiring efforts., 113.

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., McCarthy, N., Meybeck, A., Neufeldt, H., Remington, T., Sen, P. T., Sessa, R., Shula, R., Tibu, A., & Torquebiau, E. F. (2014). Climate-smart agriculture for food security. *Nature climate change, 4(*12): 1068-1072.

Luo, Z., Wang, E., & Sun, O. J. (2010). Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments. *Agriculture, ecosystems & environment, 139*(1-2): 224-231.

Matson, P. A., Parton, W. J., Power, A. G., & Swift, M. J. (1997). Agricultural intensification and ecosystem properties. *Science*, *277*(5325): 504-509.

McCullough, E. B., Pingali, P. L., & Stamoulis, K. G. (2012). Small farms and the transformation of food systems: an overview. *The Transformation of Agri-Food Systems:* 27-70.

McCullough, E. B., Pingali, P. L., & Stamoulis, K. G. (Eds.). (2008). The transformation of agri- food systems: globalization, supply chains and smallholder farmers. *Food & Agriculture Org*.

Ministry of Agriculture & Farmers Welfare: Sub-Mission on Seeds & Planting Materials. (2021). https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1697977

Mishra, A., Kumar, P., & Noble, A. (2013). Assessing the potential of SRI management principles and the FFS approach in Northeast Thailand for sustainable rice intensification in the context of climate change. *International journal of agricultural sustainability, 11*(1): 4-22.

Mittal, S., & Mehar, M. (2012). How mobile phones contribute to growth of small farmers? Evidence from India. *Quarterly Journal of International Agriculture, 51*(892-2016- 65169), 227-244.

Mohanty, A., Wu, Y., & Cao, B. (2014). Impacts of engineered nanomaterials on microbial community structure and function in natural and engineered ecosystems. *Applied microbiology and biotechnology*, *98*(20): 8457-8468.

Mupambwa, H. A., & Mnkeni, P. N. S. (2018). Optimizing the vermicomposting of organic wastes amended with inorganic materials for production of nutrient-rich organic fertilizers: a review. *Environmental Science and Pollution Research, 25*(11): 10577-10595.

Murphy, S. (2010). Changing perspectives: Small-scale farmers, markets and globalization. *International Institute for Environment and Development* (UK) and Hivos (Netherlands).

Muto, M., & Yamano, T. (2009). The impact of mobile phone coverage expansion on market participation: Panel data evidence from Uganda. *World development, 37(*12): 1887-1896.

Mythili, G., & Goedecke, J. (2016). Economics of land degradation in India. In Economics of land degradation and improvement–a global assessment for sustainable development (pp. 431- 469). Springer, Cham.

Nair, R., Varghese, S. H., Nair, B. G., Maekawa, T., Yoshida, Y., & Kumar, D. S. (2010). Nanoparticulate material delivery to plants. *Plant science*, *179*(3): 154-163.

Narayanamoorthy, A., & Alli, P. (2018). Agriculture market reforms are a must. The Hindu Business Line, 8.

Narayanan, S. (2014). Profits from participation in high value agriculture: Evidence of heterogeneous benefits in contract farming schemes in Southern India. *Food Policy, 44:* 142-157.

National Agriculture Market (eNAM). (2017). Training Manual for National Agriculture Market. https://enam.gov.in/web/docs/eNAM%20Portal.pdf

Neelam, A. A., Gaur, A., Bhalla, E., & Gupta, S. R. (2010). Soil aggregate carbon and diversity of mycorrhiza as affected by tillage practices in a rice-wheat cropping system in northern India. *Int. J. Ecol. Environ. Sci., 36*: 233-243.

Nirmal, R. (2017). Why the eNAM platform hasn't taken off despite all the

NITI Aayog. (2021). Poverty Alleviation Programme. https://niti.gov.in/planningcommission.gov.in/docs/plans/planrel/fiveyr/9th/vol2/v2c2-1.htm

OCED. (2018). OECD Food and Agricultural Reviews. http://www.indiaenvironmentportal.org.in/files/file/agricultural%20policies%20in%20India.pdf

Ogutu, S. O., Okello, J. J., & Otieno, D. J. (2014). Impact of information and communication technology-based market information services on smallholder farm input use and productivity: The case of Kenya. *World Development, 64*: 311-321.

Paramesh, V., Dhar, S., Dass, A., Kumar, B., Kumar, A., El-Ansary, D. O., & Elansary, H. O. (2020). Role of integrated nutrient management and agronomic fortification of zinc on yield, nutrient uptake and quality of wheat. *Sustainability*, *12*(9): 3513.

Paterson, R. R. M., & Lima, N. (2011). Further mycotoxin effects from climate change. *Food Research International*, *44*(9): 2555-2566.

Paul, B. K., Vanlauwe, B., Ayuke, F., Gassner, A., Hoogmoed, M., Hurisso, T. T., Koalab, S., Lelei, D., Ndabamenyea, T., Six, J.,& Pulleman, M. M. (2013). Medium-term impact of tillage and residue management on soil aggregate stability, soil carbon and crop productivity. *Agriculture, ecosystems & environment, 164*: 14-22.

Pingali, P. (2010). Agriculture renaissance: making "agriculture for development" work in the 21st century. *Handbook of agricultural economics, 4*: 3867-3894.

Pingali, P. L. (2012). Green revolution: impacts, limits, and the path ahead. Proceedings of the *National Academy of Sciences, 109*(31): 12302-12308.

Pingali, P., Aiyar, A., Abraham, M., & Rahman, A. (2019). Linking farms to markets: reducing transaction costs and enhancing bargaining power. In Transforming food systems for a rising India (pp. 193-214). Palgrave Macmillan, Cham.

Pingali, P., Khwaja, Y., & Meijer, M. (2005). Commercializing small farms: Reducing transaction cost.

Planning Commission. (2011). Report of the Working Group on Agricultural Marketing Infrastructure, Secondary Agriculture and Policy Required for Internal and External Trade for the XII Five-Year Plan 2012-17. Agriculture Division, Planning Commission, New Delhi.https://niti.gov.in/planningcommission.gov.in/docs/aboutus/committee/wrkgrp12/agri/weg_rep_market.pdf

Plant Protection, Quarantine & Storage: Statistical Database. (2021). http://www.ppqs.gov.in/statistical-database/all-india-statistics-area-under-cultivation-and-under-use-chemical-bio

Poulton, C., Dorward, A., & Kydd, J. (2010). The future of small farms: New directions for services, institutions, and intermediation. *World development, 38*(10): 1413-1428.

Prasad, R. (2009). Efficient fertilizer use: The key to food security and better environment. *Journal of tropical agriculture, 47*(1): 1-17.

Pretty, J., Toulmin, C., & Williams, S. (2011). Sustainable intensification in African agriculture. *International journal of agricultural sustainability, 9*(1): 5-24.

Rajib, P. (2015). Indian agricultural commodity derivatives market–In conversation with S Sivakumar, Divisional Chief Executive, Agri Business Division, ITC Ltd. *IIMB Management Review, 27*(2), 118-128.

Rao, N. C., Carl, E. P., & Ronald, J. H. (2018). Biotechnology for second green revolution in India, overview of issues. Biotechnology for a second green revolution in India, socioeconomic, political and public policy issues. Academic Foundation, New Delhi.

Ravindran, B., Nguyen, D. D., Chaudhary, D. K., Chang, S. W., Kim, J., Lee, S. R., & Lee, J. (2019). Influence of biochar on physico-chemical and microbial community during swine manure composting process. *Journal of environmental management, 232*: 592-599.

Reddy, A. (2017). Impact of e-markets in Karnataka, India. *Indian Journal of Agricultural Marketing, 30*(2), 31-44.

Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T., & Woznicki, S. A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. *Climate Risk Management, 16,* 145-163.

Roy, T. (2020). Precision farming: A step towards sustainable, climate-smart agriculture. In Global Climate Change: Resilient and Smart Agriculture (pp. 199-220). Springer, Singapore.

Sacco, D., Moretti, B., Monaco, S., & Grignani, C. (2015). Six-year transition from conventional to organic farming: effects on crop production and soil quality. *European Journal of Agronomy, 69*: 10-20.

Senthilkumar, K., Bindraban, P. S., Thiyagarajan, T. M., De Ridder, N., & Giller, K. E. (2008). Modified rice cultivation in Tamil Nadu, India: yield gains and farmers' (lack of) acceptance. *Agricultural Systems, 98*(2): 82-94.

Shen, Y., Sui, P., Huang, J., Wang, D., Whalen, J. K., & Chen, Y. (2018). Global warming potential from maize and maize-soybean as affected by nitrogen fertilizer and cropping practices in the North China Plain. *Field Crops Research, 225*: 117-127.

Shiao, T., Maddocks, A., Carson, C., & Loizeaux, E. (3). 3 maps explain India's growing water risks.

Shibusawa, S. (2002). Precision farming approaches to small-farm agriculture. Food and Fertilizer Technology Center.

Singh, O. P., Singh, R., Lakra, K., & Singh, P. K. (2016). Impact of zero tillage on environment and wheat productivity: evidences from Gorakhpur District of Eastern Uttar Pradesh, India. *International Journal of Agricultural and Statistical Sciences, 12*(Suppl. 1), 21-28.

Singh, S. (2000). Contracting Out Solutions: Political Economy of Contract Farming in the Indian Punjab.

Singh, S. (2011). FDI in retail: Misplaced expectations and half-truths. Economic and Political Weekly, 13-16.

Swain, B. B. (2011). Contract farming in Andhra Pradesh: A case of rice seed and gherkin cultivation. *Economic and Political Weekly*, *46*(42), 60-68.

Swinnen, J. F., & Maertens, M. (2007). Globalization, privatization, and vertical coordination in food value chains in developing and transition countries. *Agricultural economics, 37*: 89-102.

Talaviya, T., Shah, D., Patel, N., Yagnik, H., & Shah, M. (2020). Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. *Artificial Intelligence in Agriculture, 4:* 58-73.

Thorat, S. (2009). Economic exclusion and poverty linkages: A reflection on concept, consequences, and remedies in an Asian context. About IFPRI and the 2020 Vision Initiative, 421.

Vetter, S. H., Sapkota, T. B., Hillier, J., Stirling, C. M., Macdiarmid, J. I., Aleksandrowicz, L., & Smith, P. (2017). Greenhouse gas emissions from agricultural food production to supply Indian diets: Implications for climate change mitigation. *Agriculture, ecosystems & environment, 237:* 234-241.

Warner, M., & Kahan, D. (2008). Market-oriented agricultural infraestructure: appraisal of public-private partnerships (No. N10/9778). FAO, Roma (Italia).

Sharma, U., Paliyal, S. S., Sharma, S. P., & Sharma, G. D. (2014). Effects of continuous use of chemical fertilizers and manure on soil fertility and productivity of maize–wheat under rainfed conditions of the Western Himalayas. Communications in soil science and plant analysis, *45*(20): 2647-2659.

How to cite this article: Balkrishna, A**.,** Phour, M., Thapliyal, M. and Arya, V. (2021). Current Status of Indian Agriculture: Problems, Challenges and Solution. *Biological Forum – An International Journal, 13*(3): 361-374.