



Situational Analysis of Government Initiatives for the Welfare of Farmers in India: Impact and Futuristic Insights

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Abstract: Agriculture in India has been continuously progressing, however, rural inhabitants and arable farmland per person is decreasing. In this context, every Indian farmer must adopt new and modern technologies and practices to balance food demand and supply problems. The Indian government implemented various missions and schemes for uplifting the agriculture sector and farmers, but due to varied geographical environments, and other loopholes like planning, execution issues, lack of awareness, integration failure of schemes, needs to be addressed to improve the existing condition of farmers as well as the agriculture sector. In this regard, this review sheds light on various impacts and gaps associated with the implementation of schemes. The mission for integrated development of horticulture was found to be the most successful scheme that increased farmer's income by 40%, and National food security mission is also associated with bumper production, but in some states where this mission is not integrated with irrigation schemes, the production is low. Further, when we applied the exponential model for the futuristic projections of production, area expansion, an increase was observed. Overall, the information about various factors influencing yield as well as production predictions can be efficiently managed using data-based digitalized agriculture approach.

Keywords: Indian agriculture, Schemes, Gaps, Digitalized agriculture, Exponential model

The agriculture sector is one of the prime contributors to India's economy, offering approximately 17.8% of the country's gross value added (GVA) during FY 2019-20 (PIB-MOF 2021). The Indian agriculture sector has been found successful in alleviating poverty (90 to 15%), with just 48.9% of India's workforce as compared to 75% at the time of independence (Acharya 2020). There is a hike in agricultural production which has made us self-sufficient and uplifted our condition after independence from begging bowl for food to a net exporter of agriculture and other allied products. Although the country has reached a good position still adequate efforts are required to reach the remarkable milestone. But the irony is despite this, neither the farmers can achieve economic satisfaction, nor there is any food or nutrition security for the malnourished population (14.8%) including 38.4% of children (FAO 2020, Babu et al 2021). Therefore, leaving India to rank 71 out of 113 countries in the Global Food Security Index (GFSI 2020).

Although, India is gifted with a handful of arable land with 15 agro-climatic zones, which is having almost all types of weather conditions, soil types and is thus capable of growing a variety of crops (Department of Water Resources, RD and GR 2021). Regardless of all these facts, the average productivity of many crops in India is quite low. The Indian government is always working restlessly for the welfare of

farmers through the implementation of various schemes by rectifying various loopholes of the existing system. The farmers are finding it more difficult to estimate rainfall, soil conditions, and even groundwater levels based on current environmental factors. In continuation, the financial condition of farmers remains the same due to high input cost, weather variability, and low price (Chandel et al 2021). The objective of doubling farmers' income by 2022, according to the Indian government's vision, appears to be a difficult task. To achieve this goal, a large number of veterans across the globe suggested that increased access to Big Data could be extremely beneficial to the agricultural sector and by adopting digitalized smart farming (Saiz-Rubio and Rovira-Más 2020, Shankamarayan and Ramakrishna 2020).

In this review, compiled data about various agriculture-related schemes implemented by the Indian government, their impact, gaps, and solution to the existing problems, along with their evaluation reports by Indian authorities like The Comptroller and Auditor General of India (CAG) and NITI Aayog. Further, the futuristic projections for the Mission for Integrated Development of Horticulture and National food security mission are also highlighted. In addition, the role of big data and digitalized agriculture approaches for the improvement of the agriculture sector are also discussed.

Inclusion Criteria and Statistical analysis

In this study, for data compilation, various research, review articles, and different websites like NITI Aayog, CAG (Comptroller and Auditor General of India), Ministry of Agriculture and Farmers Welfare, were utilized using various keywords like Indian agriculture, policies, beneficiaries, schemes, Digitalized agriculture, and Big data analytics, etc. Time series forecasting is a technique for predicting future values based on existing data in two successful schemes (Mission for integrated development of horticulture and National food security mission). Time series analysis is employed against non-stationary data, like economic data, weather, stock price, demand and supply, retail sales, etc. (Sharma et al 2020). The most advanced type of forecasting tool is a causal model. It expresses the relevant causal links analytically and may include pipeline considerations (i.e., inventories) as well as market survey data. It may also include the findings of a time series analysis directly. One of the most essential functions in mathematics is the exponential function. It is one of the most popular forecasting methods that use the weighted moving average of past data as the basis for a forecast. The procedure gives the heaviest weight to more recent observations and a smaller weight to observations in the more distant past (Ostertagova and Ostertay 2012). Exponential functions are used in a variety of scientific fields, including population expansion and radioactive decay. Further, they are also employed in finance, credit schemes, etc.

The exponential equation is:

$$Y = AB^t$$

where, t is the time period and Y is the observation at time t . This implies that the series is changing by a constant ratio of B per unit time.

$$Y = AB^t$$

$$\log Y = \log A + t \log B$$

$$\text{i.e. } y = a + bt$$

$$\text{where, } y = \log Y,$$

$$a = \log A \quad \text{and}$$

$$b = \log B$$

Normal equations of this model are:

$$\sum y = na + b \sum t$$

$$\sum ty = a \sum t + b \sum t^2$$

The above-normal equations were solved to get a and b constant values.

$$a = \bar{y} - b\bar{t}$$

$$b = \frac{\sum(t - \bar{t})(y - \bar{y})}{\sum(t - \bar{t})^2}$$

These values are put in the equation of exponential model to get the estimated and prediction values in horticulture and the National food security mission.

Government Initiatives

The agricultural sector provides a livelihood for 58 percent of the Indian population (IBEF 2019). Agriculture is beset by issues, particularly in developing nations where people can't afford contemporary agricultural methods (Shankarnarayan and Ramakrishna 2020). The Indian government took a favourable stance and was instrumental in the expansion of the agriculture sector. For the welfare of farmers, the Ministry of Agriculture has implemented several programs such as subsidies (food, fertilizer, petroleum, and other commodities), crop insurance, around 20 national schemes, and plenty of others at the state level (Balkrishna et al 2020). In Figure 1, various schemes initiated by the Indian government for farmer's welfare are highlighted.

Subsidies: The government of India began a plan of subsidies on the purchase of various agriculture inputs to assist farmers due to the high cost of inputs (Singh 1994). Agriculture subsidies are a significant aspect of the farmers' lives in India, and they are critical for their growth and the country's general agricultural development. The entire expenditure on subsidies (food, fertilizer, petroleum, and others) is expected to reach Rs 3,69,899 crore in 2021-22, representing a 19% annual increase over 2019-20. This is partly due to a greater food subsidy grant of Rs 2,42,836 crore (Union Budget 2021). Jain (2006) reported that the provision of electrical subsidies has harmed agriculture's long-term viability, as it has resulted in the depletion of subsurface water. Despite their substantial impact in previous decades, input subsidies (such as fertilizer, energy, finance, and irrigation) resulted in very poor marginal returns in terms of agricultural growth as well as poverty reduction (Fan et al 2007). Fan et al (2007) recommended that government subsidies for fertilizer, irrigation, power, and credit should be reduced, but investments in agricultural research and development, rural infrastructure, and education should be increased.

Subsidies have both beneficial and negative effects on the agriculture sector, yet the development of the sector would be extremely impossible without them. However, determining the exact impact of subsidies on the agricultural sector is difficult because the amount to which subsidies benefit agriculture is a major debate. The central government should enact some strict conditions for distributing subsidies, such as making subsidies as translucent as feasible, framing a farmer-friendly policy in subsidy distribution, using subsidies for well-defined financial goals, establishing systems for regular subsidy review, and so on (Kumar 2020).

Crop insurance: In India, 26% of agricultural land is insured (2017-2018) as compared to 69 and 89% in China and United States, respectively (Alexander 2019). Crop insurance

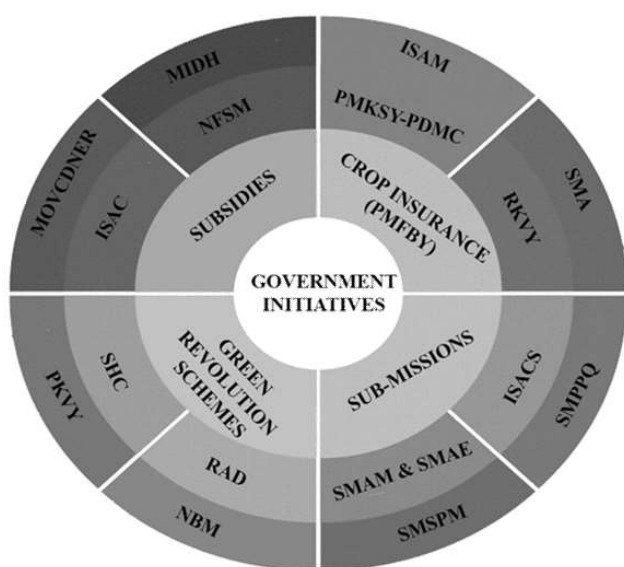


Fig. 1. Schemes implemented by the Indian Government for the welfare of farmers. PMKSY-PDMC: Pradhan Mantri Krishi Sinchayee Yojana-PDMC; RKVY: Rashtriya Krishi Vikas Yojana; MIDH: Mission for Integrated Development of Horticulture; NFSM: National Food Security Mission; SAME: Sub Mission on Agriculture Extension; SMAM: Sub Mission on Agriculture Mechanization; ISAM: Integrated Scheme for Agricultural Marketing; MOVCNDR: Mission Organic Value Chain Development for North Eastern Region; SHC: Soil Health Card; SMSPM: Sub Mission on Seed and Planting Material; RAD: Rainfed Area Development; PKVY: Paramparagat Krishi Vikas Yojana; SMPPQ: Sub Mission on Plant Protection and Plant Quarantine; SMA: Sub Mission on Agroforestry; NBM: National Bamboo Mission; ISAC: Integrated Scheme on Agricultural Cooperation; ISACS: Integrated Scheme on Agriculture Census and Statistics; PMFBY: Pradhan Mantri Fasal Bima Yojana

policies have long existed in India, but they have fallen short of covering the majority of the agriculture sector (Rajeev and Nagendran 2019). Pradhan Mantri Fasal Bima Yojana (PMFBY), the most recent crop insurance model, was introduced in 2016 (Tiwari et al 2020). Despite the introduction of PMFBY, 66% of farmers are unaware of crop insurance (Rajeev and Nagendran 2019). Crop insurance has a low distribution rate due to a lack of awareness (Rajeev and Vani 2014). Tenant farmers are not covered by crop insurance, and they account for 40% of all farmers (Rohini 2020). Although, as of January 12, 2021, the Scheme had already paid out claims for Rs. 90,000 crores (PIB-MOF 2021).

Pradhan Mantri Krishi Sinchayee Yojana-Per Drop More Crop: The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) was inaugurated in July 1, 2015, with a five-year

budget of Rs. 50,000 crores (2015-16 to 2019) to improve irrigation systems. “Har Khet Ko Pani” and “More crop per drop” are the PMKSY’s mottos (Kumar and Kumar 2016). PMKSY’s physical achievement (11.25 lakh hectare) fell short of the physical target in 2017-18 (12 lakh hectare). There was a significant discrepancy between the physical aim (16.0 lakh hectare) and the physical accomplishment in 2018-19 (7.57 lakh hectare) (Fig. 2). To assist micro-irrigation activities and encourage adoption among farmers, a specialized workforce at the field level is required (NITI Aayog 2020). In PMKSY, only three states, Andhra Pradesh, Gujarat, and Telangana, constitute 80% of the beneficiaries (DBTDACFW 2021)

Rashtriya Krishi Vikas Yojana: The Rashtriya Krishi Vikas Yojana-Remunerative Approaches for Agriculture and Allied Sector Rejuvenation (RKVY-RAFTAAR) was established in 2007 to ensure agriculture and related areas' interdisciplinary development by allowing states to do their development activities based on district and state agriculture strategies (RKVY-RAFTAAR 2020; NITI Aayog 2020). From 2017-18 to 2021-22, 56 projects in RKVY were de-sanctioned. Furthermore, 3302 projects were approved throughout this period, but only 235 were finished as shown in Figure 3 (RKVY 2021).

According to the Institute of Economic Growth (IEG), a comparison of average income per acre among beneficiaries and non-beneficiaries shows that RKVY had a positive influence on average household income in more than half of the states. By better engaging with the states, there is a purview for improvement in performance and maximizing the impact of the interventions being undertaken using scheme funding. (NITI Aayog 2020). The planning process was found to be weak in 24 states at the Gram Panchayat, Gram

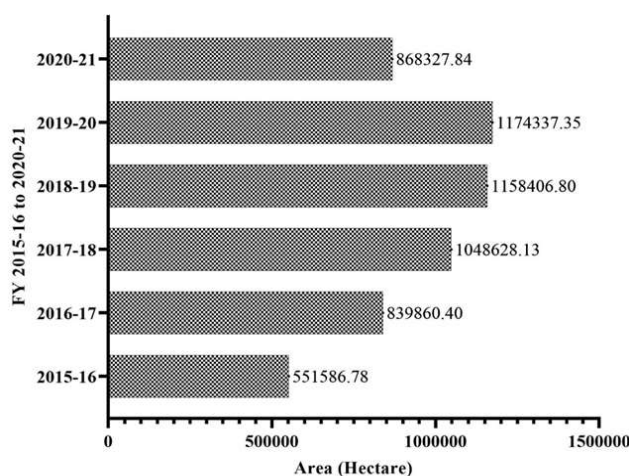


Fig. 2. Area covered (Hectare) under PMKSY from FY 2015-16 to 2020-21 (PMKSY 2021)

Sabhas, and Block level, according to the audit of RKVY. Cases of underperformance and irregularities were discovered in 150 (38%) of the 393 projects selected for audit investigation across 19 RKVY sectors (CAG report 2015).

Mission for Integrated Development of Horticulture (MIDH): National horticulture mission (NHM), Horticulture mission for North East and Himalayan States (HMNEH), National horticulture board (NHB), Coconut development board (CDB), and Central Institute for Horticulture (CIH) were all merged under MIDH in 2014-15 (NITI Aayog 2020). The fruits (5.42%), vegetables (2.51%), and flowers (1.56%) have seen a rise in the area, whereas plantation crops (0.15%), spices (0.26%), and fragrant plants have seen a modest reduction in area (0.02%) after MIDH implementation as depicted in Figure 4 (NHM and HMNEH evaluation report 2020). Before MIDH, per household average income from all sources was Rs. 4.33 lakhs, which grew to Rs. 6.06 lakhs after the scheme (Fig. 5), indicating a considerable gain of 40% (NHM and HMNEH evaluation report 2020). MIDH is the sole plan that has been found adequate at several levels of analysis such as financing, output, outcome, REESIE (Relevance, Effectiveness, Efficiency, Sustainability, Impact, Equity), and overall performance, according to the NITI Aayog report, 2020 (NITI Aayog 2020)

Futuristic projections of area and production of horticultural crops: Based on various reports, MIDH was found to be the best-implemented initiative of the Indian government. As per our investigation using the exponential model, the area, as well as production, is increasing from 2009-10 to 2034-35 (Table 1).

The exponential growth rate analysis indicated that during the study period there is positive and significant growth in area and production of horticultural crops but relative growth in the area is lower compared to that of production. The production is increased with area expansion as reported in the annual report of the Ministry of Agriculture and Farmer's welfare (Annual report 2020-21). However, there is a slight increase in the area of horticulture crops after the implementation of MIDH (NHM and HMNEH evaluation report 2020). The forecast analysis significantly indicates stagnation in the area under crops so there is a need for effective implementation of numerous programs initiated by the government to enhance the area under the crop so that the increasing demand will be met through production enhancement. This scheme might double farmer's income through area expansion and by digitalized data-based agriculture approaches.

National Food Security Mission (NFSM): NFSM was established in 2007-08 to enhance wheat, rice, and pulses production, and the country produced a record amount of

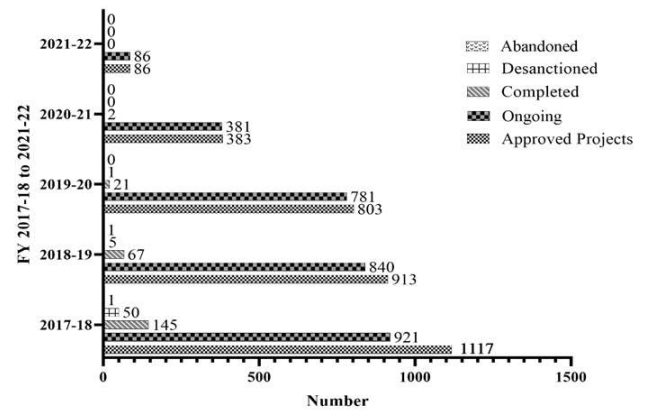


Fig. 3. Approved, ongoing, completed, de-sanctioned, and abandoned projects (RKVY 2021)

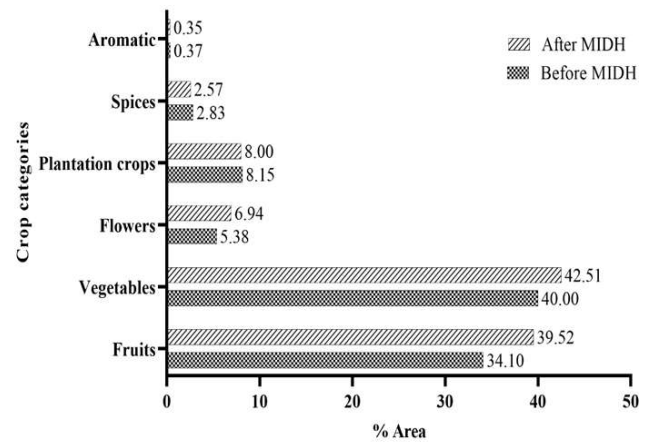


Fig. 4. Impact on area expansion after implementation of NHM and HMNEH from 2014-15 to 2018-19. NHM: National horticulture mission; HMNEH: Horticulture mission for North East and Himalayan States (NHM and HMNEH evaluation report 2020)

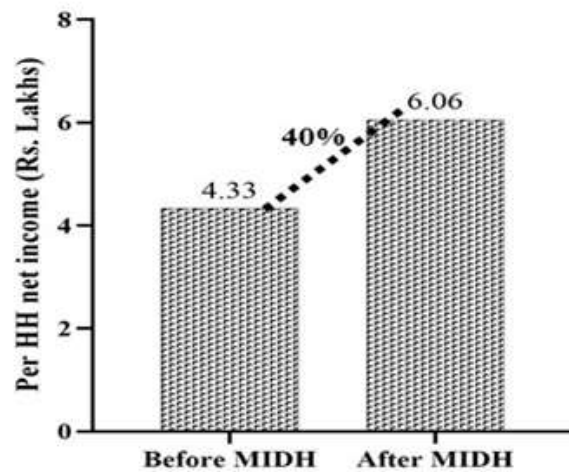


Fig. 5. Impact of NHM and HMNEH on the income of farmers from 2014-15 to 2018-19 (NHM and HMNEH evaluation report 2020)

food grains in 2017-18, totalling 285.01 million tonnes. Total food grain output in 2018-19 was 284.95 million tonnes, according to the 4th Advance Estimates. NFSM has been introduced in selected locations of 29 states across the country (PIB 2019). The Beneficiaries' earnings have increased between Rs. 3,764 and Rs. 66,763 as a result of NFSM approaches, depending on the crop. As a result, the mission has a positive impact; nevertheless, output and outcome indicators are not measured yearly (NITI Aayog 2020). In Chhattisgarh, the NFSM has benefitted merely 4% of farmers (1.38 lakh) who possess 6% of the state's cultivated land (2.76 lakh ha). Rice productivity in NFSM districts has lagged behind that of non-NFSM districts in the last five years since non-NFSM districts had more irrigation projects (25 out of 33 in the state) than NFSM districts (Fig. 6) (CAG report 2018).

To fulfill the NFSM's goal, the Department should raise awareness and educate farmers about the benefits of hybrid

seeds. It should also be assured that consultants and technicians are appointed at the state as well as district level to streamline the mission's monitoring ventures (CAG report 2018). During the years 2011-12 to 2014-15, the sown area of pulses in Madhya Pradesh increased by 3%. Further, pulse production peaked in 2012-13, the first year of NFSM adoption, and then steadily declined in succeeding years (CAG report 2017).

Futuristic projections of rice, wheat and pulses production: NFSM aims to enhance the production of food grains such as rice, wheat, and pulses. We did futuristic projections of these food grains up to 2026-27, to find the gap in demand and production. As per NITI Aayog's report, the projected demand for rice, wheat, and pulses will be 119-120, 110-111, and 27-29 Million Tonnes, respectively concerning increasing population in 2028-29 (NITI Aayog's demand and Supply report 2018). The current estimates revealed the surplus production of rice, wheat, and pulses (135.57,

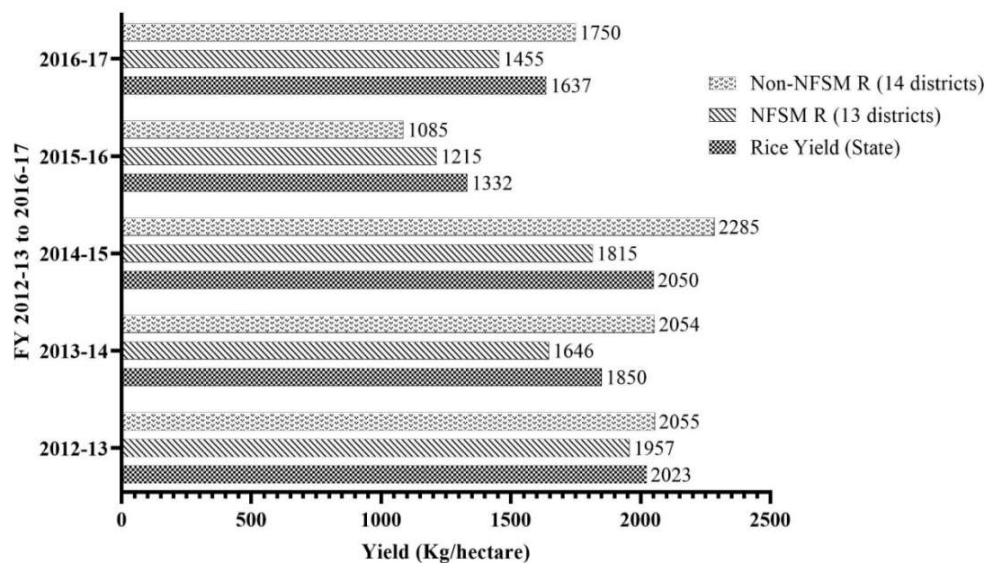


Fig. 6. Rice yield in NFSM and non-NFSM districts of Chhattisgarh (CAG report 2018)

Table 1. Futuristic area and production estimates of horticultural crops based on the exponential model

Year	Area (Million hectare)	Production (Million tonnes)	Year	Area (Million hectare)	Production (Million tonnes)
2009-2010	21.70	235.60	2018-2019	25.88	317.49
2010-2011	22.13	243.54	2019-2020	26.39	328.19
2011-2012	22.56	251.75	2020-2021	26.91	339.25
2012-2013	23.01	260.23	2021-2022	27.44	350.69
2013-2014	23.47	269.00	2022-2023	27.98	362.50
2014-2015	23.93	278.07	2023-2024	28.54	374.72
2015-2016	24.40	287.44	2024-2025	29.10	387.35
2016-2017	24.88	297.13	2025-2026	29.67	400.40
2017-2018	25.38	307.14	2026-2027	30.26	413.90

120.32, and 32.53 Million Tonnes, respectively) in 2026-27 (Table 2). The forecast analysis shows that the production of major crops shows an increasing trend in the near future, indicating a positive impact of government initiatives.

Sub Mission on Agriculture Extension (SAME): SAME trained around 4.63 crore farmers from 2016-17 to 2018-19, with 92,049 trainings conducted under the Agricultural Technology Management Agency (ATMA) scheme (NITI Aayog 2020). In SAME, on a nationwide basis, the extension personnel ratio is now less than the recommended ratio of 1:750. In comparison, India has approximately 1.2 lakh extension professionals, compared to 7.134 million local agriculture extension personnel in China (Nandi and Nedumaran 2019).

Sub Mission on Agricultural Mechanization (SMAM): More than 65% of funding in the SMAM for 2019-20 has been used as of November, indicating satisfactory progress in fund utilization (NITI Aayog 2020). In SMAM, the overall number of enrolled farmers in 2020-21 is 46677, yet only 18336 from Kerala, Tamil Nadu, and Uttarakhand has been benefitted as depicted in Figure 7 (Agri-machinery 2021).

The higher collateral, especially for loans of more than 1 lakh, higher interest rates, and comparably shorter repayment durations are some of the issues with SMAM (5-7 years). The small and marginal farm holdings account for around 85% of all farm holdings, this group of farmers must be targeted with appropriate farm machines and technologies (Tiwari et al 2019).

Integrated Scheme for Agricultural Marketing (ISAM): ISAM attempts to create competitive marketplaces and infrastructure for farmers to help them with a higher price for their produce. From 2017-18, the National agriculture market scheme, or e-NAM scheme, was integrated into ISAM (DMI 2021, NITI Aayog 2020). e-NAM has been connected with 1,000 mandis across 18 states and 3 UTs until January 24, 2021 (Lok Sabha report 2021). On the e-NAM platform, a

total of 1.55 crore farmers/sellers, 68429 commission agents, and 122171 traders/buyers were registered as of March 15, 2019. On the e-NAM site, 24288397 tonnes of agri-commodities with a trade value of Rs. 64923 crores were exchanged (e-NAM 2021). ISAM must make a significant

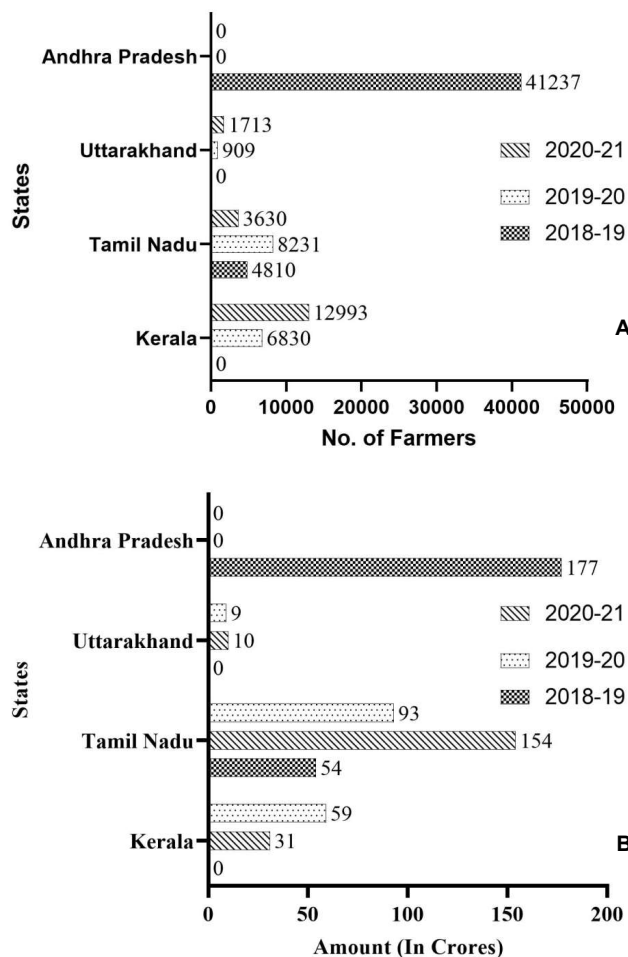


Fig. 7. Farmers benefitted (A) and subsidies allocated (B) under SMAM from FY 2018-19 to 2020-21. 0: Not available (Agri-machinery 2021)

Table 2. Futuristic production estimates of major crops based on the exponential model (million tonnes)

Year	Rice	Wheat	Pulses	Year	Rice	Wheat	Pulses
2009-2010	99.34	88.18	16.69	2018-2019	117.12	103.95	23.76
2010-2011	101.17	89.80	17.36	2019-2020	119.28	105.86	24.71
2011-2012	103.04	91.46	18.05	2020-2021	121.48	107.82	25.70
2012-2013	104.94	93.15	18.78	2021-2022	123.72	109.81	26.73
2013-2014	106.88	94.87	19.53	2022-2023	126.01	111.83	27.80
2014-2015	108.85	96.62	20.31	2023-2024	128.33	113.90	28.92
2015-2016	110.86	98.40	21.12	2024-2025	130.70	116.00	30.08
2016-2017	112.91	100.22	21.97	2025-2026	133.11	118.14	31.28
2017-2018	114.99	102.06	22.85	2026-2027	135.57	120.32	32.53

effort to overcome the sector's marketing gaps, given the extremely fragmented marketplaces, lack of marketing as well as storage infrastructure, and reduced adoption of portals like e-NAM (NITI Aayog 2020).

Mission organic value chain development for north eastern region (MOVCDNER): During the 12th Plan period, MOVCDNER is implemented in eight North-Eastern states, namely Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim, and Tripura, to improve certified organic production by establishing a full value chain for the product (MOVCDNER 2018, NITI Aayog, 2020). In MOVCDNER, except for Mizoram, practically all of the states scored well in terms of the area covered. Tripura has performed admirably in terms of cluster/ FIG establishment, obtaining more than 100% of the target as shown in Figure 8 (NITI Aayog 2020).

Soil Health Card (SHC): SHC scheme was started in 2015 to offer farmers information about the quality of their soil. Farmers are given soil health cards that contain information such as the soil's nutrient status and the recommended dose of fertilizers to be delivered to improve its fertility (Union Budget 2021; PIB 2020; SHC 2021). In Cycle I, II, and Model village program, 22,87,14,022 SHCs were dispatched (SHC 2021). Farmers believe that soil health cards have had a substantial impact on crop yields (Padmaja and Angadi 2018). The issued SHCs must be updated regularly so that farmers are informed of the changing fertility state of their

land (Chouhan et al 2017). Even though the Directorate claimed to have issued SHCs to 18% of the beneficiaries in Kerala, the study found that they had not received them (CAG report Kerala 2015).

Sub Mission on Seed and Planting Material (SMSP): SMSP was established in 2014 to increase certified seed production, farm harvested seed quality enhancement, promoting new techniques in seed production, processing, testing, and other areas, and strengthening and modernizing seed production, storage, and certification infrastructure (NITI Aayog 2020, PIB-SMSP, 2021). In SMSP, from 2014-15 to 2020-21, 4.29 lakh seed villages were established under the seed village program, with 38.01 lakh quintals of certified seeds provided at reduced costs to 170.86 lakh farmers (PIB-SMSP 2021).

The financial assistance was granted for the movement of 10.37 lakh quintals of seeds to ensure timely supply of certified/quality seeds at a reasonable cost to farmers in the North-Eastern States, J&K's UT, Ladakh, H.P., Uttarakhand, and West Bengal's hilly/remote districts under SMSP (PIB-SMSP 2021). Geo-tagging can aid in the control and tracing of scheme development in terms of asset generation in SMSP. It can also assist with traceability and certification (NITI Aayog 2020).

Rainfed Area Development (RAD): Since 2014-15, RAD has been a part of the National mission for sustainable agriculture (NMSA). For the development and conservation

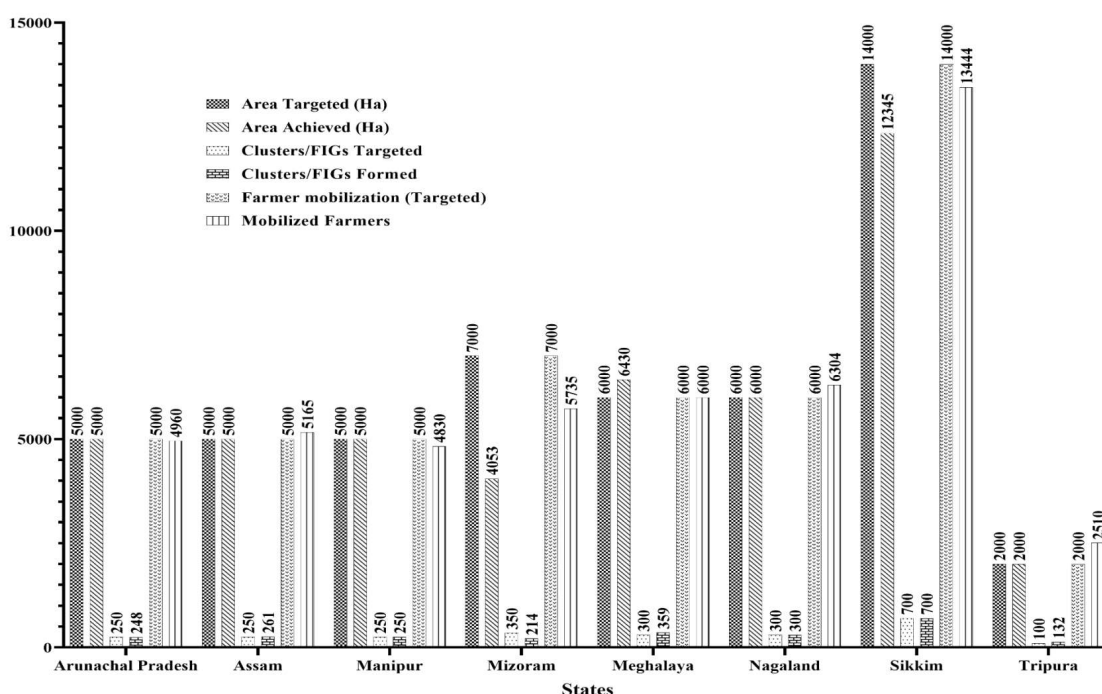


Fig. 8. Physical progress report of MOVCDNER Scheme (Phase-1) (NITI Aayog 2020).

of natural resources, as well as farming systems, RAD uses an area-based strategy. Varied systems such as integrated farming help to reduce the negative impact of crop failure (NMSA 2019, NITI Aayog 2020). From 2014 to 2019, the RAD initiative benefited around 1.5 lakh people, 45% of them were from Scheduled Castes, Tribes, and Backward Classes, and 18% were women (NITI Aayog 2020, DAFW, 2021).

RAD covers the entire country, although the states are dissatisfied with the financial scale, they can also receive assistance with interventions such as beekeeping. Furthermore, via active participation, frequent meetings, trainings, and workshops, improved coordination between farmers and implementation agencies may be developed; technical and support professionals for upgrading MIS must be rapidly hired (NITI Aayog 2020).

Paramparagat Krishi Vikas Yojana (PKVY): PKVY is an expanded component of Soil Health Management (SHM) under the NMSA, which was introduced in 2015. The goal of PKVY is to encourage and promote organic farming, which will increase soil health (PKVY 2017). The farmers' use of organic farming practices has increased year on year, according to an impact study undertaken by MANAGE after the introduction of PKVY (Reddy 2017, NITI Aayog 2020). The organic agriculture yield was 5.6%, which is less than conventional agriculture. The amount of green manure used has grown by 50%. There was a 20-50% improvement in net returns as a result of expense reductions, a positive impact of PKVY (Reddy 2017). Appointing divisional PKVY officers, separate booths for organic products at the APMC marketplace, and corporate linking are some of the gaps that need to be addressed (Reddy 2017). Due to the concentration of organic clusters in a few states, the execution of PKVY in other states such as Haryana and West Bengal should be promoted. Further, products certified by the Participatory Guarantee System (PGS) will be encouraged for increased acceptability (NITI Aayog 2020).

Sub Mission on plant protection and plant quarantine (SMPPQ): SMPPQ was launched in 2014-15 to reduce losses in agricultural crop quality and yield due to insect pests, weeds, rodents, and other pests, as well as protecting our produce from the invasion of unknown species (PIB-SMPPQ 2021). As the use of bio-pesticides/neem-based pesticides climbed from 123 MT in 1994-95 to 63540 MT in 2016-17, and the overall consumption of chemical pesticides in the country decreased, this component, SMPPQ performed admirably (NITI Aayog 2020). NITI Aayog recommended a focus on raising awareness and building capacity among private sector stakeholders, such as input distributors/handlers/distribution agents/traders/exporters, on safe chemical usage and storage for better functioning

under SMPPQ (NITI Aayog 2020).

National bamboo mission: After China, India is the world's second-largest bamboo cultivator, with 136 species and 23 taxa distributed across 13.96 million hectares. India's yearly bamboo production is predicted to be 3.23 million tonnes, according to the Union Ministry of Agriculture and Farmer Welfare. Despite this, the country only accounts for 4% of the worldwide bamboo trade (Down to Earth 2021). The National Bamboo Mission (NBM) began as a Centrally Sponsored Scheme in 2006-07 and was later merged into the Mission for Integrated Development of Horticulture (MIDH) in 2014-15 (NBM Guidelines, NITI Aayog 2020). In addition, in 2018-19, a restructured National Bamboo Mission (NBM) was launched to focus on the growth of the entire bamboo value chain and connect growers with markets (PIB-NBM 2019). The business sector's involvement and participation in NBM should be promoted. The targets for scheme output and outcome metrics are not available for 2018-19. As a result, it is proposed that annual targets be set and updated regularly to aid in monitoring the scheme's performance (NITI Aayog 2020). The government has decreased GST on bamboo furniture and bamboo flooring to 12% in response to demand from bamboo-based stakeholders and to provide cheaper bamboo items to customers (PIB-NBM 2019).

Sub-Mission on agroforestry: In 2016-17, the Sub-Mission on Agroforestry (Har Medh Par Ped) scheme was launched in 20 states (PIB-SAF 2021). The scheme's goal is to encourage high-value agroforestry products while also supplementing agricultural revenue. Although one of the scheme's goals is to create jobs, it does not track how many jobs are created. The government should keep a record of entrepreneurs leveraging the scheme for self-employment (NITI Aayog 2020). The pressure on sole agriculture crops is increasing due to rapid population expansion, shrinking land holdings, and unpredictable weather conditions. Small and marginal farmers will benefit from the incorporation of trees and cattle into farmlands since it will provide them with appropriate income and employment. For instance, the Madhya Pradesh Forest and Agriculture Department, as well as NGOs, are pushing agroforestry and farm forestry on a big scale throughout the state, in conjunction with private wood-based companies (Bijalwan et al 2019).

Integrated scheme on agricultural cooperation: The fundamental goal of the Integrated Scheme on Agricultural Cooperation (ISAC) is to address concerns such as strengthening the cooperative status and eliminating regional imbalances. Another goal is to speed up the cooperatives' overall development in areas such as agriculture marketing, processing, warehousing, and digitalization (Vikaspedia 2021). Under ISAC, the scheme for

marketing storage and processing activities currently supported over 17,000 cooperatives on average. Regional Institutes of Cooperative Management (RICM)/ICMs have trained over 60 thousand people. Furthermore, from 2012-13, the Integrated Cooperative Development Project has assisted nearly 3000 cooperatives in selected backward districts. NITI Aayog identified various weak areas under the cooperative sectors such as quality maintenance of inputs, link between produce and marketplace, storage, and others (NITI Aayog 2020).

Integrated scheme on agriculture census, and statistics: Integrated Scheme on Agriculture Census, and Statistics (ISACS) is also covered under green revolution (Pocket Book 2020, Vikaspedia 2021). Since 1970-71, the census released in 2015-16 is the 10th Agriculture Census. Under ISACS, the data of phase 1 have been released, phase 2 is being finalized, and for phase 3, it was compiled for 22 States/UTs. In ISACS, the major challenge is the unavailability of reliable, and comprehensive databases pertaining to land records. This can be resolved by the digitalization of records with pace and accuracy, while different plans need to be employed in states with non-land records (NITI Aayog 2020).

Other initiatives: As per the economic survey report an amount of 18000 crores have been distributed among 9 crore farmers in December 2020 under the PM-KISAN initiative. Subsequently, Minimum Support Price (MSPs) would be kept at 1.5 times of production cost as included in Union Budget 2018-19. The MSPs for Kharif and rabi crops in India have been enhanced by the Indian government in 2020-21. Recently proposed agricultural reform legislation are drafted for benefitting marginal farmers (85% of total farmers) as they suffered most from the regressive APMC regulated market regime. Moreover, under the Atma Nirbhar Bharat Abhiyan Rs. 1 lakh crore was proposed for agriculture and food management. In February 2020, with the inclusion of the livestock sector in Kisan Credit Cards (KCCs), 1.5 crores dairy farmers were targeted to provide KCC under the Atma Nirbhar Bharat Package. 44,673 KCCs have been distributed to fish farmers up to January 2021. Further, 4.04 lakh applications are in process (PIB-MOF 2021).

Impact evaluation: NITI Aayog assessed 17 schemes (16 centrally sponsored schemes under green revolution) in 2020 including the PMKSY-PDMC, RKVY, MIDH, NFSM, SMAE, SMAM, ISAM, MOVCDNER, SHC, SMSPM, RAD, PKVY, SMPPQ, SMA, NBM, ISAC, and ISACS. They account for almost 88% of overall spending (NITI Aayog 2020). The budgeted, revised, and actual estimates of these schemes and fund utilization are depicted in Figure 9 and 10, respectively. In terms of fund usage, 10 of the 17 schemes were deemed to be satisfactory (Fig. 11). Unfortunately,

despite using nearly 98% of available money, only one (Mission for Integrated Development of Horticulture) was deemed to be satisfactory in terms of overall performance and two in terms of output. However, in the outcome variable progress is not available in some cases (NITI Aayog 2020).

Digitalized agriculture: A ray of hope: Under the Digital Agriculture initiative, information and communication technologies (ICT) are used to facilitate the transfer of localized information and services to make farming more socially, financially, and ecologically sustainable (Madaswamy 2020). Digital agriculture is expected to bring a significant increase in efficiency, productivity, and sustainability (Aubert et al 2012, Wolfert et al 2017). Cloud computing, the internet of things,

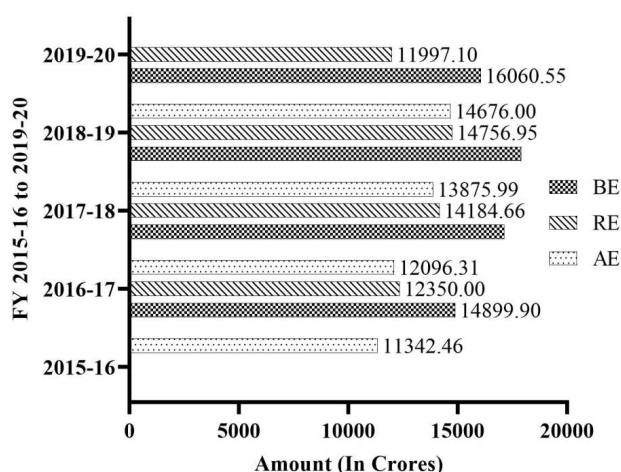


Fig. 9. Estimates for green revolution including PMKSY-PDMC. BE: Budgeted estimates; RE: Revised estimates; AE: Actual estimates (NITI Aayog 2020)

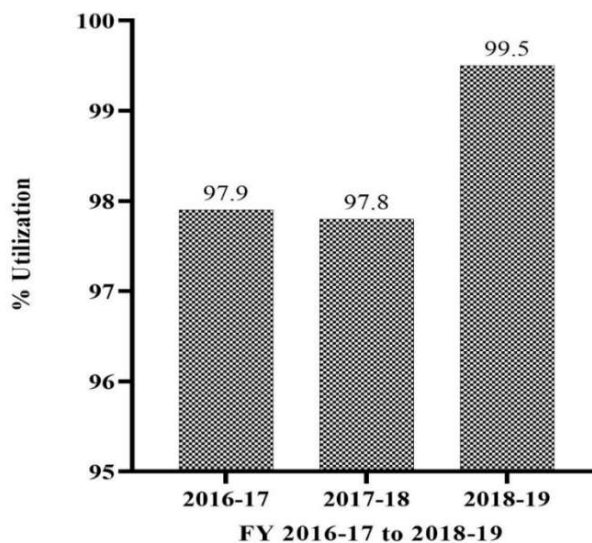


Fig. 10. Utilization of funds under green revolution including PMKSY-PDMC (NITI Aayog, 2020)

robots, and artificial intelligence are hastening the transition to smart farming to ensure agri-food sustainability (Robertson et al 2018, Ingram and Maye 2020). Moreover, crop yield forecast accuracy aids growers in developing a proper cultivation design, crop health monitoring system, effective crop yield management, and strategic objectives to reduce economic losses (Upendra et al 2020). Similarly, Shankarnarayan and Ramakrishna (2020) emphasized the value of Big Data. There is an opportunity to have access to massive amounts of satellite data, and if this information is made broadly available, it can help Indian farmers. Based on various studies, evidence is mounting that agronomic approaches such as precision farming can significantly increase farm production and income. Modern machinery, such as precision seeders, and planters, laser field levellers, and farming practices, like direct-seeded rice, rice intensification system, zero tillage, and others enable very efficient farming (Kumar 2019). Interestingly, as data has become a fundamental aspect in advanced agriculture to assist farmers with the sensible decisions, current developments in data are causing smart farming to increase dramatically. Data-driven agriculture, combined with robotic solutions that incorporate artificial intelligence approaches, lays the foundation for future sustainable agriculture (Saiz-Rubio and Rovira-Más 2020, Shankarnarayan and

Ramakrishna 2020). In Figure 12, the role of data-based agriculture for the betterment of the agriculture sector is highlighted.

The use of current data-based agriculture to make decisions can lead to more sustainable and lucrative actions to feed people in an environmentally friendly manner. Data from multiple years may be required to determine patterns in the parameters; therefore, data becomes a standard input to the farm management. Sensors are used to monitor crops and extract objective data from them. Sensing systems and analytics can provide better data to producers, users can make better real-time decisions with more obvious results while utilizing sensing technologies and machine learning to automate operations can enhance reliability. Modern farming allows for objective decision-making based on quantitative data (Big data, Internet of things, mapping GIS). People struggle to manage complex information in scenarios when several field parameters must be evaluated to make good decisions. Artificial intelligence (AI) approaches such as deep learning or neural networks, evolutionary algorithms, or expert systems can help in these situations (Saiz-Rubio and Rovira-Más 2020, Robertson et al 2018, Ingram and Maye 2020).

In India, the National e-Governance plan was first launched in seven states in 2010-11 to achieve rapid development using ICT for real-time access to agro-based information to farmers. The scheme was expanded for the remaining States and two UTs in 2014-15. Further, the program has been extended up to March 31, 2021 (PIB-February 2021). In this regard, the Indian government has signed memorandums of understanding with four groups for pilot projects. With ESRI India Pvt. Ltd. for the establishment and launch of the "National Agriculture Geo Hub," and with Amazon Web Services for the development of digital services and an agricultural value chain innovation ecosystem linked to digital agriculture. Agribazar India Pvt. Ltd. will partner with the Department of Agriculture on a pilot project to promote digital agriculture in three states (Uttar Pradesh, Madhya Pradesh, and Rajasthan). Additionally, with Patanjali Organic Research Institute for agricultural management and farmer service in Haridwar (Uttarakhand), Hamirpur (Uttar Pradesh), and Moraina (Madhya Pradesh) (PIB June 2021). On the other hand, a large number of mobile apps have been launched as a part of agro-solutions. In this regard, Balkrishna et al (2021) evaluated 73 agriculture mobile apps, which are used in different agriculture allied sectors. They found that out of these 73 apps, there are about 14% of apps are pertaining to pure agriculture, while 12% for farm management including geotagging. In the context of data-based agriculture techniques, our team at Patanjali Research Institute has developed a traceability mechanism

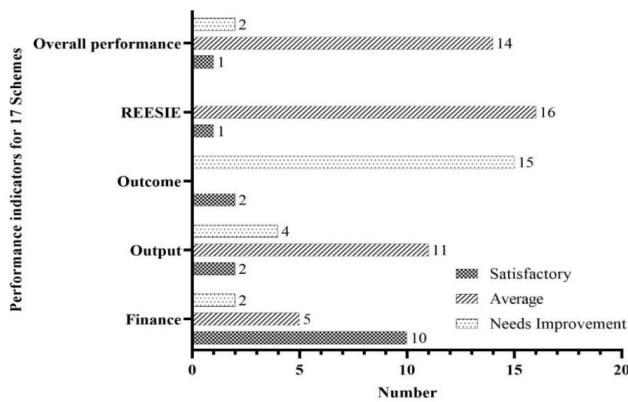


Fig. 11. Analysis of 17 schemes under Green revolution. Financial Indicators: Satisfactory: > 90%, Average: 70-90%, Needs Improvement: < 70%; Output Indicators: Satisfactory: > 80%, Average: 50-80%/physical progress, Needs Improvement: <50%; Outcome Indicators: Satisfactory: >50%, Average: <50%, Needs Improvement: Indicators need to re-aligned/not monitored/progress not available; REESIE: Relevance, Effectiveness, Efficiency, Sustainability, Impact, Equity; Overall Performance: Average of all defined parameters (NITI Aayog, 2020). Various issues, including the monitoring and planning process, are attributed to the average performance of 14 initiatives. The deployment of a digitalized agriculture approach can boost performance

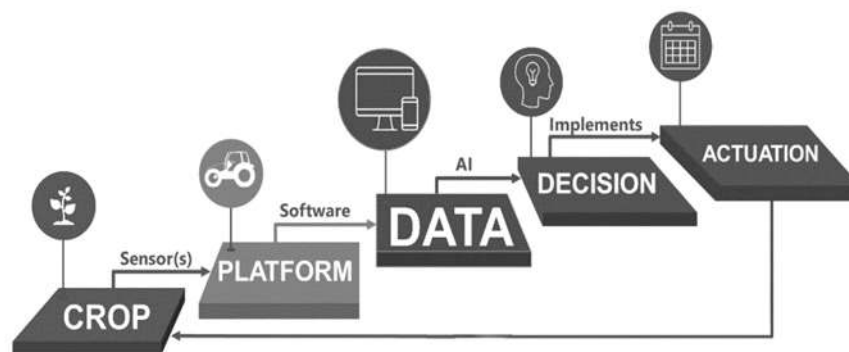


Fig. 12. Data-driven approaches for the management of agriculture (Reproduced from Saiz-Rubio and Rovira-Más 2020 under Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>))

from soil to the consumer through satellite with a digital solution. It will perform soil testing and recommend fertilizer based on soil nutrients. Along with this, an organic automotive certification program with app support accompanying it will be provided to the farmers. Parallel to this, an E-commerce portal system is also developed to reflect the farm produce along with quantitative details of both crop and other agriculture produce. This solution would be able to predict demand, shortage, and actual yield as per the commodity. A lot of work has already been done on these agro-solutions. This study will pave a new revolution in the field of digital agriculture-based initiatives in India.

CONCLUSIONS

Despite enormous efforts and a substantial proportion of the Indian economy spent on agriculture, the farmer's situation has not changed. In terms of output, Indian government efforts such as MIDH and NFSM have shown to be successful; however, several gaps in other initiatives must be addressed to improve the situation of farmers. The farming methods in India are confronted with numerous obstacles, including changing climate conditions, a diverse geographical region, traditional agricultural practices, and the country's economic and political situation. These can be overcome by implementing advanced agricultural technologies. Smart farming, digital agriculture, and Big Data Analytics are examples of these technologies that provide important information on many agricultural yield influencing elements and accurate crop production predictions. These technologies also help in the successful implementation of various government schemes.

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