

Chapter 16

Driving Growth in Agriculture and Allied Sectors Through Public–Private Partnerships

M Srikanth

National Institute of Agricultural Extension Management, Hyderabad, India

G Naveen Kumar

National Institute of Agricultural Extension Management, Hyderabad, India

Kanchan Bhagwat

National Institute of Agricultural Extension Management, Hyderabad, India

ABSTRACT

Public Private Partnerships (PPPs) are important for effective delivery of a service or facility for the use of general public in order to drive growth not just in agriculture but also in other sectors of the economy. While the PPPs are well-established in infrastructure sector, they are relatively new in agriculture. After tracing the origin, and setting theoretical context, this chapter analyses significant developments in the Ag-PPPs by narrating a few case studies across the globe, along with their practical challenges at the field level. Further, the chapter suggests certain policy measures to achieve the sustainable development in an agrarian economy like India. The analytical insights are useful for the policy makers as well as the stakeholders.

INTRODUCTION

As agriculture has not been a commercially viable enterprise in India due to a variety of reasons such as sale of spurious inputs by agri-input dealers, inadequate and untimely credit from banks/financial institutions, scarce and expensive access to water, lack of proper extension services, exploitation of farmers by various agents, and limited alternative sources of (non-farm) income (Dev, 2005), innovative solutions are necessary to make the sector financially sustainable. Further, according to the World Bank (2024), exponential growth in population, climate change coupled with increasing greenhouse gas emissions from agri-food systems, shrinking of arable land, and alarming rate of food loss and waste (FLW) have been

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putting additional pressure on agriculture to enhance its efficiency by 70 per cent by 2050. Therefore, it is very much essential to bring in a transformative change in the agriculture & allied sectors to meet the welfare needs of the farming community by involving all stakeholders in the development process, through workable collaborations such as Public Private Partnerships (PPPs or P3).

The PPPs are collaborative mechanisms wherein public sector entities and private enterprises share risks and rewards with a view to achieving efficiency in producing and delivering public goods and services. Essentially, these partnerships are built on '*common interest / comparative advantage*' for effective delivery of a service or facility for the use of general public. The PPPs are institutional mechanisms to mobilize resources, share risks, and overcome various challenges in order to achieve inclusive and sustainable agricultural development (FAO, 2013 a; Delmon, 2010). The PPPs are essential for ensuring social and environmental sustainability and the commercial viability of food supply chains (World Economic Forum, 2013). In today's competitive economy, quantity as well as quality of agri-produce are very important and the PPPs have the potential to achieve these, along with modernization of agriculture sector by engaging the small holders (Appolloni et al., 2021).

Specifically, Agriculture-Public Private Partnership (Ag-PPP) can be broadly formed in respect of *i*) development of agricultural supply chains; *ii*) joint agricultural research, technology transfer, and innovation; *iii*) building post-harvest processing and market infrastructure; *and* *iv*) providing business development and market-linkages to the farmers, micro and small enterprises. Potential partnerships in agriculture & allied sectors could be categorized into Public-Public, Public-Private, and Private-Private. While certification of seeds, ecological studies, technology incubation, applications of science and biotechnology among various institutes of Indian Council of Agricultural Research (ICAR), agricultural universities and line departments may fall under Public-Public partnership; activities such as extension services, crop insurance, contract farming, and agri-tourism come under the Public-Private partnership; and manufacturing of agri-inputs, farm machinery, processing, marketing and distribution of agri-produce may be classified as Private-Private Partnership. These partnerships may be formed primarily with a view to filling up certain voids such as financial constraints, knowledge deficits, skill gaps, obsolete technology, absence of market linkages, and inadequate infrastructure apart from addressing the issues like crop failures, pests & diseases, climate change, and disaster management in agriculture & allied sectors. The PPPs in agriculture & allied sectors lead to mobilization of farmers, youth, poor, and women for their social, economic, political, and financial empowerment, while achieving the greater public good (Brinkerhof and Brinkerhof, 2004). In view of the above, the Ag-PPPs are essential tools to achieve 'synergy by unlocking the energy' of both the public and private partners mainly for the benefit of small holders.

The Ag-PPPs have been instrumental in driving innovation, adoption of advanced technology, and sustainable agricultural practices especially in countries like Brazil (export of agri-commodities), China (integration of technology and good agricultural practices) and the USA (high yielding varieties and farm mechanization) (Srikanth and Rana, 2024). In a developing country like India, Ag-PPPs are essential to promote agricultural sustainability and address issues related to food and nutritional security. The PPPs help provide access to technology so that the farmers can be linked to the markets (Agarwal et al., 2023). Also, the Ag-PPPs are frequently marketed as a way to modernize the industry and offer numerous advantages to the small and marginal farmers¹ in achieving sustainable development in agriculture & allied sectors. While the governments primarily concentrate on infrastructure development through the Ag-PPPs, private partners play a crucial role in enhancing efficiency of scarce natural resources and delivering economic value to the farmers (Ponnusamy, 2013). In agrarian societies, the Ag-PPPs have been

instrumental in fostering technology transfer, enhancing value chain development, boosting agricultural productivity, promoting commercialization, generating income, and ensuring food / nutritional security for well-being of the population. P3 facilitates constructive engagement among various stakeholders thereby enabling them to leverage their strengths and mitigate risks effectively (Menezes et al., 2018).

In the Indian context, while the public sector partners typically consist of government entities such as ministries, departments, municipalities, or state-owned enterprises, private partners may include local or international businesses, investors possessing relevant technical or financial expertise, and increasingly, non-governmental organizations (NGOs) and community-based organizations (CBOs) such as self-help groups (SHGs), Cooperatives, and farmers producer organizations (FPOs).

As the Government of India aims at sustainable growth through 'ease of living', rapid growth in agriculture, it opts for private intervention in the sector as the appropriate policy response (Bhardwaj et al., 2022). Accordingly, in the union budget for FY2021-22, the Government announced provision of hi-tech services to the farmers through the PPP mode. Economic value of use of technology in Indian agriculture is estimated to be around US\$ 50-65 billion by 2025 (Hans, 2024). Thus, the PPPs in agriculture have immense potential and are set to gain momentum in the near future, transforming agriculture & allied sectors as well as the country's economy.

Rest of the chapter is organized in the following manner. Section 2 provides historical perspective on the PPPs. Section 3 focuses on theoretical background. Section 4 narrates 12 case studies across the globe in Ag-PPP space, along with their field level challenges. Section 5 analyzes relevant data and reports major constraints in the Ag-PPP and the last section concludes by offering a few policy recommendations.

Historical Perspective of PPPs

In the world history, the PPPs mainly existed for construction of ports and inland harbours during the rule of Roman empire till the 15th Century. Later, the industrial revolution in the 19th Century paved the way for urbanization, and consequent expansion of public networks for water supply, sewage, energy, and transportation, etc. During the First World War, transport infrastructure projects were executed with the government funding. Subsequently, there has been a renewed push for creation/expansion of public infrastructure through liberalization, privatization, and globalization moves throughout the industrialized and developing nations since 1980s. Accordingly, the PPPs have been resurfaced as the governments in emerging economies like Brazil, China, Chile, Hungary, and India found it difficult to finance the infrastructure projects, which require massive capital outlays. Therefore, these governments primarily focused on outsourcing public services to private partners in education, healthcare, and infrastructure (Gerrard, 2001). Further, as majority of the developing countries are agri-based economies with limited (financial) resources and expertise to provide the public goods and services for all, the PPPs have gained traction as collaborative models that bring together government, businesses, and social organizations on a common platform to boost productivity thereby driving growth. While the PPPs are well-established in infrastructure, healthcare, and education sectors, they are relatively new in agriculture (FAO, 2016).

However, in India, it is observed that contract farming is the common form of Ag-PPP and around 45 per cent of cash crops and livestock farms are engaged in this business (Chazovachi et al, 2021). In fact, the contract farming has been in practice in India since 1960s in the seed sector; and in other farm produce since 1990s, with Pepsico procuring Chilly, Potato and Tomato (Singh, 2022). Using Meta-analysis, Cariappa et al. (2023) concluded that contract farming can reduce input costs by 28 per cent, enhance productivity by 20 per cent, and increase profits by 51 per cent. As such, the contract farming is

considered as an institutional solution to mitigate price and market risks, and to provide private extension services to small holders in a cost-effective manner.

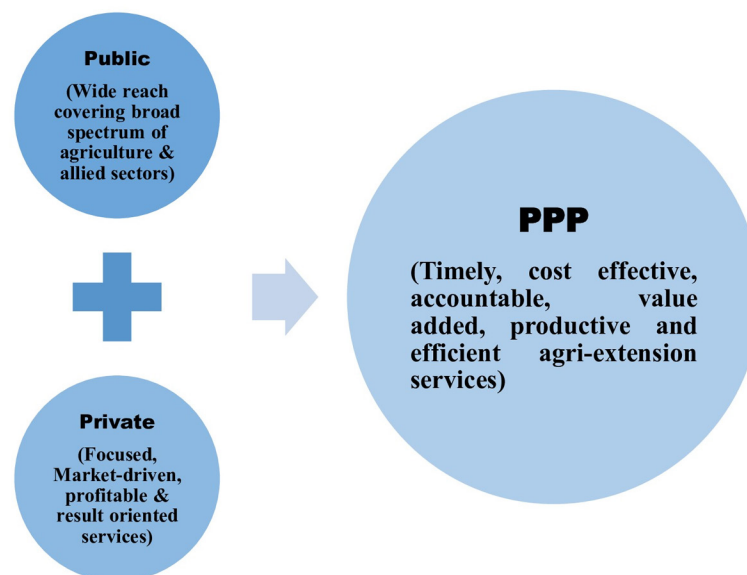
Theoretical background of PPP

According to Food and Agriculture Organization (FAO), the world population would reach 9.1 billion by 2050 and in order to feed them, agriculture sector needs to produce 70 per cent more food than the present levels – that too with existing resources. Scarcity of natural resources such as water and land, coupled with climate change calls for innovative collaborations among institutions and sectors to make agriculture sustainable in the 21st Century (Ivanova, 2021; Goodarzian et al., 2021). Besides, it is imperative to address problems emanating from middle-men induced (escalated) pricing of agri-commodities (Agarwal et al., 2023). Specifically, economic viability of the farmers, promotion of environmental-friendly practices, and engagement of community for collective action should be undertaken through Ag-PPPs for achieving sustainability of the agriculture & allied sectors (Dagar et al., 2021).

The PPPs aim at leveraging the strengths of both sectors to enhance agricultural productivity, integrate value chains from production to processing to marketing, and boost rural economies. Key enabling factors for successful Ag-PPPs are well-defined roles and responsibilities of the partners to ensure their commitment and ownership, transparent and competitive bidding process for award of the projects, right engagement of stakeholders, inclusive market access, effective risk management, and continuous monitoring & evaluation (Mohania and Pandey, 2024) and suitable mechanisms for resolution of conflicts (Katyial, 2005). Obayelu (2018) concluded that strong political will, good governance, and provision of enabling economic and regulatory environment for the private sector to operate are major drivers of successful PPPs in agri-business.

There are four pre-requisites for successful PPP models with regard to market driven agri-extension: *i*) market potential; *ii*) Connectivity to the market; *iii*) suitability of crops (agro-ecological conditions) to a specific region; *and iv*) crop diversity (Singh, 2013). Through the Ag-PPPs, the small holders could enhance the productivity and intensity of established crops, and experiment with non-traditional/high-value crops (Singh et al., 2020). Figure 1 captures the PPP model in agriculture & allied sectors.

Figure 1. PPP in Agriculture & Allied Sectors



Source: Review of literature

Stakeholder theory emphasizes on the importance of involving all relevant stakeholders in the PPPs. Effective stakeholder engagement ensures that the interests and needs of all parties are considered, leading to more sustainable and inclusive outcomes. According to *complementarity theory*, public and private sectors have complementary strengths that, when combined, can produce better results than either could achieve alone. In agriculture, the public sector often provides regulatory frameworks, infrastructure, and research, while the private sector contributes in terms of technology, efficiency, and capital investment. *The resource mobilization theory* posits that the PPPs pool resources like assets, finance, human capital, technology, and knowledge which are critical for large-scale agricultural development. As per this theory, the private sector partners normally bring advanced technologies and innovative practices, whereas public institutions facilitate their dissemination and adoption through extension services, training, and capacity building programmes.

The PPPs are generally successful, if the concerns of both public and private parties are taken care of, while forging alliances (Rao et al., 2023). However, there are a few successful and working business models in the Ag-PPP, which are worthy for emulation; even if there are success stories, sufficient data are not available to validate and replicate the same elsewhere (Singh and Agrawal, 2020). In a typical Ag-PPP setting, while the public sector is focusing on creation of infrastructure facilities, the private sector emphasizes on enhancement of productivity of natural resources to secure economic benefits to the farmers by investing in technology, land reclamation and improvement, farm equipment, etc. (Ivanova, 2021).

In a recent paper on PPPs in the Indian agricultural sector, Mohania and Pandey (2024) found that the P3 model leads to favourable outcomes for the farmers in terms of increased production, productivity, and turnover through specific interventions. It is well documented that the role of the PPPs in agricultural research domain in providing access to cutting-edge research tools, materials, skills, and proprietary

knowledge associated with product development, deployment, and marketing (Pray, 2001; Spielman and Grebmer, 2006); such partnerships benefit the private firms by providing access to emerging markets and opportunities to strengthen corporate social responsibility programmes, scientific talent, corporate brand equity, and investor confidence (Reinhardt, 2004; Hall, 2005).

The Ag-PPPs are evaluated, broadly, on parameters such as enhancement in production, productivity, income levels of the stakeholders, mainly smallholders, development and transfer of technology, leveraging agri-value chains for establishment of market linkages, return on investment including social / environmental benefits. At a macro-level, contribution of the Ag-PPPs will be measured in terms of outcomes such as achievement of the Sustainable Development Goals (SDGs).

Case Studies in Ag-PPPs

At present, the PPP is one of the time-tested and classic strategies to achieve intended objectives to deliver public goods and services and infrastructure facilities in agriculture, extension, education, healthcare, science & technology within the time frame (Ponnusamy, 2013). The World Bank sponsored a PPP project in India involving establishment of market-oriented collaborative alliances resulting in 51 value chains covering agro-forestry, Cobia, Cotton, Marigold, nutraceuticals, etc. (Kochu Babu et al., 2011). International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) collaborated with 34 small and medium enterprises for commercializing Sorghum, Millet, and Pigeonpea hybrids, thereby contributing to the commercial viability of domestic seed firms and wider seed market in India. By obtaining approval from the Government of India, Mahyco partnered with Monsanto to introduce Bt Cotton in India and this resulted in unprecedented rise in cultivation of Bt Cotton from 29,000 Ha. in 2002 to 9.4 million Ha. in 2010 (James, 2010). Besides, the productivity of cotton witnessed increase from 301 kg/ha in 2003 to 526 kg/ha in 2010 apart from decline in cost of production up to 46 per cent (Ramasundaram et al., 2011). The Government of Nepal partnered with Dabur India Limited to grow 7 high-value medicinal plants under buy-back arrangement (Shakya, 2005). In 2008, Syngenta Foundation in Kenya and Telenor group in Thailand formed the Ag-PPP to help farmers obtain data on weather and markets using mobile phone. Further, crop insurance against drought was made truly affordable in the East Africa through the PPP using data from weather station leading to quick settlement of claims through the phone (Narrod et al., 2007).

Of late, the governments especially in the global South, actively promote agri-tourism as a vital form of PPP model by offering subsidies and incentives to support the farmers and other stakeholders. The goal is to encourage tourists to participate not only in agricultural activities, but also in various aspects of rural life, such as local cuisine, traditions, culture, arts, and sports (Dsouza et al., 2023). Through 'Incredible India' initiative, the Government has been making concerted efforts to position the country as a global tourism destination by 2047. Further, the Government of Maharashtra launched the Agri-tourism Development Corporation to impart training and skilling to the farmers, while Kerala State Government introduced Sustainable, Tangible, Responsible, Ethnic Tourism (STREET) initiative in May 2022, thereby pioneering experiential rural tourism. Inspired by these, several State Governments in India are encouraging the farmers to embrace agri-tourism with a view to attracting tourists across the globe. However, the main challenges in agri-tourism are huge capital investment, weak communication skills of staff, and lack of specific policy for promotion of agri-tourism (Krishna, 2019). It is reported that absence of clear-cut policies, resource assistance, and incentives remain major hurdles to the expansion of agri-tourism (Sennimalai et al., 2025). Pinky and Kaur (2014) concluded that lack of government's

support, seasonality of tourists, absence of proper credit facilities and unwillingness of the tourists to purchase farm products are the major issues in agri-tourism PPP model.

Apart from the above, certain Ag-PPPs have been implemented in India and elsewhere in order to attain equitable and inclusive growth.

Table 1. Details of the case studies in the Ag-PPPs.

Name of the Ag-PPP	Country	Major Impact (+ve and -ve Factors)
1. Oil Palm Development Plasma Programme	Indonesia	+ Improved standards of living of the farmers; villages became vibrant market places - deforestation, deprivation of land rights, and exploitation of farmers in few instances.
2. Bio-gas Project	Thailand	+ Conservation of 2.72 million litres of crude oil and 2.28 million kilo grams of liquefied petroleum gas per annum due to implementation of the project; + the project could reduce the annual energy cost of THB 13.46 million and reduce emission of greenhouse gases to the extent of 41.6 million kilo grams per annum (thereby contributing to climate resilience)
3. Farmer Enterprise Groups	Pakistan	+ Creation of direct employment to 26,168 farmers and indirect employment to 9,935 people which led to enhancement of their income levels
4. Market Infrastructure Development Project	Bangladesh	+ Increased crop yields of the farmers, resulting in additional income per farmer ranging from BDT 3,000 (US\$40 in respect of fruits) to BDT 21,000 (US\$270 with regard to fish) + Strong market linkages - Many infrastructure facilities were planned but could not be completed
5. International Flower Logistic Port	China	+ Seamless export of flowers with an internal rate of return of 15.2% through creation of sustainable agri-value chains
6. Production of Maize for Food Security	China	+ Enhanced level of Maize yield potential + Reduced reactive nitrogen losses and greenhouse gas emissions significantly
7. Saagu Baagu for Sustainable Agriculture	India	+ By using AI/ML and robotics, the farmers could witness higher plant growth of 21%, reduction of 9% and 5% in use of pesticides and fertilizers respectively, and received increased average sales revenue to the extent of 8% with regard to Chilli crop
8. Agri-Infrastructure Fund	India	+ Affordable financial assistance for establishment of integrated post-harvest management infrastructure by the farmers/collectives - Inadequacy of loan amount for creation of sizable infrastructure facilities - Non-sanction of working capital funds - Inordinate delay in receipt of interest subvention as well as guarantee fee - Lack of awareness of bank officials/line department officials on the mechanics of the scheme
9. Crop Insurance Scheme	India	+ Financial support to the farmers in the event of failure of any of the notified crop due to natural calamities, pests, and diseases + Nominal premium to be paid by the farmers and the balance by the Government to the insurance companies - Lack of awareness of the scheme among the farmers and hence low coverage - Non-settlement of claims by the insurance companies in a transparent manner - Insurance companies are getting richer at the cost of public exchequer
10. Electronic National Agricultural Market (e-NAM)	India	+ Price discovery of agri-commodities in on-line mode in a transparent manner + access to quality agri-produce in bulk, at one place - low awareness level of the stakeholders on the operational aspects of e-NAM and negligible level of participation of farmers; - lack of proper infrastructure at APMCs - prevalence of cash transactions and delay in payments to the farmers

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Table 1. Continued

Name of the Ag-PPP	Country	Major Impact (+ve and –ve Factors)
11. Development of Food Grain Silos	India	+ Fully automated operations ensured quick service, transparent, and accurate transactions at all stages and timely payment to farmers and minimizing the losses
12. Contract Farming in Potato	India	+ higher yields, remunerative prices, and better profitability for the chip-grade Potato growers - Higher costs of production under the contract - Potatoes were frequently rejected by PepsiCo

- 1) **Oil Palm Development Plasma Programme in Indonesia** Local governments of Indonesia had tied up with private partners during 2002-06 and developed oil palm estates in South Sumatra province with a view to improving knowledge as well as income levels of farmers. The main aim of the project is to develop the Oil Palm value chain and empower 2,500 local farmers who are the members of village unit cooperatives in Indonesia. While Local Estate Crops Agency, South Sumatra Province District Government, National Land Agency and Bank BNI and Bank Mandiri are public partners of the project, London Sumatra Indonesia Tbk, Village Unit Cooperatives and the farmers are private partners. Total cost of the project was estimated at USD 16.7 million, with public and private shares of 37 per cent and 63 per cent respectively. While the public partners of the project provided land permits/land-use rights for implementation of the project apart from developing and monitoring of Oil Palm plantations, the private partner - London Sumatra Indonesia Tbk provided technical services, including training to the stakeholders, besides maintaining guarantee fund for the project. While village unit cooperatives developed the Oil Palm estates, they were also involved in transfer of technology, and bought-back Oil Palm produce from the farmers. The main role of the farmers was to maintain Palm Oil plantations, harvest, and sell the produce according to the instructions and technical guidance of the private partner. Main outcomes of the project were enhanced standards of living of the farmers and the villages became vibrant centres of economic activity in Sumatra Province of Indonesia (FAO, 2013 b). However, the Plasma project was criticised in respect of deprivation of land rights, deforestation, and exploitation of farmers in few instances.
- 2) **Bio-gas Project in Thailand** With a view to promoting bio-mass technology, and producing alternative energy from bio-gas through treatment of waste water in poultry sector of Chiangmai Province, Thailand a PPP project was implemented during 2008-13. In the capacity of public partner, Energy Research and Development Institute provided technical know-how, apart from design, installation, monitoring & evaluation of poultry slaughter houses of the bio-gas project. The private partners were responsible for bringing equity capital, selection of construction companies, promotion, development and distribution of bio-gas systems. Estimated cost of the project was USD 620,000. While the public partner's share was 30 per cent, private partners contributed 70 per cent of the cost of the project. The project was instrumental in introducing bio-gas generation systems, by conserving 2.72 million litres of crude oil per annum, and 2.28 million kilo grams of liquefied petroleum gas per annum. Besides, Chiangmai Province could reduce its annual energy cost close to THB 13.46 million and reduce emission of greenhouse gases to the extent of 41.6 million kilo grams per annum due to implementation of the PPP project (FAO, 2013 c).

- 3) **Formation of Farmer Enterprise Groups in Pakistan** Agri-business Support Fund (ASF) mobilized 20,000 Pakistani farmers during 2006-07 for developing farm enterprises by implementing a PPP project at a total cost of USD 4.80 million. Key responsibilities of ASF include formation of farmer enterprise groups, providing handholding support through technical assistance and matching grants to the extent of 50 per cent, arranging credit, monitoring & evaluation of the development of enterprises. Few non-governmental organizations too participated in the project by imparting technical and managerial training and agri-extension services to the farmer enterprises. At the end of the project, 2,000 Farmer Enterprise Groups had been formed and 1,121 micro agri-business enterprises were created. Thus the project created direct employment to 26,168 farmers and indirect employment to 9,935 people which ultimately led to enhancement of their income levels. More specifically, the treatment group experienced an increase of 165 per cent in average initial profit, in real terms i.e., USD 673 more profit when compared with the control group (FAO, 2013 d).
- 4) **Market Infrastructure Development Project in Charland Region, Bangladesh** Market Infrastructure Development Project was implemented during 2006-13 in Charland region, one of the poorest and the most remote areas in Bangladesh, to strengthen linkages among farmers, input suppliers and high-value agricultural market participants. This PPP project aimed at enhancing smallholder farmers' productivity by providing technical knowledge and fostering market linkages. The Rural Enterprise Component, led by the international NGO iDE, helped smallholders access remunerative market opportunities by developing sustainable value chains. Total cost of the project was US\$ 43.9 million. While International Fund for Agricultural Development (IFAD) granted a loan of US\$24.9 million for implementation of the project, the remaining amount was contributed by Pari Karma Sahayak Foundation (PKSF), a non-profit organization established by the Government of Bangladesh. The project assisted 72,000 poor micro-agri-entrepreneurs through training and micro-credit in selected value chains. Significant outcomes of the project were increased crop yields of the farmers, additional income per farmer ranging from BDT 3,000 (US\$40 in respect of fruits) to BDT 21,000 (US\$270 with regard to fish), strong market linkages between farmers and other value-chain stakeholders and supply of better quality inputs to the producers (IFAD, 2013). The major concerns of the project were many infrastructure facilities were planned but could not be completed (ex: deep tube wells and latrines, digging of canals and twin houses were constructed but not completed/allotted). Though the bus stand was constructed, buses won't ply in that route.
- 5) **Beijing International Flower Logistic Port Project of China** The local government of China namely Beijing Shunyi District Authority collaborated with a private partner (Beijing Shunxin Agricultural Co. Ltd) to construct the international flower logistics port and also to set up a company for the export operations during 2008-10. Total cost of the project was US\$ 174.9 million. While the public partner provided land use rights for implementation of the project, Beijing Shunxin Agricultural Co. Ltd. constructed the horticulture market infrastructure facilities. The main outcome of the PPP project is seamless export of flowers from China with an annual business income of US\$42 million, with an internal rate of return of 15.2 per cent through creation of sustainable agri-value chains (FAO, 2016).
- 6) **Production of Maize for Achieving Food Security in China** This PPP model in China aimed at increasing production of Maize to enhance both food security and environmental sustainability. While the private sector enterprises supplied fertilizers, bio-pesticides, and new proprietary seeds and varieties, along with equipment like large-scale harvesters and farm machinery, the public sector provided cropping system technologies and best management practices (Hou et al., 2020). Specifically,

the public sector research institutes provided extension services on region-specific optimal sowing and harvesting dates, controlled-release of fertilizers and efficient irrigation systems. This PPP model achieved 78.7 per cent of Maize yield potential, compared to 61.8 per cent in smallholder farms. Additionally, the PPP significantly reduced reactive nitrogen losses up to 35.5 per cent and greenhouse gas emissions by 19 per cent in 2019. Also, the PPP effectively reduced soil acidification potential significantly (Wang et al., 2021).

- 7) **‘Saagu Baagu Project’ for Sustainable Agriculture in Telangana** The Telangana State Government is implementing ‘Saagu Baagu Project’ with a view to transforming agriculture into a scalable, inclusive, and sustainable venture by deploying artificial intelligence and block chain technologies. The project engages around 100,000 farmers over four crop cycles for scaling up of the interventions across the state. The project is funded by the Bill and Melinda Gates Foundation, while Digital Green, a global non-profit organization, serves as the project implementation partner. Through digital channels like chatbots and videos based on real-time data and soil analysis, the farmers receive customized crop recommendations to mitigate climate change and natural disasters. The project facilitates real-time market access for farmers to sell their produce directly to customers. Till date, Saagu Baagu Project has provided customized advisory content to 17,408 farmers through various channels, helping them manage their Chilli, Cotton and Groundnut crops more effectively and improve quality of production. Consequently, the farmers could witness higher plant growth of 21 per cent, reduction of 9 per cent and 5 per cent in use of pesticides and fertilizers respectively, apart from experiencing increase in average sales revenue to the extent of 8 per cent, compared to traditional methods, with additional savings on commissions, transportation, and packaging costs, as well as access to transparent pricing (WEF, 2023). In sum, the Saagu Baagu project is a successful digital intervention in Ag-PPP space to showcase how emerging technologies like artificial intelligence can be leveraged by engaging agri-startups to transform the agriculture in India, through promotion of sustainable practices to achieve food security and increase the farmers’ income.
- 8) **Creating Post-Harvest Infrastructure through AIF** The Government of India created Agri-Infrastructure Fund (AIF) in July, 2020 for channelling investment in integrated post-harvest management infrastructure and community farming assets namely warehouses, silos, pack houses, assaying units, sorting & grading units, cold chains, logistic facilities, primary processing centres, and ripening chambers, etc. The CBOs like FPOs/Cooperatives/SHGs are eligible for interest subvention of 3 per cent per annum on a loan of up to Rs.20 million for a maximum period of 7 years under the scheme. One salient feature of the AIF scheme is that the sanctioned projects are being geo-tagged to avoid double funding from the banking system. Further, disbursement of funds by the banks is made to Aadhar linked bank accounts of beneficiaries which will improve transparency and accountability of the scheme. Though the AIF has the potential to take agriculture into the next orbit through creation of post-harvest infrastructure, it has been facing certain operational hurdles at the grassroots level: *i*) inadequacy of loan amount (Rs. 2 crore is not sufficient to establish medium/major projects like cold storage chains, 2 MW solar power plants, rural godowns, etc.); *ii*) non-sanction of working capital funds under the AIF may result in low or no capacity utilization of the project leading to non-performing assets in the books of banks; *iii*) non-availability of credit guarantee cover beyond Rs.2 crore irrespective of the number of projects granted to the borrower under the AIF; *iv*) inordinate delay in receipt of interest subvention as well as guarantee fee; *and v*) lack of awareness of bank officials/line department officials on the mechanics of the scheme (Srikanth, 2024).

- 9) **Crop Insurance through PMFBY, India** With a view to providing insurance coverage and financial support to the farmers in the event of failure of any of the notified crop owing to natural calamities, pests, and diseases, the Government of India introduced *Pradhan Mantri Fasal Bima Yojana* (PMFBY) in 2016 under the PPP model. The scheme provides crop insurance cover to the farmers at reasonable premium rates with a nominal contribution from the farmers. Accordingly, the farmers' share in premium under the PMFBY is limited to 2 per cent for Kharif crops, 1.5 per cent for Rabi crops in respect of cereals, pulses, and oilseeds and 5 per cent in case of horticultural and annual commercial crops (UNDP Report, 2022). The difference between actuarial premium rate and the farmer's contribution is shared equally between the Central and the State Governments. As per the extant guidelines of the scheme, all risks except price risk, are redistributed from the farmers to the implementing insurance companies (through complete *or* partial risk transfer approach). The PMFBY is the largest crop insurance programme in the world in terms of enrolment of farmers, and the third largest in respect of collection of crop insurance premium (Ministry of Agriculture & Farmers' Welfare, Government of India, 2024). As of March, 2024 approximately 40 million farmers have been insured under this scheme, representing roughly one-third of the cultivators in the country. The claim settlement ratio under the PMFBY hovered between 56 and 99 per cent during the period 2018-23. The main challenges of the PMFBY are lack of awareness of the farmers in respect of the scheme (Gummagolmath et al., 2023), information asymmetry in respect of the risk-behaviour of the farmers, negligible level of involvement of the state governments' officials, inordinate delay in conducting crop cutting experiments (CCEs) as well as settlement of claims, inaccurate data in respect of areas under notified crops and appropriate yield estimates (Shroff and Phadke, 2022) and absence of transparency on the part of insurance companies. In a survey conducted on 146 farmers in Jalna district of Maharashtra, it was observed that IFFCO Tokio Insurance Company, a private insurance company, had not made a single claim settlement to the (loanee) farmers as authorized State Bank of India branch did not send the requisite documents to the company on time (Nirmal and Babu 2021). Further, it is noticed that substantial portion of the applications got rejected due to lack of financial/digital literacy of the farmers. Under the PMFBY, less than one-fourth of gross cropped area has been insured so far. Though the farmers' share in insurance premium has been coming down over the years, insurance companies have been making profit at the cost of public exchequer and the (poor) farmers. It is also reported that major hurdles of the PMFBY are lack of proper marketing, negative publicity, and bureaucratic approach of line departmental staff in implementation of the scheme (Pradeepika 2017). Further, demand for crop insurance in India is highly price-sensitive and relies on prior experience of the farmers (Cole et al 2013; Stein 2011). The farmers who depend mainly on uncertain rainfall tend to insure their crops especially in drought-prone areas; however, they don't insure if they feel that they have protective irrigation or if there is adequate rainfall or enough moisture in the soil. It is revealed that less than half (43.80%) of the sample farmers had favourable attitude towards the PMFBY while increasing the confidence level of the farmers to take up diversified farming activities and adopting innovative agricultural practices (Jiragal and Ganesamoorthi 2022).
- 10) **Electronic National Agricultural Market (e-NAM)** e-NAM is an on-line trading platform for agricultural commodities launched by the Government of India in 2016. It is a pan-India, virtual, unified national market for agricultural commodities. The main objective of e-NAM is better price discovery through electronic bidding and facilitating marketing of agri-produce by the small and marginal farmers. The e-NAM is linked to over 1400 markets/Agricultural Produce Market Committees

(APMCs) in 23 States and 4 Union Territories. It has over 1.80 crore farmers as members to trade in 219 agri-commodities. More than 4,000 FPOs are also transacting in the e-NAM markets. The e-NAM has become popular as the crops are weighed immediately and the stock is lifted on the same day and the payments are cleared through electronic means. The e-NAM is helping traders and exporters in procuring quality products in bulk, at one place and ensures transparent and safe financial transactions within 24 hours. However, the farmers have been facing the following practical problems: *i*) low awareness level of the stakeholders on the operational aspects of e-NAM and hence negligible level of participation of the farmers; *ii*) lack of proper infrastructure at APMCs, especially in respect of grading/assaying facilities, internal transportation, storage place especially for unsold agri-produce; *iii*) presence of middle-men in the value chain and payment of commissions by the farmers; and *iv*) prevalence of cash transactions and delay in payments to the farmers.

- 11) **Development of Food Grain Silos** Under this Ag-PPP project, development of grain silos was undertaken on Design, Build, Finance, Operate and Transfer (DBFOT) model in Ujjain, Madhya Pradesh (MP) during 2014-15. Land for the project was provided by the State Government to Adani group on license basis for 30 years. The cost of the project was estimated at Rs. 30.55 crore for construction of 50,000 MT capacity of steel grain silos. It is interesting to note that the public partner (Government of MP) could select the best technology that offers significant advantages over traditional storage facilities for the project in terms of functional, structural, and financial aspects. The government provided the requisite assistance in terms of allotment of land, according statutory approvals and viability gap funding to the project, which led to achievement of specified key performance metrics by the private partner. The project handled the entire operations of food grain silos, right from receiving, cleaning, drying, storage, and transportation to field depots in bulk form, thus minimizing the losses. Fully automated operations ensured quick service, transparent, and accurate transactions at all stages and timely payment to farmers. This project is a replicable PPP grain storage model across other states in India (Gulati et al., 2021).
- 12) **Contract Farming in Potato, India** Basix, a Non-Governmental Organization based in Hyderabad, Telangana collaborated with Frito Lay India, a subsidiary of Pepsico under the PPP in 2005-06. The primary aim of the project is to help farmers in Jharkhand by creation of farm-based livelihoods through microfinance. As part of implementation of the project, Basix tied up with the farmers to produce chip-grade Potatoes under contract farming model. As per the memorandum of understanding, BASIX acted as a negotiator of contracts between PepsiCo and 1,442 small holders, who cultivated Potatoes during 2007-08. The contract specified to supply certain quantities of Potatoes of a pre-determined quality and price to PepsiCo's chip-making factory in Kolkata. This partnership resulted in higher yields, remunerative prices, and better profitability for the chip-grade Potato contract cultivators compared to traditional Potato growers, even if the costs of production under the contract were slightly higher. Although, the contract resulted in higher yields and better incomes for the farmers in the initial years, the farmers broke the contract subsequently as they found their Potatoes were rejected by PepsiCo at the factory; and they also found that they could obtain remunerative prices in the open market.

In a research study, Ray et al. (2021) observed that rejection of agri-produce (Potato in Mouza village, West Bengal, India) is common by the contract firm, if the quality is not up to the benchmark. As a result, the contract firm will not pay for the rejected produce, but the farmers need to bear the cost of inputs supplied by the firm, which puts additional psychological pressure on the farmers. On the other

hand, even after obtaining the inputs from the contract firm, a few farmers covertly sell their produce to intermediaries, especially when the ruling market price is higher than the contracted price.

Further, the contract firms generally prefer large, well-resourced farmers due to economies of scale, potentially discriminating against small holders (Singh 2002b). This marginalization of resource-poor farmers can lead to a capitalist model of agricultural development, wherein small holders lease their land to larger farmers, resulting in a ‘reverse tenancy’ trend. Though contract farming promotes crop diversification, gender equity is missing, while making payment of wages to women labourers (Kaur et al., 2021). As the contract farming firms stipulate eligibility criteria such as minimum land holding, irrigation system, and education, small holders are automatically excluded (Singh, 2012).

DISCUSSION

While the PPP projects are very common in infrastructure sector, they are few and far between with regard to agriculture & allied sectors. Recent announcement of Agricultural Research Fund by the Government of India in its budget 2024-25 for financing not only public sector institutions but also agri-startups is a positive sign for development of the Ag-PPP ecosystem. Also, this is expected to bring in much-needed accountability with regard to release of research grants besides triggering market-driven research in the country. The World Economic Forum launched the AI4AI (Artificial Intelligence for Agriculture Innovation) initiative and Food Innovation Hubs in collaboration with the Ministry of Agriculture, Government of India and several State governments. The idea is to launch and scale up Ag-PPPs to drive innovation, evidence based learnings from pilot studies on the ground. For instance, Telangana state’s *Saagu Baagu* scheme enables digital agriculture through PPP-based pilots to transform crops like Cotton, Chilli, and Groundnut. While Meghalaya state has been examining how to leverage technology to improve its turmeric value chain, Madhya Pradesh state set up Food Innovation Hub to promote various crop value chains under the P3 mode.

Table 2 depicts cumulative position of P3 projects across various sectors in India during 2007 - 2024.

Table 2. Cumulative Position of PPP Projects in India during 2007-24

Sector	No. of Projects	Total Project Cost (Rs. in Billion)	%
i) Airports	10	90.17	1.33
ii) Ports	41	661.15	9.77
iii) Roads	264	3,401.99	50.28
iv) Other infrastructure projects	40	2,592.05	38.31
v) Post-harvest infrastructure in agriculture & allied sectors	3	21.01	0.31
Total	358	6,766.37	100.00

Source: Indiatat.com

According to Table 2, out of 358 projects under PPP, just three projects, in post-harvest storage infrastructure for agriculture and horticulture produce (cold storage facilities), were implemented at a total cost of Rs.21.01 billion (0.31%) between 2007 and 2024. Further, it is noticed that among agriculture & allied sectors, food processing & additives segment has the highest potential for investments

to establish infrastructure facilities to the extent of 56.3 per cent, followed by horticulture (33.5%), post-harvest storage capacity (3.8%) and others (6.1%) based on the estimates prepared by the National Infrastructure Pipeline². Under this, the Government of India proposed to establish cold chains, mega food parks, establish/expand food processing / preservation facilities, agro-processing clusters, etc. It is observed that the states like Maharashtra, Madhya Pradesh, Tamil Nadu, Uttar Pradesh, and West Bengal, in that order, have the highest number of opportunities in the food processing and agriculture sectors. Notwithstanding the above, mega-food parks in various locations are non-functional due to high operating costs and absence of direct linkages with the farmers (CII, 2019). Table 3 shows the Foreign Direct Investment (FDI) inflows in the Indian food processing sector.

Table 3. FDI Inflows in Food Processing Sector in India

Financial Year (April – March)	FDI Inflows (in million US\$)
2014-15	516.72
2015-16	505.02
2016-17	727.22
2017-18	904.90
2018-19	628.24
2019-20	904.70
2020-21	393.41
2021-22	709.72
2022-23	895.34
2023-24	608.31
Total	6793.58

Source: Ministry of Food Processing Industries, Govt. of India

As per Table 3, food processing sector in India received higher inflows in 2017-18, and 2019-20. Afterwards, the inflows sharply declined mainly due to Covid-19 pandemic. Post-Covid, however, the inflows surged in the sector and the cumulative inflows in the sector reached to the extent of US\$ 6.79 billion till March, 2024. Table 4 presents total investments in agriculture extension & research activities during 1981-2020 (based on 2011-12 prices).

Figure 2. FDI Inflows

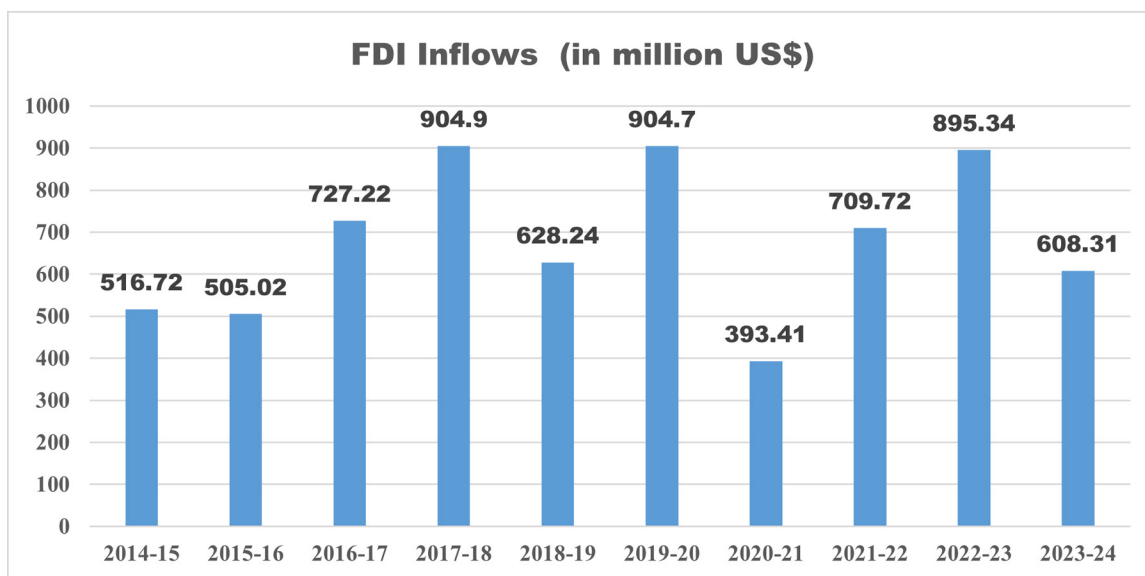
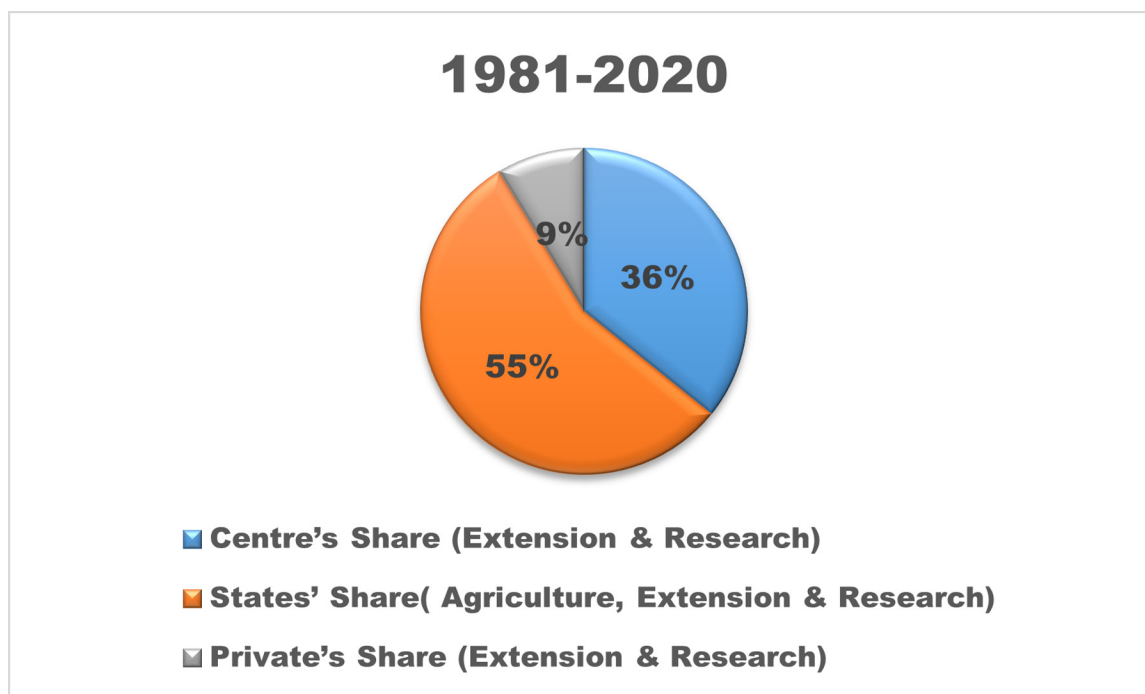


Table 4. Investments in Agri-Extension & Research during 1981-2020 (Rs. in Million)

Period	Centre's Share	States' Share	Private's Share	Total
1981-1990	10,496 (33.80)	19,120 (61.50)	1,480 (4.70)	31,096 (100.00)
1991-2000	18,031 (33.00)	29,668 (54.10)	7,090 (12.90)	54,789 (100.00)
2001-2010	35,701 (41.90)	41,865 (49.10)	7,670 (9.00)	85,236 (100.00)
2011-2020	50,254 (33.80)	87,010 (58.50)	11,390 (7.70)	148,654 (100.00)
1981-2020	114,482 (35.80)	177,663 (55.56)	27,630 (8.64)	319,775 (100.00)

Source: ICAR - National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi; Note: figures in parentheses represent per centage

Figure 3. 1981-2020



According to Table 4, contribution of Central (35.80%) and State Governments (55.56%) with regard to investments in agriculture extension & research has been substantial during 1981-2020. As agriculture is a state subject, contribution of the states in this regard is significant. However, the share of private sector in agriculture extension & research was mere 8.64 per cent, which needs to be increased further. Besides, the total investments rose by 378 per cent during this period.

Challenges in the Ag-PPP Space

In general, prototypes in the Ag-PPP models are successful mainly because they are pilot-tested under controlled environment. However, when the actual business model is implemented in the field, it usually does not have all supporting actors, market conditions, and other conducive factors. Besides, India is a diverse country with different climatic zones, irrigation systems, soils, and cultures, hence implementation of the Ag-PPP in letter and spirit poses several practical challenges.

While the PPPs are relatively simple to enter but ensuring sustainability of partnerships will be difficult mainly due to conflicts among the partners (Bovaird, 2004). Breach of contracts in the past, political interference, political instability, and change in regulatory regime result in negative perception of both the parties of the PPP, thereby denting their confidence level. Ayele, et al. (2006) concluded that the PPPs tend to be small, donor-dependent, and loosely coordinated; highly supply-driven, rather than end-user oriented; and limited in scope with regard to their impact on agricultural innovation and reduction of poverty. After implementation of the PPPs, few countries failed to receive the expected outcomes and this led to a significant rise in the government's fiscal liabilities (Akitoby et al., 2007; Bain, 2009).

One of the major issues in the Ag-PPPs is the lack of enabling infrastructure, which discourages private investment in the agriculture (Mukherjee and Maity, 2015). The private players are more interested in a few crops and areas, where profits are assured and high (Ramasundaram et al., 2011; Sulaiman and Van Den Ban, 2003). Besides, private partners are keen to deal with large farmers rather than small holders. Therefore, latest advanced technologies in agriculture, efficient farm machinery, and high yielding varieties often bypass the small holders, who don't possess the financial resources, energy, and skills. Further, the PPPs have limitations such as focus on high-end technologies, perceived mistrust, and lack of transparency, and non-adherence to the agreement (Ponnusamy, 2013).

While the private sector perceives that the public sector is inefficient, slow and unwilling to change, the public sector views the private players with suspicion. (TAAS, 2024). The public and private sectors often operate in different systems, with their own set of beliefs, practices, and institutional logic (Poulton and Macartney, 2012). The public sector aims at enhancing social welfare, whereas main objective of the private sector is to maximize profits (by perceiving that 'greed is good'). As the parties in a PPP come from different backgrounds, their values often collide and create complexity in implementation of the project (Fanzo et al., 2021).

It is noticed that the public sector has weak negotiating skills in respect of Ag-PPPs and the government officials have limited experience in partnering with the private sector, especially in a commercial setting. Also, regulations in respect of intellectual property rights (IPR) hinder the intended progress of the PPPs in agriculture. The 'concept to commissioning of the PPPs' is associated with time and cost over runs, which will increase their complexity and potentially lead to mission drift (Iossa, and Martimort, 2016). Further, there is a high probability for both public and private sectors to exploit and misuse proprietary technologies (Economic Survey, 2022). For instance, technology related to plant breeding, and finished varieties can be accidentally or intentionally transferred to competitors or any other entity, which can harm a firm's profitability (Spielman et al., 2007).

Further, the PPPs suffer from lack of decision-making authority at the ground level, general reluctance within the ecosystem to initiate and absence of a robust monitoring mechanism to oversee the activities. Long-term viability of the PPPs will be a question mark, when there is no public access to documents related to agreements, and this situation leads to opaqueness and corruption (Suebvises, 2014; Dechev, 2015; Alvarado, 2022).

In a recent paper, Agarwal et al (2023) found that complex and time consuming procedures, governance issues, corruption of public officials, lack of enabling environment, costly contracting, coordination failures, absence of trust and transparency are the major challenges in the Indian Ag-PPPs. Mis-governance of Ag-PPPs pose greater threat and termination of the projects. Besides, uncertainty in the governments' policies and various political developments lead to unpredictable outcomes of such partnerships.

CONCLUSION

In order to address the age-old structural issues in agriculture, stronger Academia – Industry – Government (AIG) linkages are needed in research, extension, and education under the PPP. Agricultural educational and research institutions in India have many resources as well as farm innovations to their credit but these can be effectively commercialized through suitable PPP models. Here, the European

PPP model may be emulated wherein the Government approaches the industry with a target of specific product development (high yielding variety of seeds, vaccines for animals, etc.).

As less than 2 per cent of farm produce is being processed in India, there is a tremendous potential for the PPPs in agriculture & allied sectors, especially in case of food processing. Accordingly, the FLW can be reduced through creation of adequate post-harvest processing infrastructure. Agri-startups and collectives (like FPOs and cooperatives) may be promoted in a big way to unleash the power of aggregation coupled with the power of innovation. Besides, affordability of new technologies, data privacy of the public, and other interests of small holders and women farmers may be kept in mind while implementing any PPP. Collaborative research projects may be undertaken for composites and open-pollinated varieties, which would be useful for the small and marginal farmers, as they may not afford to buy the hybrid seeds.

As climate change is a hard-core reality coupled with increasing scarcity of land and water resources, P3 will provide right solutions to achieve food/nutritional/income security in a country like India. Subsistence farming in India can be transformed into sustainable agri-business by focusing on establishing remunerative agri-value chains, transfer of technology, and market-driven research & development in view of climate change and disaster management. Digital technologies like artificial intelligence, machine learning, internet of things, and block chain should be leveraged by involving agri-startups for the benefit of all stakeholders. Further, ag-tech and fintech are expected to bring in transformative change in agriculture & allied sectors through the PPPs in the near future.

Training and capacity building of all stakeholders should be ensured to integrate 'science of discovery with science of delivery'. The policy makers may extend tax credits on sales, sharing the benefits between public and private sectors proportionately, and enforcement of IPRs, once granted. The Government must create an enabling environment for the Ag-PPPs in terms of proper regulatory framework, providing access to finance, and promoting research & development. Building of trust through 'ease of doing business' should be the way forward. SDG no. 2 (zero hunger), SDG no. 12 (Responsible Consumption and Production) and SDG no. 13 (Climate Action) may be achieved through good governance, proper monitoring & evaluation of the Ag-PPPs.

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ENDNOTES

- ¹ While marginal farmer in India is a person who holds a farm land of up to one hectare, small farmer has a land of above one hectare but not more than 2 hectares; one hectare is equivalent to 2.5 acres.
- ² The **National Infrastructure Pipeline (NIP)** is a group of social and economic infrastructure projects in India over a period of five years with an initial sanctioned amount of 120 trillion or US\$1.4 trillion). This was announced by Government of India in August, 2019.