

A Review on Policy Gaps of Agriculture Research and Development (R&D) in India and Their Effect on Agriculture Stakeholders

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ABSTRACT

Purpose: *An impressive stride in the agriculture sector in India after green revolution from a food deficient to food surplus country is attributed to the well-established infrastructure and contribution of various farm families in this sector. In the current scenario, various cons of food surplus and other stagnation issues of the policies need to be contemplated. The various policy reforms should inculcate well utilization of agriculture investment funds, methodologies to allow increments in farmer's income to prevent their suicidal rates, incentives and requirements for private R&D investment in agriculture while maintaining the sustainable development goal of India. A complete transparent paradigm approach to be followed by the central, state governments and private sectors for fostering agriculture growth is analyzed in this review. The impetus behind the lack of agriculture growth in spite of tremendous productivity measures adopted by farmers, policy makers; public and private investment lies in lacking of an appropriate infrastructure as per current need and demand. It is imperative to foster paradigm protocol in agriculture with articulate government intermediaries to prevent monopoly of a particular authority in due course of time. It develops spurring behavior among stakeholders to form a consortium to revitalize the complete agriculture R&D to obviate the bottle necks hampering agriculture proliferation.*

Design: *The present review highlights the mandatory need in the current scenario to review the agriculture research and development policies and desired amendments as per the needs of the associated stake holders.*

Paper Type: *Review article*

Keywords: Agriculture; Policy-gaps; Stakeholders; Farmers; Private investment; Social scientists.

1. INTRODUCTION :

Agriculture is one of the main domains of public interest to ensure food security, which is basically a permanent demand driven approach. Therefore, there exist ample investment protocols, incentives, strategies and platforms due to its substantive interest and less risk factors [1]. However, the current policies in India lacks incentives for private investment in agriculture R&D of India due to austerity by government in creating a niche and transparent environment for private stakeholders to invest in agriculture R&D [2]. Commercialization of agriculture will incentivize the privatization but its spurring behavior will be facilitated with appropriate regulations, liberalization policies, trained manpower, amenable agriculture scientists with transparent protocol and fiscal policies for sharing benefits and resources (Fig. 1) [1, 2]. The international donors like United States Agency for International Development (USAID), Consultative Group on International Agricultural Research (CGIAR), World Bank, National Agricultural Research Project (NARP), National Agricultural Innovation Project (NAIP) and many more have significantly contributed to agriculture R&D during Green revolution period. USAID played a vital role in providing financial assistance and training scientific manpower to State Agriculture Universities (SAUs). However, after development of well infrastructure of Indian Council of Agriculture Research (ICAR), ICAR-SAUs in 1963, CGIAR has shifted its priority towards the African region. The same expectancy is there from other international donors on account of observation of slowing down of donor funding in recent years. The lack of funds inculcates agrarian

distress which has led to increase in farmer's suicide in recent years as reported by Swami Nathan Report, October, 2006. Moreover, as per the report by the "Committee on Doubling Farmers Income", Shri. Narendra Singh Tomar, Minister of Agriculture and Farmers Welfare, mentioned that the additional private investment in agriculture sector will be mandatory to ensure the doubling of farmers' real income in India by 2022-23.

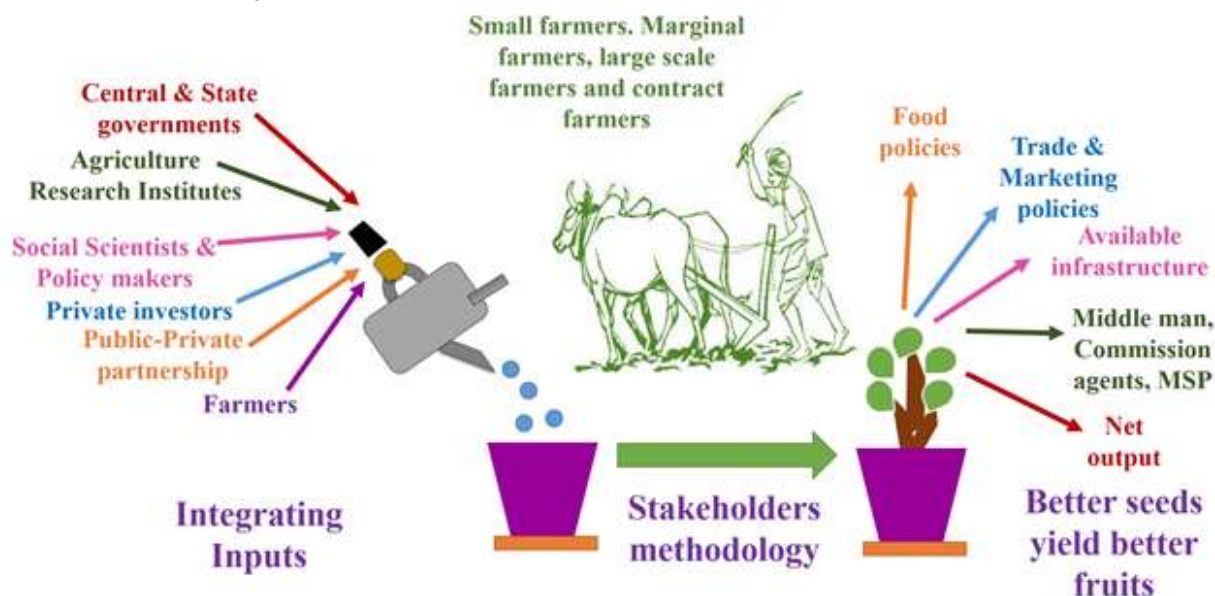


Fig. 1: Role of each stakeholder forms a consortium for fostering agriculture R&D.

The private investment should increase from Rs. 61, 000 crores in 2015-16 to Rs. 139,424 crores by 2022-23 to support agriculture R&D. Hu et al. [3] has reported that public crowding in agriculture investment results in absence of private investment. However, Pal et al. [4] has remarked that it is not true for India because, China follows commercialized agriculture, whereas India has subsistence nature of agriculture [3, 4]. Moreover, ample empirical evidences have been reported which shows that public and private agriculture investment can't be treated as substitute of each other as there exists complementation between public and private investments in India [4]. Therefore, in India, government needs to intervene as a communicating medium between private investors and stakeholders to foster a transparent chain to protect rights of both sides. For instance, more than 60 % Indian farmers are illiterate; therefore, in order to protect their rights, we need government as an intermediate to prevent exploitation of farmers in due course of time. This is because a market is secular and profit based and state need to intervene to secure the farmer's right while delivering profit outputs to the private firms. Moreover, appropriate well written policies and acts should be furnished to ensure rights and securities of each stake holder associated with agriculture R&D policies. For instance, the Minimum Support Price (MSP) which is fixed by government every year to prevent exploitation of farmers should be put in well written form so as to protect their rights from monopolies of middleman constituting Arhtiyas, traders and commission agents.

The stagnation in agriculture infrastructure after 1990's due to continuity in old practices from Green revolution onwards has affected various indigenous crops, soil infertility, diminishing agriculture lands, inefficient utilization of irrigation services, crop diversification, etc [5, 6]. This is attributed to the echoed dependency of farmers on essential commodity services on Minimum Support Price (MSP) provided by the government. The free and cheap power supply availability to around 9 Indian states namely; Punjab, Haryana, Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Gujarat, Rajasthan and Tamil Nadu has led to over-exploitation of water resources. This is because $\approx 85\%$ of India's ground water blocks have been used extensively leading to lowering of their water levels [7-10]. Singh et al. [10] and Gulati et al. [11] conducted a study on the effect of electrical subsidies in Punjab, Andhra Pradesh and Karnataka to amend the financial and operational performance of power utilities. They have recommended the use of Minimum energy support (MES) which could be defined in terms of quantity of electricity in kWhs and number of hours of supply. The amount of subsidy to be provided should be determined by the land categories, land holdings and agro-climatic groundwater zones. Performance based incentives should be provided to gain utilization among employees for sustaining and implementing the scheme. It will help in creating enabling conditions to enhance rural

power supply without burdening states fiscal. Katyaini et al. [12] has suggested an evidence based unsustainable virtual water-flows patterns for policy makers to furnish recommendations for water policies to handle water scarcity issues in agriculture [12]. In Punjab-Haryana, availability of free electricity had created consortia of farmer's working on essential commodities wheat, paddy and other 23 essential commodity grains leading to lack of crop diversification. Recently, Rajshekhar Patil (a farmer's son) case of diversifying his farming towards bamboo not only helped him to obviate his father's debt but also made him amenable to earn \approx 1 crore a year [10]. This indicates that the amendment of Indian Forest Act in 2017, which bestowed suitable and liberal platform for utilizing bamboo helped the farmers to practice their farming skills in bamboo. This is a perfect epitome of the advantage of policy reforms for increasing farmer's income and promoting private investments. Nelson et al. [5] has articulated the negative impacts of long-term adaptation of reforms of Green revolution period on agriculture mechanism, which is indispensable for contemplating by the stakeholders. Committee for Formulation of Agriculture Policy for Punjab State in March, 2013 has reported 10 million tones import of edible oil and export of paddy by India [7]. It spillovers a revitalizing message to opt for import substitution strategy by shifting area under paddy to oilseed crops [7]. It also provides impetus for the policy makers and social scientists to analyze the current agriculture distress in India and give suitable recommendations for policy reforms to obviate these impediments. It will not only prevent dwindling of agriculture R&D but also attribute assets for stakeholders, especially the most suffered community: the farmers. Chatterjee et al. [13] has reported the impact of stubble burning practice by Indian farmers in various states, especially in Punjab-Haryana which has resulted in significant pollution contributing factor in Delhi [13, 14]. Stubble burning is adopted by the farmers as it is a quick, easy and cheaper method for cleaning the operational area after harvesting [13]. Stubble burning not only results in the air pollution, but also hampers soil quality as heat generated from the stubble enters the soil and reduces its moisture and essential nutrients [13]. However, as per the farmer's opinion, the cost and time required for cleaning the harvested land by the labors, results in their significant loss of funds and time. The government in this context should emphasize suitable incentives to provide alternative quick and cheap method of cleaning the operational land through R&D developed agriculture machinery. It will not only provide relaxation to the farmers, but dwindling of air quality index is a serious issue that need to be resolved while emphasizing more on R&D in this domain.

2. OBJECTIVES OF THIS PAPER :

Present review demonstrates the role of each stakeholder integrating his/ her input in agriculture R&D. The infrastructure, government policy norms, incentives for private investment and role of public private partnerships (PPP) for fostering agriculture R&D in India. Its three major objectives inculcate:

- (i) To evaluate adequacy of measures adopted by government including various liberalizations policies introduced by the government for incentivizing private investment and analyzing positive and negative impacts of policies.
- (ii) To study the Knowledge Attitude and Practices (KAP) among various stakeholders on agriculture R&D.
- (iii) Analyzing the various policy gaps for incentivizing PPP in agriculture R&D.

3. ROLE OF VARIOUS STAKEHOLDERS IN AGRICULTURE R & D :

3.1 Role of state and central government in agriculture policies of India

Fig. 2 illustrates the legislative powers inculcated in the State list and Concurrent list (both state and central level) for articulating the agriculture policies in India. Before, 1954, agriculture subject was completely under the influence of state list as mentioned in the entry 14, 26 and 27, respectively of the state list [15] (Fig. 2).

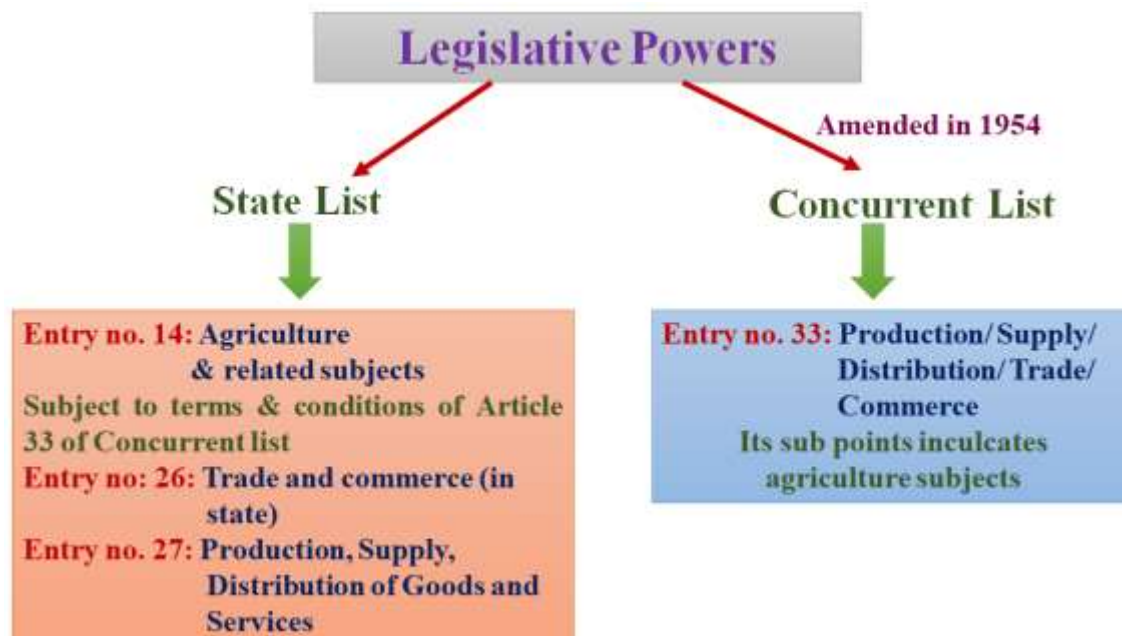


Fig. 2: Illustration of the legislative powers of state and concurrent list for Indian agriculture.

All the decisions relevant to Trade and Commerce (T&C) and Production, supply, distribution of goods and services (P, S, D, G/S) were taken by the state representatives. However, in 1954, our then Prime Minister Sh. Jawaharlal Nehru amended these legislative powers to solve the issue of land reforms and to protect farmers from review of Supreme Court and other exploitations by the middle men. Hence article 33 of the concurrent list was amended (Fig. 2) in 1954 in which the decisions regarding Production/ Supply/ Distribution/ Trade/ Commerce (P/S/D/T/C) can be taken by both central and state governments. To avoid contradiction between the state and concurrent list, entries 26 and 27 of state list were made under subject to the conditions of article 33 of the concurrent list. This implies that in the case of controversial situation, decisions of the concurrent list will prevail.

The central government funds are communicated through ICAR and block grants from the state are channeled through SAUs [16]. ICAR has created the country wide network of 722 Krishi Vigyan Kendras (KVKs) to provide technical support, guidance and other infrastructure to the farmers and other stake holders [17]. The council has also established 50 Agri-business incubators (ABI) at various ICAR institutes to proliferate entrepreneurship in agriculture [17]. State provides the infrastructure, liberalization policies, collect taxes and generate revenue from Agriculture Produce Marketing Committee (APMC). As per the national agricultural policy commission bill no. 107 of 2019, it is the responsibility of the state government to furnish information regarding total area under agriculture for areas under its jurisdiction, total production in the agriculture, annual demand of the agricultural products, potential for the increase in the export of the agricultural exports and further establishment of relevant industries [8]. It generates $\approx 26\%$ revenue through state taxes and fees from the farmers. SAUs who were given state wide responsibility for agriculture R&D receives direct funding from the state. The first SAU was established in 1960 at Pantnagar in Uttar Pradesh [18]. The various National Institute for Transforming India (NITI) Ayog policies take feedback and consultations from various state representatives for formulating final draft of the policy. For instance, Model Act on Agriculture produce and contract farming formulated on 22nd May, 2018 with an objective to allow the farmers to decide the price of their produce and negotiate with buyers from pre-production to post-harvest marketing strategies. This Act was unanimously adopted by the States. However, the implementation part has to be done under appropriate supervision mechanisms by the state to utilize the act wisely. This act will enable farmers to add value to their products without their exploitation. But articulate legal mechanism needs to be established by the state government to protect rights of farmers and buyers, while acting as a transparent intermediate. The modal act on agriculture land leasing for the same objective formulated in 2017 was also agreed by 8 chief ministries of the respective states. Similarly, Agriculture export policy of 2018 emphasized the role of global export environment and emerging demand due to continuous dwindling in global commodity prices since 2011. The role of policy makers and research scientists is to understand the impact of policies on the stakeholders and give further recommendations to reform the policies as per the consultations and priorities of associated stakeholders.

3.1. Role of farmers and their available infrastructure for their sustainable development.

Farmers fall into four major categories; small scale farmers, marginal farmers, large scale farmers and contract farmers [19]. Around 45 % of India’s workforce is dependent on agriculture which implies that agriculture sector has over employment and only 14 % Gross Domestic Product (GDP) comes from agriculture. The government legislative reforms have made provisions in accordance with the farmer’s amenability to sell their agriculture produce. Local markets, APMC board and MSP are three broad disseminating sources for farmers to sell their products as demonstrated in Fig. 3. APMC was introduced after 1950 to prevent exploitation of farmers from local market owners. MSP was initiated in 1965 to prevent exploitation of the farmers by middle man in APMC and protecting farmer’s suicide rate. MSP constitutes the input cost of farmers and his profit. Even if any private firm wants to invest and purchase farm produce from the farmers, they have to go through these three channels set up by the government. Therefore, in current existing scenario private farms do not prefer to invest in agriculture due to limited source of communicating channel.

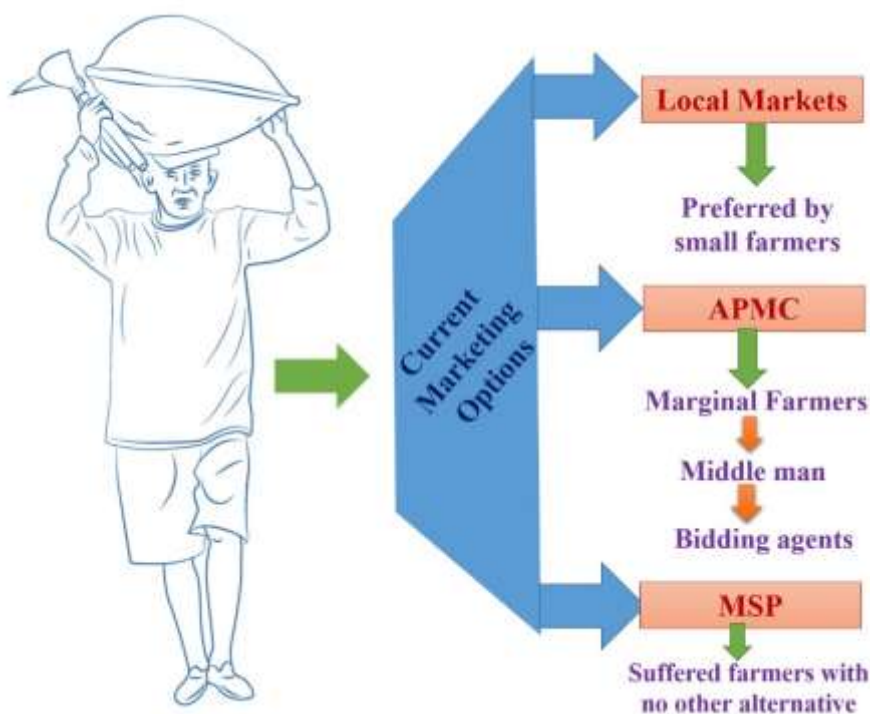


Fig. 3: The three major categories available for farmers to sell their production.

Small scale farmers prefer local markets to sell their agriculture produce due to their small produce of 30-50 kgs that does not require expensive infrastructure. Marginal farmers who produce quintals of seed opt for APMC board constituting a complete infrastructure like cold storage, warehouses, commission agents, bidding agents, Arhtiyas and other middle men to the farmers. Commission agents undertake the process of loading, unloading, assist the middle man and farmers in bidding process. Basically, these stake holders act as a communicating chain between farmers and consumers but farmers need to manage the transport mechanism on their own. This implies that farmers cost input also inculcates the transport charges for bringing their agriculture output to the APMC mandis. However, APMC board does not inculcate a transparent mechanism due to absence of any written document related to MSP price and other legal formalities. Moreover, on account of government restrictions regarding selling their produce through these 3 channels only and state barriers, farmers are forced to sell their large produce as per the offers, terms and conditions of the commission and bidding agents. Lack of any storage facilities, restricted trade area and hoarding issues by the farmers compel them to sell it at minimum prices to survive their livelihood. It incentivized majority of the farmer’s preference to grow only wheat and paddy to avoid risk factors. This gives an indirect impetus to the middle man and commission agents to have monopoly over farmers. These factors have led to dwindling of small farmers, while leasing out their lands to large land holders and operators [10]. The increase in debt due to low generated incomes from agriculture produce and in-amenability to survive their livelihood and

other emergency situations led to increase in suicide rate of the farmers. In 2013, a report was submitted by in-charge of agriculture marketing and committee of state ministers regarding promoting new reforms in APMC, but was only adopted by 16 states [20]. In 2016, government of India constituted an online trading option namely; electronic- National Agriculture Market (eNAM) for the farmers constituting small farmers' agribusiness consortium as its leading promoter interlinking around 800 markets with the portal [21]. However, these reforms could not re-solve the issues of farmers and most of the markets were not linked to this portal. Due to inadequate tech-savvy issues by the farmers, e-NAM portal did not receive much attention. As a result, dominance and monopolies of middle man prevailed [21, 22].

3.2.1 Pros and Cons of MSP:

In order to protect farmers from exploitation of middle man and APMC, MSP was set by government, in which the farmer can sell his agriculture output to the government on MSP, irrespective of need and demand of government. This was done to protect suicide rate of farmers. However, MSP is provided only for 23 essential commodities with dominating crops wheat, paddy and cotton. Moreover, this MSP was misused by bidding agents and commission agents as Maximum support price instead of Minimum Support price. With smaller landholdings and higher cost of input, the MSP could not match the cost of cultivation over the period. And with the increase in MSP, demand remains stagnant at the current price. The stress rate of farmers is increasing because of limited returns per investment cost that does not cover their daily agricultural and livelihood needs, irrespective of surplus productivity. Due to lack of infrastructure and storage issues, farmers are forced to sell their large produce as per the offers by the commission and bidding agents. MSP are even provided on pulses, which can earn better profit to farmers in terms of capital intensive and capital output ratio [7]. But to avoid further risk factors during selling their outputs, majority of the farmers rely completely on growing wheat and paddy, which resulted in various impediments in agriculture. It resulted in the movement from a problem of food deficiency in 1960s to the problem of surplus food since 2000 onwards. As a result, $\approx 40\%$ the agriculture produce is damaged due to lack of storage, supply chain and demand. There is a need to diversify the crop by the farmers to prevent their soil infertility, depletion of ground water resources and replenishing its essential nutrients. Moreover, reduction in dietary diversification leads to serious effects on the nutrition and health of rural and urban populations. This is because dietary diversification is widely accepted as a cost effective and sustainable way of improving malnutrition (Food and Agriculture Organization (FAO)-2014). It will also act as incentives for private investors (both small scale and large scale) and will provide more profit for farmers. For instance, growth of pulses may enable farmers to get more capital output in comparison to wheat and paddy, especially for Punjab farmers [7]. Cotton, maize and pearl millets have been reported to contribute ample incentives for private investment in comparison to wheat and paddy by public as per the 2010 data reported [4]. Among the market size, fertilizer and pesticides occupy the largest and food-beverages the smallest incentives for private R&D in terms of market size [4]. However, in terms of research intensity, seed and biotechnology contributes 6.9 % with least contributed by Fertilizers (0.1 %) [4].

3.2.2 Causes of Punjab agrarian stress:

As per the report by Punjab agriculture university (PAU), in 1970-1980s, Indian agriculture growth rate was 2.3 % and Punjab agrarian growth rate was 5.7 %. However, in the last two decades, Indian agriculture growth rate climbed to 2.94 % and Punjab rate dwindled to 3 % and 1.61 % in 2004-05 and 2015-2015, respectively. In 1975-76, agricultural share in Punjab's GDP was 60.2 % and diminished to 23.5 % by 2015-16. The workforce engaged in agriculture fell from 62.7 lakh in 1975-76 to 35.6 lakh in 2015-16 [10]. These figures illustrate dwindling of agricultural employment interest for farmers [10]. In current scenario, landholdings have become narrow and potential for further enhancement in crop area is nearly exhausted. Therefore, farmers need to work on crop rotation and diversification to prevent them from wheat-paddy monoculture as depicted in Fig. 4 and table 1. From Fig. 4 and table 1, we observe that from 1960 onwards, there is a steep increase in wheat and paddy production area and sharp diminishing in pulses and other crops area under cultivation. Cotton production has still maintained its consistency but maize and barley operational areas have also reduced significantly. It significantly articulates dominance of wheat-paddy monoculture in Punjab. It not only has led to depletion of water table and hence requirement of more power supply for digging underground water, but also has

increased the stubble burning practice by the farmers, leading to abundant air pollution and other soil deteriorating impediments. Ample dependence on paddy, which is not even traditional crop of Punjab, has created an additional stress factor. Bajra production area has reached nil percentage in 2018-19 (Fig. 4 and table 1).

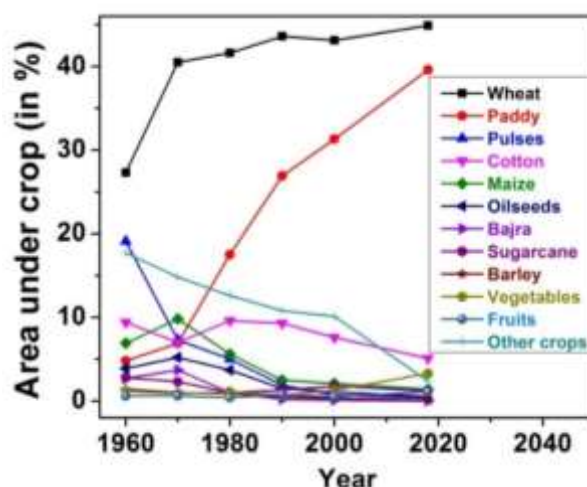


Fig. 4: Area under crop production from 1960-2019 (Source: Punjab Economic Survey 2019-20).

Table 1: Variations in percentage of crop area share in Punjab from 1960 onwards.

S.No.	Crop type	1960-61	1970-71	1980-81	1990-91	2000-01	2018-19
1	Wheat	27.3	40.5	41.6	43.6	43.1	44.9
2	Paddy	4.8	6.9	17.5	26.9	31.3	39.6
3	Cotton	9.4	7.0	9.6	9.3	7.6	5.1
4	Pulses	19.1	7.3	5.0	1.9	0.7	0.4
5	Oilseeds	3.9	5.2	3.7	1.5	1.1	0.5
6	Maize	6.9	9.8	5.6	2.5	2.1	1.4
7	Bajra	2.7	3.7	1.0	0.2	0.1	0
8	Barley	1.4	1.0	0.9	0.5	0.3	0.1
9	Sugarcane	2.8	2.3	1.0	1.3	1.8	1.2
10	Fruits	0.6	0.6	0.4	0.8	0.5	1.1
11	Vegetables	1.2	0.9	1.1	0.7	1.3	3.3
12	Other crops	17.7	14.8	12.6	10.8	10.1	2.4

(Source: Punjab Economic Survey 2019-20).

According to Punjab Agriculture University (PAU) out of the total current area for paddy cultivation (2.8 million hectares), 1.6 million is sufficient for obtaining high yield production and rest 1.2 million hectares area can be utilized for diversified crops requiring minimum water for their growth [7]. The crops which can replace paddy cultivation area are cotton, sugarcane, pulses, soybean, groundnut, etc. Fruits and vegetables are other substitutes for replacing some area under paddy and also for increasing income of farmers. However, the bottle necks for absorbing diversification are lacking economic returns from alternative crops, assured marketing coupled with unreliable marketing infrastructure and absence of proven technology for other crops. This inculcates focused R&D to obtain high yield varieties (HYV) of these crops, which can survive pesticides (as was done for paddy during green revolution) [7, 10]. Growing of basmati rice, which requires comparatively less water for their growth as compared to normal HYV paddy should be more spurred [7].

There is an imperative need to make suitable amendments in policy reforms, especially for Punjab-Haryana farming practices as wheat-paddy crops are not even part of their traditional crop cycles. The stagnation in the policies adopted during green revolution from food deficiency to surplus food utilization need to be reformed. A spurring R&D mechanism need to be revitalized to asset promising technologies for oilseeds and pulses, where India faces large deficit to make them economically competitive with paddy [7]. There is an impetus to forge new revolution for agriculture with diligent

knowledge intensive approach unlike the Green revolution based on input intensive paradigm. The 14 national research centers, 4 deemed universities and 62 research institutes for national mandate established under ICAR for resource and commodity research should develop an imperative project proposal in this regime. Basic research thrust areas should inculcate breeding of crop varieties with amended tolerance to biotic and abiotic stresses, high nutrition value and suitability of processing. Both public and private R&D participation should be encouraged to foster this new revolution. Albeit, it will require bold decisions and strong mind-set to allow implementation of these revitalizing reforms, but appropriate consultations and feedback with consortium of stake holders will develop spurring behavior among them.

3.2. Role of private investment in agriculture R&D and its expected impact:

As discussed in our previous section, private R&D should be felicitated to proliferate agriculture R&D of India. Moreover, Naseem et al. [23] has reported that major input from private sector is mandatory to enhance pro-poor agriculture R&D to generate ample income generating opportunities and provide diversified livelihood options for the poor farmers. Recent data from National Bank for Agriculture and Rural Development (NABARD) shows that only 23 % of rural income is from agriculture produce and livestock. This indicates that income from the agriculture is not enough for the farmers and diverse livelihood need to be adopted to strengthen their present status. It will further add better nutritional intake to the food consumers on account of better technology and innovation development through private investors [23, 24]. Pray et al. [25] have explained the role of two significant policies namely: liberalization of industrial policies and patents and tax incentives for incentivizing private investment in agriculture R&D in developing countries including India. Alfranca et al. [26] has examined evidence-based approach on the effect of public policies, economic incentives and institutes on private R&D agriculture investment and their various inter-relations. Till date private investment is restricted to the small-scale agriculture R&D in the domain of selective crops, fertilizers and pesticides unlike the requirement of large-scale capital-intensive farm mechanisms that can alleviate poverty level of farmers and other stakeholders [23, 24]. However, the present agriculture mechanism, governing policies and legislature reforms does not inculcate direct incentive measures for private R &D. For instance, if we take the case of purchasing agriculture produce of the farmers, private investor has to undergo through the three-way channel as demonstrated in Fig. 2. Moreover, private companies are profit based companies and hence they prefer to invest on the basis of per capita interest and pecuniary achieved. Due to current state barriers of purchasing and selling agriculture produce, probability of profit earning and competitiveness is less. For example, if a crop is sold in food surplus areas, instead of food deficient region, it will not get the desired value to it. Therefore, a mandate is needed to provide liberalization policies in state barriers and expand the marketing infrastructure for the producers, purchasers and consumers. It will also widen the channels for private R&D investment in agriculture and may further help the farmers to earn better profit.

Socio-economic, political, institutional and agro-ecological, agricultural productivity, population growth and rural literacy are some of the significant factors impacting public investment in agriculture [27, 28]. Similarly, for private investors, private household investment and corporate investment are the two investment strategies with 40 % and 60 % investing percentages, respectively. The factors affecting the private household investment are price factors constituting trade, farm wage rate, interest rate and subsidies, non-price factors inculcating rate of return on the investment, access and availability of institutional credits, allocate preference of the farmers, rural road, irrigation, market, electrification, etc. [28, 29]. Corporate investment incentivizes depending on the government policies towards taxation and land ceiling, level of infrastructural development in the region and overall economic environment in the country (and in the state particular) [28, 29].

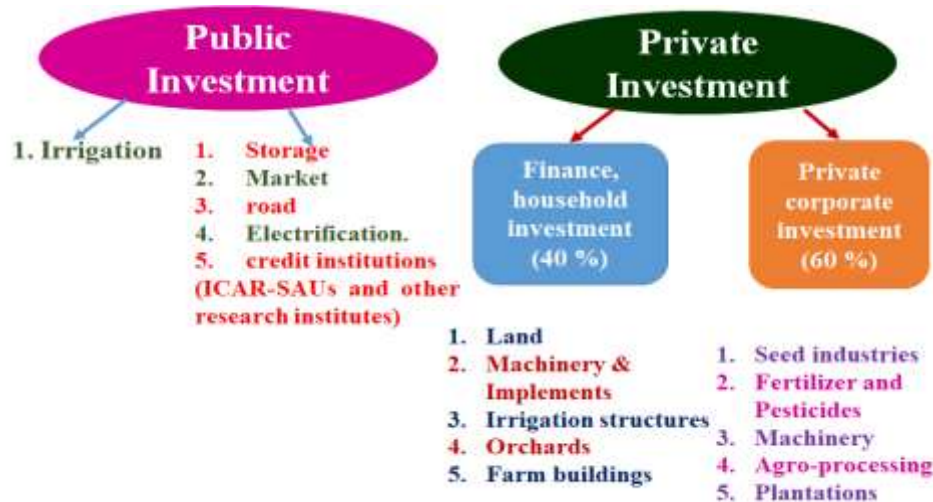


Fig. 5: Current scenario of agriculture R&D investments by public and private.

Till date finance household investments have contributed in land improvements, machinery and implements, irrigation structures, orchards and farm buildings in which irrigation structures contribute 30 % and farm buildings 47 % private R&D investments, respectively (Fig. 5) [4]. It is pertinent to mention that the share of irrigation structures increased from 26 % to 30 % due to extended incentives in terms of the tube wells and power subsidies [4, 29]. Private firms are classified into 5 major categories namely; crops (seed, vegetables and fruits, tea and coffee, mulberry, silkworm), livestock (pork, poultry, cattle and veterinary), food processing (milk, meat, vegetables, grains, fruits and other food products) and others inculcating investment in pesticides, fertilizers and machinery industries [24, 25]. After the implementation of the New Policy on Seed Development (NPSD) 1988, Indian domestic seed industry was added value from Rs. 600 crores in 1988 to Rs. 10,000 crores in 2011 [30]. As a result, 50-60 % of the seed procurement was done through private firms and from 2010 onwards, 80 % private seed sector dominated the seed supply [30].

Multi-national companies (MNCs) which lead research in agrochemicals and seed in India are DuPont, Monsanto, Dow, Bayer and BASF. Rasi seeds, JK seeds, Mahyco, Indo-American hybrids and Nuzi vedu. John Deere, TAFE and Mahindra & Mahindra undergo research in tractors and farm machineries. Similarly, companies investing and working in R&D of micro-irrigation are Netafim and Jain irrigation. This indicates that an appropriate platform is already created for suitable private R&D investment in agriculture and modification in legislative policies will foster its growth and development. The Patent act 1999 and the Protection of Plant Variety and Farmers Right (PPV&FR) Act 2001 ensured Intellectual Patent Rights (IPR), an encouragement to the private sector, attracted more MNCs to invest in both R&D in seed production and distribution in India [29, 30]. Positive impact of Bt cotton (insect-resistant transgenic crop) contributed by the Mahyco through international collaboration with Monsanto USA, in 1996 was adopted by India in 2002. At the end of 2006, India became the third largest producer and exporter of cotton from third largest importer in 2002-03 [31]. The introduction of Bt cotton has not only reduced the requirement of insecticides and pesticides but its early duration and less water requirement makes it an amenable sowing crop in northern areas of India [31]. However, after 2012, cons of Bt Cotton were observed including high cost of Bt cotton seeds due to lack of their re-usability, increase in immunization of pink bollworm, which dwindled its effective use and monopoly issues by Mahyo [32-34]. Therefore, it emphasizes the significant role of PPP in overcoming the negative aspects of private investment and dynamic R&D in this domain to study the effect of a particular crop on soil, insecticides, pesticides and associated stakeholders. Similarly, the new seed bills introduced in 2004 and re-drafted in 2019 will create niche environment to accelerate private investment in seed sector while taking appropriate feedback from all the stakeholders [35]. Manjunatha et al. [30] has conducted a study regarding priorities and requirements of various stakeholders from the Indian seed industry in Bihar and Andhra Pradesh (AP). The study constituted 6 sets of stakeholders inculcating 30 State Agriculture Department representatives (SADR), 240 farmers, Private seed companies (PSCs) and seed dealers, NGOs and researchers from SAUS and ICAUs, respectively. A vast difference in priorities of PSCs and other stakeholders was reported, with PSCs emphasis more on liberalization of Indian seed sector by the government and providing PSCs access to germplasm [30]. In contrary, all other stakeholders including farmers, NGOs, SADR and researchers from ICAR-SAUs were more focused

on granting enough powers to state governments for regulating seed industries and its associated protocols in their respective states [30]. PSCs differentiated on all 12 contentious issues as per the farmer’s priorities, researchers and dealers and SADR differentiated on 8 and 5 issues, respectively. However, NGOs priorities were similar to that of farmer’s priorities. On account of farmer’s welfare and stress conditions, Department of Agriculture and Cooperation, Ministry of Agriculture was re-named as Department of Agriculture, Cooperation and Farmer’s Welfare in new-drafted Seed bill in 2019 to emphasis on priorities of farmers in each agriculture act. Therefore, appropriate study mechanism should be proposed and conducted by the social scientists to review responses of each stakeholder and get feedback from each of the responses to well draft an implementing policy.

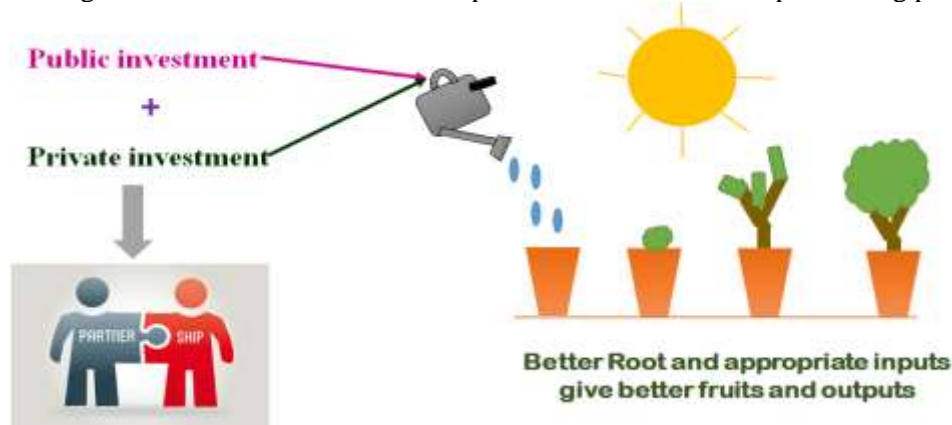


Fig. 6: Role of public-private partnership in agriculture R&D of India.

With public-private partnership, the R&D, technology transfer and commercialization can be fostered for further development of agriculture scenario to achieve better global ranking of India and amend present farmer’s situations. For instance, CGIAR centers like International Food Policy Research Institute (IFPRI), International Maize and Wheat Improvement Center, known by its Spanish acronym, CIMMYT, International Rice Research Institute (IRRI) and other international centers have strong coordination with Indian agricultural research system [4]. These international collaborations had played a significant role for the success of Green revolution.

3.3. Role of public-private partnership (PPP) in agriculture R&D and its expected impact

The dynamic nature of agriculture in accordance with consumer’s demands and expectations allows ample need of PPP for better livelihood and economic conditions of agriculture sector and related stakeholders. PPP in agriculture inculcates a shared mechanism among the public and private partners for integrating their inputs and strengths like market, infrastructure, resource, technology, risks and benefits (Fig. 6) [35, 36]. It is typically a long-term collaborative and cooperative agreement between a private entity and a public agency (state, local or federal) [37, 38].

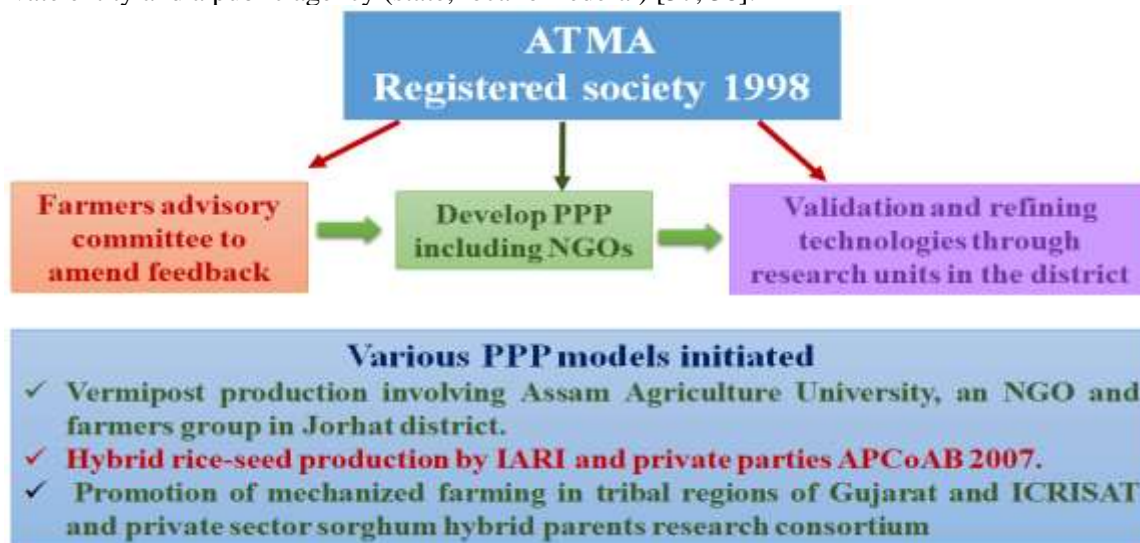


Fig. 7: Various features of ATMA for promoting PPP.

The first step of PPP was taken by the government in 1998 with the establishment of a registered society Agricultural Technology Management Agency (ATMA) at the district level (Fig. 7) [4]. ATMA received 90 % funding by the central government and 10 % by the state government. ATMA can spend or receive project grants, can associate agreements and contracts and can collect fees of the services. This implies that ATMA act as a common pool for integrating inputs from the line departments, private firms, research institutes, farmer’s consortium, NGOs and other agriculture development associations. Singh et al. [39] had pilot tested ATMA model from 1998-2005 in 252 districts of India and further extended this pilot study in Bihar [40]. By 2006, ATMA had extended to 60 districts and intended to spread nationwide in 5 years. ATMA model has facilitated dissemination of technologies, farmers produce, supplying seed, fertilizers, and other agriculture inputs to the farmers and creating a niche platform and intermediate channel between investors, producers, traders, consumers and market [39, 40]. In 2010, Kapoor et al. [41] reported the bottlenecks associated with ATMA inculcating lacking qualified human resource, financial and technical support, delivery mechanisms and transparent pipeline for partnerships [41, 42]. PPP will be beneficial not only for R&D, but in crop production with its quality enhancement, marketing and extension. Ponnusamy et al. [35] has emphasized the need of suitable incentive measures to enable effective and transparent PPP to ensure food security in terms of qualitative and quantitative needs. Current examples of PPP in agriculture R&D of India are Mahyco-Department of Biotechnology (DBT) partnership on plant genomics, Mahyco-Indian Institute of Vegetable Research (IIVR) which is basically the Agriculture Bio-technology Support Programme (ABSP) II model. In this PPP project, funding is supported by ABSP with regulatory support burden shared by DBT. Mahyco integrates the inputs like cry gene and IIVR has the responsibility to develop the resistant varieties. In 1987, Pepsico started working with tomato farmers in Punjab via providing firm prices and suitable technology and has currently partnered and supported ≈ 24, 000 famers across 13 states. Moreover, utilization of potato, corns and fruit farmers by Pepsico in the manufacturing of their processed products like potato chips (Lays), Doritos snacks and Tropicana juices also make ample incentives for PPP collaborations. Pepsico, India was the first corporate to introduce collaborative farming of process grade potatoes in India in 2004-05 and has now spread across varied states like Maharashtra, West Bengal, Karnataka, Gujarat, Uttar Pradesh (U.P.), Bihar, Chhattisgarh and Haryana

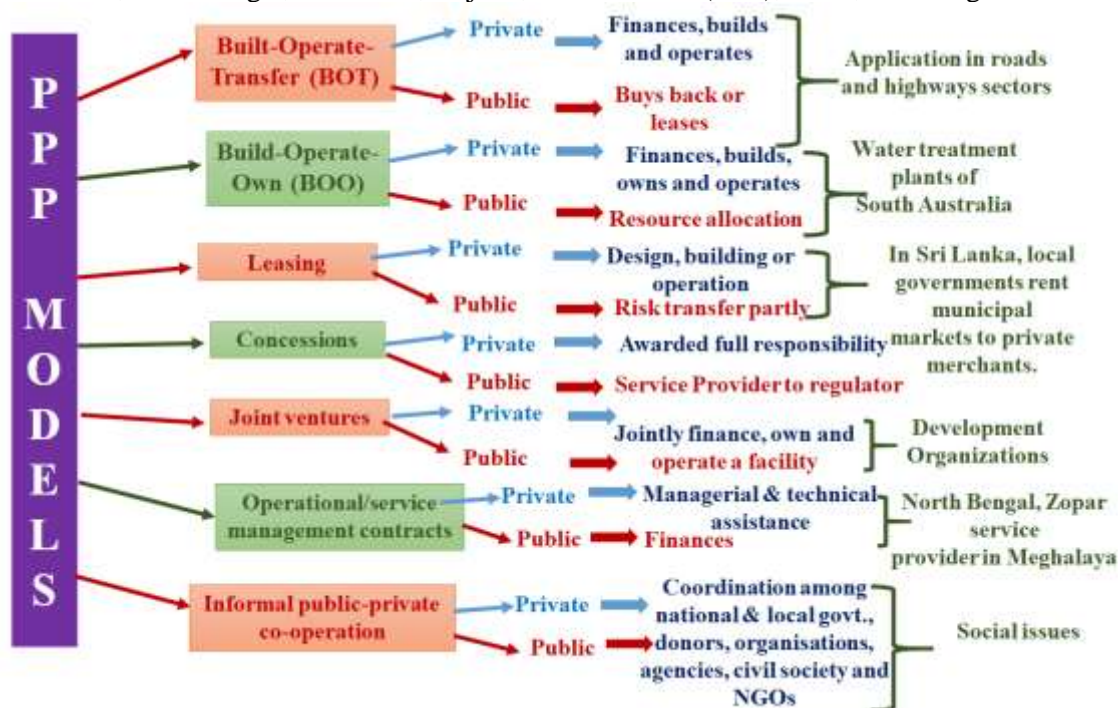


Fig. 8: PPP Models in agriculture infrastructure.



Fig. 9: Various PPP achievements in Indian states.

Tamil Nadu Agricultural University has started a project in which private firms can become a member of the consortium while paying a registration fee and can access their various technical facilities to undertake testing and characterization of their R&D innovative products [4]. Fertilizer industries have been impacted by positive extent through Department of Scientific and Industrial Research (DSIR) accreditation [4-6]. However, few successful PPP are reported till date due to versatile bottle necks such as varied aims and objectives of each sector, mutual mistrust and high transaction costs for coordinating the partnerships and negative perceptions. Especially, if we take the case of farm sector, the significant constraints that need to be overcome inculcate articulation of public-private role in PPP, establishing sufficient and practical solutions for amending the poor infrastructure [36, 37]. For instance, the non-success of PPP project of Bio-ethanol production from sweet sorghum in rain-fed areas associated with the safal terminal is attributed to the undue advantage taken by market in Bangalore by the private partner [38, 43]. Most important is to generate awareness among farmers and stakeholders relevant to their services, rights, making them aware of the positive aspects of PPP and demonstrating the complete transparent paradigm protocol to them.

Marbaniang et al. [36] has demonstrated an articulate picture of the various PPP models with appropriate role of public and private sectors in agriculture R&D using the source from Shukla et al. [44]. We have demonstrated it pictorially in Fig. 8 which clearly differentiates the role of public and private in PPP in specific domain with the relevant examples. From Fig. 8, we find that each model signifies the aim of the project with specific role of each member of the consortium from design, project building, management, finance, land leasing authorities, sharing risks and profits to technology transfer. Before furnishing any PPP project, appropriate paradigm protocol with transparent line chain describing rights and duties of each participant should be well defined and planned under secured legal documents [44, 45]. It will not only provide security to the stakeholders but will also make them enthusiastic to give their inputs.

PPP programs have been conducted in Indian regime also and most of them have proven to be successful in amending the quality and livelihood of agriculture institutes and stakeholders associated with it. Fig. 9 illustrates the positive aspects of PPP in Indian states reported till date [35]. In Gujarat, partnership of the state with Deere and Company, which is a global leader in terms of agriculture equipment, has resulted in amending the current situation of tribal farmers. Opening of various agriculture resource centers by Deere Company coupled with allowing utilization of its ≈ 500 tractors by the Gujarat farmers with Gujarat government as an intermediate link has reduced the daunting of both farmers and private firm.

The collaboration of Uttarakhand Organic Commodity Board (UOCB) and Kohinoor Food Limited (KFL) as PPP has provided ample employment opportunities to the Uttarakhand farmers associated with organic farming inculcating basmati rice. It not only amended quality and quantity of basmati rice and its respective dissemination in Uttarakhand, but has also spillover its influence and contact with Basmati farmers' federation in Dehradun district [35, 43]. This implies that this PPP program has outpaced to cover other districts as well. Punjab government has utilized PPP for crop diversification and contract farming while collaborating with private players through Punjab Agro Food Grains Corporation (PAFC)

and utilizing contract farming [35, 43]. In Madhya Pradesh (M.P.), Dhanuka Agritech group works for dissemination of pesticides, fertilizers and other eco-friendly products served as a private partner for facilitating agriculture extension in Hyderabad. The public partners in this domain inculcated the state government, national institute of agricultural extension management (MANAGE) and Department of Agriculture (DoA). The objective and success of this PPP lodges on fostering the standard of farms and farmers, establishment of market linkages, cyber dhabas (highway food courts in India) and exhibitions for disseminating agriculture produces [35].

Another achievement of PPP in India is Mahagrapes creation in Maharashtra state with a consortium of Government of Maharashtra, Maharashtra State Agricultural Marketing Board (MSAMB), Agricultural Products Export Development Authority (APEDA), Department of Cooperation, National Horticulture Board (NHB) and the National Cooperative Development Corporation (NCDC) for disseminating grapes in global market. For linking production centre and consumption centre, terminal market model is adopted by the government in various states like Chandigarh, Kolkata, Bhopal, Nashik, Mumbai, Rai Patna and Ahmedabad. According to this model, market (producer) will be linked to various collection centers (consumers) located at the key production centers as per the convenience of small farmers [35, 43]. Therefore, this model may serve as a successful model for upliftment of small farmers and amend their livelihood. The technology assessment can also be conducted successfully through PPP model using parameters like adoption rate of technology, expected life of technology, depreciation rate of technology, refinement of technology and feedback to research system [43, 45]. Moreover, design of a particular technology and initiation of a project should be made depending on the requirement of stakeholders. This implies that in addition to PPP, partnership of technical scientists and social scientists is mandatory to take idea from laboratory to market, take significant inputs and feedbacks from the stakeholders. It will enable efficient technology transfer mechanism and commercialization of the products.

4. CONCLUSIONS :

The current agrarian stress among farmers and lack of interest by private investors in agriculture, irrespective of permanent demand domain lies in mandate requirement of government policies modifications. Government has always opted for policies of extending subsidies to farmers in different forms but not inclined to support R&D, infrastructure and market development programs. Moreover, current R&D system suffers from the dominance of commodity based research forgetting a focus on holistic approach, strict compartmentalization of R&D agencies, i.e. lack of flow of information among research extension and implementation departments. ICAR has generally sacrificed its autonomy in favor of government protocols and rules. In addition, scientists in ICAR and SAU's work in wider isolation and thereby are unaware of each other's work, often overlapping their research work. In current scenario, the social scientists are absent in the system who can help to sensitize government policy makers to institutionalize priority setting mechanisms in Indian NARS. The plateau in the agriculture system after the success of green revolution needs to be scaled again while renewing R&D on diversified crops and to move out of wheat-paddy monoculture. Research on HYV of new crops including nutritious underutilized plants should be started with innovations in agriculture equipment. Emphasis should be made on PPP for agriculture R&D with appropriate legislative reforms that will enable stakeholders to work effectively in this domain.

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6. DECLARATION OF INTERESTS :

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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