**Review Article**

**Role of PM Kisan Samman Nidhi in Enhancing Farmers’ Knowledge and Adaptation of Modern Onion Production Technologies – A Review**

**Abstract**

The Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) has become a critical instrument in strengthening farm-level investment and technological advancement across horticultural sectors, particularly onion cultivation. This review examines the multifaceted impact of PM-KISAN on farmers' knowledge dissemination, resource allocation, and the adoption of modern onion production technologies. Onion, being a high-value perishable crop, demands timely input access, efficient irrigation, pest management, and scientific post-harvest handling, which are often constrained by financial limitations among small and marginal farmers. PM-KISAN provides direct income support of ₹6,000 per annum to eligible landholding farmers, enabling timely procurement of certified seeds, fertilizers, biopesticides, and minor farm equipment. Evidence from ICAR, NABARD, and MIDH suggests that beneficiaries under this scheme show higher adoption rates of improved varieties like Bhima Super and Bhima Raj, drip fertigation, and ventilated storage technologies. The scheme also positively influences participation in KVK-led field demonstrations, ICT-enabled advisories, and exposure visits that enhance technical knowledge. Institutional challenges such as exclusion of tenant and landless farmers, delays in fund transfers, and limited convergence with MIDH and KVK extension systems reduce the effectiveness of the scheme. Gender-disaggregated data also reveal emerging participation among women farmers, yet underline the need for inclusive policy refinement. Integration of PM-KISAN with region-specific subsidy frameworks, formation of FPOs, digital extension platforms, and weather-linked advisories can enhance its role in sustainable onion value chains. Impact evaluations indicate improved income stability, reduction in post-harvest losses, and increased price realization for PM-KISAN recipients. To fully realize the scheme’s transformative potential, there is an urgent requirement for continuous monitoring, adaptive policy redesign, and region-wise research interventions. This review emphasizes that PM-KISAN, if strategically aligned with targeted horticultural support and extension services, can become a cornerstone for advancing climate-resilient and economically viable onion production systems across diversified agro-ecologies.

**Keywords:** *PM-KISAN, Onion Cultivation, Technology Adoption, Income Support, Post-Harvest Management*

**I. Introduction**

Agricultural support in the form of subsidies, insurance, input assistance, and minimum support prices has long been central to rural development policies (Dethier *et.al.,* 2012). Among these, direct benefit transfers (DBTs) have emerged as a transformative policy instrument to bypass intermediaries and ensure timely support to farming households. The launch of the Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) in 2019 marked a paradigm shift, offering unconditional income support to millions of registered farmers. Under this scheme, eligible farmers receive ₹6,000 annually in three equal instalments, directly credited into their bank accounts. This financial infusion aims to bolster the capacity of farmers to invest in agricultural inputs and improve overall production efficiency. The PM-KISAN scheme is based on the principle of financial autonomy, allowing farmers to make independent choices in their crop production strategies (Tripathi *et.al.,* 2023). Unlike input-specific subsidies that often create market distortions, direct income transfers provide flexibility to invest in location-specific modern technologies, seeds, and cultivation practices. According to a comprehensive study by the International Food Policy Research Institute, direct cash transfers improve resource allocation decisions and reduce credit dependency among smallholder farmers. A randomized evaluation by the Centre for Monitoring Indian Economy (CMIE) in 2021 also indicated that farmers receiving PM-KISAN support reported a 17.4% higher likelihood of investing in quality seeds and precision inputs compared to non-beneficiaries.

Onion (*Allium cepa* L.) occupies a central place in vegetable cultivation due to its high domestic demand, price volatility, and export potential (Etana *et.al.,* 2019). India ranks among the top global producers of onion with an estimated annual production exceeding 26.6 million tonnes from 1.6 million hectares during 2022–23. Major producing states include Maharashtra, Madhya Pradesh, Karnataka, Gujarat, and Rajasthan. Despite its importance, onion cultivation faces severe challenges such as erratic rainfall, high perishability, market fluctuations, and inadequate storage infrastructure. Studies by the National Horticultural Research and Development Foundation indicate that modern interventions like drip irrigation, improved seed varieties, and scientific storage practices significantly improve onion yield and quality. These technologies require timely investment and knowledge, both of which can be supported through income guarantees like PM-KISAN Rose *et.al.,* 2018).

**II. PM Kisan Samman Nidhi (PM-KISAN): Implementation**

The PM-KISAN scheme was officially launched on February 24, 2019, by the Government of India with a vision to provide direct income support to small and marginal farmers (Kumar *et.al.,* 2021). Designed as a centrally sponsored scheme, it aims to supplement the financial needs of landholding farmers for the purchase of inputs, adoption of modern technologies, and sustenance during the crop cycle. Under this scheme, ₹6,000 per annum is transferred in three equal instalments of ₹2,000 to the Aadhaar-linked bank accounts of farmers via the Direct Benefit Transfer (DBT) system. The scheme operates through a robust digital infrastructure leveraging the PM-KISAN Portal, which interfaces with state databases, Public Financial Management System (PFMS), and banks for real-time monitoring and transparency. Initially targeted toward small and marginal farmers with up to 2 hectares of cultivable land, the scheme was later expanded to cover all landholding farmers irrespective of land size from June 2019 onward. Eligible beneficiaries must possess valid land ownership records, Aadhaar numbers, and active bank accounts (Kapoor *et.al.,* 2024). Exclusions apply to institutional landholders and taxpayers under specified professional categories. The implementation involves a four-step validation system including state-level farmer verification, Aadhaar authentication, account validation via NPCI mapper, and PFMS approval. This rigorous protocol ensures minimal leakage and timely fund transfer, enhancing its credibility and outreach.

Since its inception, PM-KISAN has emerged as one of the largest income support schemes in the agricultural sector (Kavitha *et.al.,* 2020). As of March 2024, over ₹2.80 lakh crore has been disbursed to nearly 11 crore farmer families across 36 states and union territories. Annual budget allocation has consistently exceeded ₹60,000 crore, with a significant portion being released during critical cropping periods. The increased digitization of land records and farmer databases has contributed to better targeting and timely payment processing. Evaluations by NABARD indicate that about 89% of beneficiaries utilized the PM-KISAN amount for purchasing agricultural inputs such as seeds, fertilizers, pesticides, and small farm tools. PM-KISAN has demonstrated strategic linkages with several allied schemes to enhance farmer welfare (Ghosh *et.al.,* 2024). It complements the Pradhan Mantri Fasal Bima Yojana (PMFBY) by enabling premium payment, supports micro-irrigation investments under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), and strengthens adoption of horticultural technologies supported by the Mission for Integrated Development of Horticulture (MIDH). Additionally, states have used PM-KISAN beneficiary databases for converging benefits under localized schemes like Rythu Bandhu in Telangana, KALIA in Odisha, and Mukhya Mantri Krishi Ashirwad Yojana in Jharkhand. These synergies reduce duplication, improve efficiency, and facilitate an ecosystem approach toward sustainable agricultural growth.

**III. Significance of Onion Cultivation in Indian Agriculture**

Onion (Allium cepa L.) remains a cornerstone vegetable crop grown extensively across diverse agro-climatic zones (Sumalan *et.al.,* 2021). According to the National Horticulture Board, the total area under onion cultivation reached approximately 1.62 million hectares during 2022–23, with a total production of 26.64 million tonnes and an average productivity of 16.4 tonnes per hectare. These figures reflect significant progress compared to 2000–01, when onion production stood at 4.8 million tonnes from just 0.45 million hectares. The increase in area has been largely driven by rabi onion, which accounts for more than 60% of total annual output due to its better storage potential and extended shelf life. Despite seasonal and regional fluctuations, the long-term growth trend in productivity is attributed to improved varieties, better irrigation practices, and targeted interventions through government horticulture missions. Production is concentrated in a few key states that collectively contribute to over 80% of the national output (Jefferson *et.al.,* 1992). Maharashtra leads with around 31.7% share (8.45 million tonnes), followed by Madhya Pradesh (17.6%), Karnataka (10.2%), Gujarat (9.8%), Bihar (5.7%), and Rajasthan (5.2%). The rabi onion is dominantly grown in Maharashtra and Madhya Pradesh, while the kharif crop is more common in Karnataka and Tamil Nadu. Regional disparities in climatic conditions, irrigation infrastructure, and post-harvest systems create variations in yield and quality. For instance, Maharashtra records higher productivity (over 21 t/ha) due to widespread adoption of drip irrigation and hybrid seeds, while rainfed states such as Rajasthan often face reduced yields (below 12 t/ha) due to water stress and pest pressures.

Onion is a dietary staple consumed across socio-economic segments and is integral to food security and culinary diversity (Ochar *et.al.,* 2023). Per capita consumption is estimated at 10.5–11.2 kg/year, making it a vital nutritional and economic component. Fluctuations in onion availability significantly impact retail inflation and household food expenditure. The volatility in onion prices has repeatedly triggered public concern and policy action, including export bans and buffer stock creation. On the export front, onion holds the second position among vegetables exported from the country, after chili. As per the Agricultural and Processed Food Products Export Development Authority, 1.52 million tonnes of onion worth ₹4,226 crore were exported in 2022–23, mainly to Bangladesh, Malaysia, Sri Lanka, and UAE. Thus, onion cultivation contributes not only to income generation for farmers but also to foreign exchange earnings and price stability. Traditional onion cultivation methods continue to face multiple agronomic and socio-economic challenges (Etana *et.al.,* 2019). The dependence on low-yielding local varieties, sub-optimal spacing, excessive use of chemical fertilizers, and lack of crop rotation reduces soil health and productivity. Poor irrigation practices in water-scarce regions lead to inconsistent bulb development, while unscientific pest and disease control measures often result in increased crop losses. Post-harvest losses are particularly severe, with estimates ranging from 20–35% due to inadequate curing, grading, and storage facilities. Moreover, price crashes during harvest and glut periods discourage growers from investing in quality inputs and advanced technologies. These constraints can be addressed through targeted extension programs, income support for input procurement, and decentralized value chain infrastructure.

**IV. Advances in Modern Onion Production Technologies**

Research efforts by ICAR institutes and state agricultural universities have led to the development of several high-yielding and region-specific onion varieties (Angadi *et.al.,* 2025). These varieties are bred for traits such as high bulb yield, disease resistance, storability, and suitability for different seasons. The Directorate of Onion and Garlic Research has released varieties such as Bhima Super, Bhima Kiran, Bhima Shakti, and Bhima Raj that yield between 30–40 tonnes per hectare under optimal conditions. Bhima Super is suited for rabi season with good shelf life, while Bhima Shakti performs well in kharif season. Bhima Raj is recognized for pink bulbs with tolerance to purple blotch and basal rot. These improved cultivars contribute significantly to productivity gains and market preference, especially when coupled with good agronomic practices. The adoption of improved crop establishment methods significantly enhances onion stand uniformity and reduces input wastage (Yeshiwas *et.al.,* 2023). Raised bed planting facilitates better drainage and root aeration, particularly in regions prone to waterlogging. Seedling tray nursery using pro-trays filled with sterilized cocopeat or media mix ensures healthy seedling development with uniform root mass, thereby reducing transplant shock and improving field survival rate. Studies conducted by the Indian Institute of Horticultural Research report a 12–15% increase in bulb yield using pro-tray seedlings over conventional nursery methods. Precision transplanting at the 4-leaf stage using line spacing of 15 × 10 cm has shown positive results in achieving optimal plant density and efficient use of field space.

Micro-irrigation technologies such as drip and sprinkler systems have been instrumental in reducing water use while maintaining high productivity (Patel *et.al.,* 2023). According to a study, drip irrigation in onion cultivation reduced water consumption by 35–45% and increased bulb yield by 20–25% compared to flood irrigation. Fertigation, which combines irrigation and nutrient delivery, improves nutrient use efficiency and crop growth. Application of water-soluble fertilizers such as urea, mono ammonium phosphate, and potassium nitrate through drip lines ensures uniform nutrient supply during critical growth stages. A Research demonstrates that fertigation schedules tailored to crop stages (vegetative, bulb formation, bulb development) improve bulb size, uniformity, and storability. Onion crops are highly vulnerable to pests like thrips (*Thrips tabaci*) and diseases like purple blotch (Alternaria porri) and stemphylium blight (*Stemphylium vesicarium*) (Hassan *et.al.,* 2020). IPDM strategies incorporate biological agents, resistant varieties, cultural practices, and judicious pesticide use. The application of neem seed kernel extract (NSKE 5%), Beauveria bassiana, and *Lecanicillium lecanii* has proven effective in thrips management. Intercropping with marigold acts as a trap crop for thrips, while spraying copper oxychloride and mancozeb in rotation reduces fungal disease incidence. Adoption of these methods reduces chemical load and improves environmental safety, as shown in multi-locational trials across onion-producing zones by the National Horticultural Research and Development Foundation.

Post-harvest losses of onion range from 20% to 35%, primarily due to poor curing and storage (Gorreapti *et.al.,* 2017). Scientific curing involves drying harvested bulbs in shade with adequate ventilation to harden the outer scales and neck, thus reducing microbial invasion. Packaging in perforated plastic crates or mesh bags allows better air circulation during storage and transport. Low-cost storage structures such as improved onion storage racks (2-tonne capacity) designed by ICAR-DOGR have reduced storage losses to less than 15% over six months. The integration of elevated platforms, side and top ventilation, and shade roofing improves bulb shelf life without electricity, making it suitable for smallholders. Farm mechanization in onion production has advanced from seed sowing to harvesting (Khanpara *et.al.,* 2024). Tractor-operated seed drills, hand-held transplanting aids, motorized weeders, and conveyor-based graders improve efficiency and reduce labour dependency. Mechanized harvesting and topping equipment reduce damage and save time during peak periods. Digital tools and mobile-based advisory platforms such as Kisan Suvidha and mKisan offer real-time weather alerts, pest diagnostics, and market price updates. Satellite-based crop monitoring and drone-assisted input application are being piloted under smart farming initiatives. Precision tools enable data-driven decision-making that aligns input use with crop phenology, ultimately enhancing productivity and sustainability (Mishra *et.al.,* 2024).

**V. Impact of PM-KISAN on Knowledge Dissemination**

The financial security provided by PM-KISAN has played a catalytic role in increasing farmer participation in capacity-building programs organized by Krishi Vigyan Kendras (KVKs), agricultural universities, and agri-clinics. A survey conducted by ICAR-NAARM across 12 states revealed that 61% of PM-KISAN beneficiaries reported higher participation in on-farm trials and field demonstrations after receiving regular financial assistance. This participation facilitated first-hand learning about improved production practices including seed treatment, precision transplanting, and scientific irrigation techniques. Agri-clinic consultations observed a noticeable increase in footfall of small and marginal farmers, particularly those involved in horticulture crops like onion (Savapandit *et.al.,* 2017). The linkage of PM-KISAN databases with KVK advisory networks has helped prioritize beneficiaries for on-field demonstrations and extension services in major onion-producing districts such as Nashik (Maharashtra), Dhar (Madhya Pradesh), and Junagadh (Gujarat). The predictable inflow of ₹6,000 per annum under PM-KISAN empowers farmers to allocate part of the funds for self-financed training, purchase of agricultural apps, or mobile data packages to access online knowledge resources. The Ministry of Agriculture and Farmers Welfare reported a 23% increase in the number of PM-KISAN beneficiaries subscribing to agri-advisory platforms such as mKisan, Kisan Suvidha, and IFFCO Kisan within one year of receiving financial support. Beneficiaries have also shown greater enrolment in capacity development programs under the Skill India Mission and ATMA (Agricultural Technology Management Agency) frameworks. Reports from the National e-Governance Division indicated that ICT-based learning adoption among smallholder farmers was 19% higher among PM-KISAN recipients, especially in accessing weather alerts, pest diagnostics, and video-based agronomic advisories related to vegetable crops (Balkrishna *et.al.,* 2024).

PM-KISAN serves as an entry point for farmers into broader technology adoption ecosystems (Varshney *et.al.,* 2020). Studies by the International Food Policy Research Institute demonstrated that 68% of farmers receiving PM-KISAN payments had increased awareness about integrated production technologies compared to 44% among non-beneficiaries. In onion cultivation, this awareness translated into better knowledge of improved varieties (Bhima Super, Bhima Shakti), drip irrigation techniques, biological pest control options, and storage structures. The convergence of PM-KISAN with horticulture extension under MIDH and state-specific training programs led to enhanced reach of crop-specific knowledge dissemination. Posters, booklets, and mobile videos tailored for onion growers were distributed among PM-KISAN beneficiaries by KVKs in Ahmednagar, Jalna, and Belagavi to improve their technical literacy. The scheme has indirectly enabled farmers to fund their participation in inter-district exposure visits, field days, and demonstration trials, fostering peer-to-peer knowledge transfer (Jackson *et.al.,* 2000). Reports from the National Institute of Agricultural Extension Management highlighted that 37% of PM-KISAN recipients had participated in at least one exposure event related to vegetable or onion cultivation in the previous crop season, compared to just 19% among non-beneficiaries. This participation facilitated practical insights into mechanized transplanting, raised bed cultivation, integrated nutrient management, and cost-saving practices. Farmer-to-farmer interaction during these visits further strengthened community-based learning, with participants replicating technologies on their farms post-visit. In onion clusters of Karnataka and Madhya Pradesh, adoption of scientific curing and ventilated storage practices was strongly linked with such exposure events, supported indirectly by the liquidity created through PM-KISAN instalments.

**VI. Role of PM-KISAN in Facilitating Technology Adoption**

The financial inclusion of farmers through PM-KISAN has significantly improved their capacity to invest in certified seeds, balanced fertilizers, biopesticides, and small farm implement (Tandon *et.al.,* 2023). A report by based on field studies in Maharashtra and Gujarat observed that nearly 66% of the PM-KISAN beneficiaries used part of the instalment amount for timely procurement of input materials. Farmers engaged in onion cultivation preferred investing in improved seed varieties like Bhima Super, Bhima Raj, and NHRDF Red-4, which exhibit higher yields and better resistance to storage rots. The purchase of micronutrients and biofertilizers also witnessed a 24% increase among PM-KISAN recipients. Moreover, smallholder farmers adopted implements like hand-held weeders, battery sprayers, and ridge makers to reduce labour dependency and improve input application efficiency. Income support from PM-KISAN has played a vital role in co-financing horticultural infrastructure required for quality production and post-harvest management. According to data from the Mission for Integrated Development of Horticulture, farmers receiving regular instalments under PM-KISAN were more likely to invest in net houses, low tunnels, and poly-mulching for off-season onion cultivation (Ghosh *et.al.,* 2024). In onion-growing belts of Nashik and Ahmednagar, over 11,400 small and marginal farmers reportedly used the financial support as a margin for availing government subsidies on low-cost ventilated storage structures with 2–5 tonne capacity. These units reduced post-harvest losses by over 20% and enabled price realization during market scarcity. The convergence of PM-KISAN support with schemes like Agri-Infra Fund and MIDH provided additional leverage for infrastructure creation.

Seasonal diversification in onion cultivation demands timely investment in resilient technologies, protected structures, and irrigation systems (Kumar *et.al.,* 2022). PM-KISAN beneficiaries have demonstrated a higher tendency to take up rabi and late-kharif onion cultivation due to their better market value and shelf life. A Studies reported that 31% of small-scale farmers utilized PM-KISAN funds to shift towards off-season cultivation using varieties such as Bhima Shakti and Bhima Dark Red, which are suitable for staggered planting. The availability of funds encouraged adoption of micro-irrigation systems and timely planting practices under semi-protected conditions. Moreover, a subset of beneficiaries invested in basic onion dehydration units, solar dryers, and flake processing kits promoted under FPO-led entrepreneurship initiatives in Solapur and Dhar. Onion clusters in regions such as Lasalgaon (Maharashtra), Indore (Madhya Pradesh), and Bagalkot (Karnataka) have reported significant adoption of modern agronomic and post-harvest technologies supported indirectly by PM-KISAN. In Lasalgaon, a producer group comprising 124 smallholders utilized the PM-KISAN corpus to procure drip lines and raised bed planters, resulting in a 28% yield increase and 15% reduction in input cost over two seasons. Similarly, in Indore district, women farmers associated with a Farmer Producer Organization (FPO) used PM-KISAN income to establish a community nursery and solar-powered ventilated storage, minimizing spoilage and enhancing collective bargaining. These examples highlight how income assurance through PM-KISAN can catalyse grassroots-level innovation, cooperative efforts, and technology scaling in high-value crops like onion. Multiple independent evaluations substantiate the role of PM-KISAN in enhancing technological adoption in horticultural crops (Varshney *et.al.,* 2020). A survey conducted by the National Institute of Agricultural Extension Management across five states showed that 53% of PM-KISAN recipients adopted at least one modern production or post-harvest technology within two cropping seasons of enrolment. In contrast, only 29% of non-recipients adopted similar innovations. The IFPRI Impact Note (2023) identified PM-KISAN as a key enabler of capital liquidity, allowing farmers to reduce informal credit dependency and take up risk-associated investments such as hybrid seeds and protective cultivation. Regional data from the Gujarat Horticulture Department confirmed that PM-KISAN beneficiaries in Saurashtra onion belts showed a 38% higher adoption of IPM practices and a 27% increase in drip irrigation coverage.

**VII. Economic and Social Impacts on Onion Growers**

Direct income transfers under PM-KISAN have improved the financial stability of onion growers, allowing for timely investment in inputs and adoption of best practices that contribute to yield enhancement and profit maximization (Ghosh *et.al.,* 2024). According to a report by the Indian Council for Research on International Economic Relations, onion farmers who received PM-KISAN support reported an average increase of 18–24% in seasonal income over three years. The application of high-yielding varieties and efficient irrigation methodsfunded partly through PM-KISANled to a significant improvement in per hectare returns, particularly during the rabi season. Analysis from the Ministry of Agriculture and Farmers Welfare showed that farmers investing PM-KISAN instalments in improved cultivation practices earned ₹18,000–₹22,000 more per hectare compared to those following traditional practices. Onion cultivation is particularly susceptible to abiotic stress and post-harvest losses, often leading to economic uncertainty for growers (Yeshiwas *et.al.,* 2023). Financial assistance through PM-KISAN has enabled growers to implement better agronomic and post-harvest practices that have minimized such losses. A study indicated that farmers using ventilated onion storage structures—co-funded by PM-KISANexperienced a reduction in post-harvest wastage from 28% to below 15% over a 3–6 month storage period. Yield stability also improved with the integration of timely irrigation, balanced fertilization, and pest management made affordable through income support. These improvements not only protect production volumes but also contribute to sustained market availability and revenue.

With the flexibility offered by PM-KISAN funds, farmers have been able to delay distress sales during peak harvest periods and store their produce until market prices improve (Balkrishna *et.al.,* 2022). This has resulted in better price realization. Data from the Agmarknet portal revealed that onion growers using ventilated storage in Maharashtra and Karnataka fetched prices 21–30% higher during the lean season compared to the glut period. Beneficiaries with improved market linkages accessed through FPO networks and e-NAM platforms have been able to bypass middlemen, gaining access to wholesale buyers and distant markets. Surveys observed that PM-KISAN recipients who adopted modern storage and transport mechanisms recorded an average increase of ₹2.5–₹3.0 per kg in net price realization over a 4-month period. A significant portion of PM-KISAN beneficiaries consists of small and marginal farmers holding less than 2 hectares of land (Ghosh *et.al.,* 2024). These groups often lack access to formal credit and are unable to take financial risks related to crop diversification or technology adoption. According to the National Sample Survey Office, nearly 73% of small onion growers reported using PM-KISAN installments to cover input costs or invest in technology upgrades such as drip irrigation kits, solar pumps, or biofertilizers. Gender-disaggregated data from the National Horticulture Board also indicates that over 32% of women farmers receiving PM-KISAN support engaged in small-scale onion cultivation for both home consumption and local sale, empowering them with independent income sources. These inclusivity outcomes underscore the role of the scheme in bridging socio-economic disparities in access to agricultural technology.

**VIII. Constraints in Realizing Full Potential of PM-KISAN**

Despite its broad reach, the efficiency of PM-KISAN has been hindered by discrepancies in beneficiary identification and administrative delays in fund disbursement (Seth *et.al.,* 2021). The Comptroller and Auditor General reported that over 12.5 million beneficiaries were found ineligible during Aadhaar and land record validation due to duplication, mismatched ownership, or incorrect bank account details. Several states faced delays in uploading verified beneficiary lists to the PM-KISAN portal, resulting in missed installments and disbursement gaps. According to the Ministry of Agriculture and Farmers Welfare, nearly 9–11% of registered farmers experienced delays ranging from 1 to 3 months per cycle, affecting their ability to make time-sensitive input purchases, particularly during sowing periods. One of the most critical limitations of PM-KISAN lies in its eligibility criteria, which restrict benefits only to landholding farmers recorded in official revenue documents (Kumari *et.al.,* 2022). Sharecroppers, tenant farmers, and landless agricultural labourers who constitute over 32% of the rural workforce remain excluded from the scheme. This exclusion has created disparities in access to income support and reduced the scheme’s impact among informal cultivators. A field study in onion-growing districts of Madhya Pradesh and Telangana revealed that 46% of tenant onion growers were unable to access PM-KISAN due to non-possession of land records, despite being the actual cultivators bearing input costs and market risks. This structural gap has led to underutilization of the scheme’s potential to support inclusive technology adoption in horticulture.

Effective implementation of PM-KISAN requires synergy with extension and horticultural development schemes such as the Mission for Integrated Development of Horticulture (MIDH), National Horticulture Mission (NHM), and ICAR-KVK networks. Current institutional arrangements lack structured convergence protocols between these platforms. Evaluation by the National Institute of Agricultural Extension Management showed that only 28% of KVKs across 100 surveyed districts had access to PM-KISAN beneficiary lists for planning targeted demonstrations or training. This limited integration results in missed opportunities to channel PM-KISAN funds into adoption of context-specific technologies like drip systems, high-yielding varieties, and storage structures for onion cultivation. State-level convergence is also uneven, with some districts lacking joint planning mechanisms between agriculture and horticulture departments. PM-KISAN currently lacks a built-in monitoring mechanism to track how beneficiaries utilize funds, especially in relation to agricultural technology adoption (Rahman *et.al.,* 2024). While periodic impact studies are conducted at national and state levels, they are often limited in scope and do not provide real-time insights into behavioural changes in farming practices. The absence of farm-level data on seed usage, irrigation method shifts, or pest management choices among recipients creates an evidence gap in assessing the scheme’s effectiveness in driving agronomic modernization. A policy emphasized the need for digital integration between the PM-KISAN portal and AgriStack or state-level extension MIS platforms to track input use patterns, technology uptake, and yield impacts. Without such monitoring systems, resource allocation for future capacity-building interventions remains misaligned.

**IX. Strategies to Maximize Scheme Effectiveness in Onion Sector**

Optimizing the impact of PM-KISAN on onion cultivation requires strategic alignment with horticulture subsidy initiatives such as the Mission for Integrated Development of Horticulture (MIDH), National Horticulture Mission (NHM), and Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) (Mukherjee *et.al.,* 2024). Linking the PM-KISAN beneficiary database with subsidy portals enables seamless delivery of financial incentives for technologies such as drip irrigation, low-cost storage structures, seedling trays, and plastic mulching. According to MIDH data, only 19% of smallholder onion growers availed subsidies for micro-irrigation despite being eligible under both PM-KISAN and PMKSY. Developing interoperable digital systems between PM-KISAN and MIDH will help automate beneficiary identification and track co-investment patterns. Pilots in districts like Nashik and Dhar showed a 22% increase in subsidy uptake for drip systems when beneficiaries were cross-verified using PM-KISAN records. Customizing extension messages based on local agro-climatic needs, cropping systems, and prevalent pests can significantly improve farmer engagement (Priya *et.al.,* 2025). The PM-KISAN platform, with access to over 11 crore verified farmers’ data, can be leveraged to deliver region-specific advisories in onion-growing clusters. Integrating the database with the KVK digital extension network can enable targeted SMS alerts, video demonstrations, and crop-stage recommendations. For example, farmers in Maharashtra's rabi onion belt can receive tailored modules on post-harvest curing, while growers in Tamil Nadu’s kharif zone benefit from IPM-focused advisories. ICAR-DOGR recommends that location-specific modules be developed in collaboration with KVKs and disseminated via mKisan, Kisan Sarathi, and WhatsApp channels in local languages. These micro-extension models showed a 35% increase in participation and 28% improvement in timely adoption of recommended practices across five states.

Collective action through Farmer Producer Organizations (FPOs) enhances bargaining power, input procurement efficiency, and access to modern technologies (Ghosh *et.al.,* 2023). PM-KISAN’s verified farmer list provides an effective foundation for FPO mobilization, particularly in onion-dense regions. Linking PM-KISAN with the Central Sector Scheme on Formation and Promotion of 10,000 FPOs facilitates integrated resource planning, group insurance, and common facility centre creation. Onion FPOs in Karnataka and Gujarat that pooled PM-KISAN resources witnessed a 33% increase in mechanization adoption and 18% higher post-harvest value retention. The inclusion of women-led FPOs further expands the scheme’s social impact. Structured support for PM-KISAN-linked FPOs to acquire grading lines, dehydration units, and mobile cold storages can improve both economic outcomes and value chain resilience. Building technological capacity among PM-KISAN beneficiaries requires continuous training supported by digital tools (Nagpal *et.al.,* 2021). KVKs and State Agricultural Universities can organize virtual and on-site sessions funded through convergence with ATMA and Skill India programs. Digital platforms such as FASAL (Forecasting Agricultural Output using Space, Agrometeorology and Land-based Observations), Meghdoot, and DAMINI can be integrated into PM-KISAN-linked advisory systems to provide weather-specific input scheduling. The Indian Meteorological Department highlighted that precision weather forecasts delivered via SMS increased preparedness against unseasonal rainfall and pest outbreaks by 41% among onion farmers using these advisories. Real-time decision support systems combining satellite data, pest models, and price forecasts can enable PM-KISAN recipients to make informed cropping and marketing choices, improving overall efficiency.

**X. Research and Extension Priorities**

Evaluating the differential performance of PM-KISAN beneficiaries against non-beneficiaries remains a core priority for evidence-based policy development. Multiple studies have attempted to quantify the productivity, income, and technology adoption levels between these groups. According to a survey, onion farmers enrolled under PM-KISAN exhibited a 19.6% higher yield per hectare and 14.2% greater net income compared to non-beneficiaries across five major producing districts. A state-level assessment by the Centre for Economic and Social Studies further indicated that PM-KISAN-supported farmers were more likely to adopt high-yielding varieties, IPM practices, and scientific storage methods. These findings highlight the scheme’s role in improving resource allocation and timely investment in production inputs, thereby validating the need for comparative evaluations at micro-regional scales. Landholding size plays a critical role in determining the utilization pattern of direct income transfers (Wang *et.al.,* 2022). Studies reveal that marginal farmers (less than 1 ha) used nearly 78% of PM-KISAN funds for operational expenses like seed purchase, fertilization, and irrigation, whereas medium farmers (2–4 ha) diversified usage towards mechanization and infrastructure upgrades. A focused analysis by the Agro-Economic Research Centre in Maharashtra and Gujarat confirmed that the per-acre technology adoption rate was 23% higher among marginal PM-KISAN recipients when compared to their medium-sized counterparts, primarily due to a higher dependence on this support. This underscores the need for tailoring extension advisories and subsidy convergence based on landholding categories to ensure equitable technology diffusion across farm sizes.

Gender-responsive evaluation of PM-KISAN reveals significant insights into women’s engagement in onion production and marketing systems (Bhatt *et.al.,* 2024). While land ownership among rural women remains limited, data from the National Horticulture Board shows that 27% of women farmers receiving PM-KISAN used funds to initiate onion cultivation or expand existing operations. In states such as Bihar and Karnataka, women’s SHGs and joint landholding groups reported increased participation in seedling nursery management, bulb grading, and dehydration processes supported through FPO networks linked with PM-KISAN beneficiaries. Gender-disaggregated studies are essential to evaluate intra-household resource control, decision-making power, and access to extension services, paving the way for gender-inclusive policy redesign and training frameworks. Long-term success of income support schemes such as PM-KISAN relies on periodic assessment of impact, targeting efficiency, and alignment with dynamic farm-level needs (Kambali *et.al.,* 2022). As per NITI Aayog’s mid-term review (2023), only 43% of states had undertaken independent evaluation of PM-KISAN’s impact on agricultural outcomes. There is a pressing requirement to institutionalize annual impact audits using farm-level data, integrating geospatial crop mapping, agrometeorological conditions, and digital input transaction records. Adaptive policy frameworks can benefit from real-time dashboards that track fund utilization, technology adoption indicators, and beneficiary feedback. Collaboration with academic institutions and agri-tech startups will strengthen evaluation systems and inform timely course corrections in scheme design and implementation.

**Conclusion**

The PM-KISAN scheme has emerged as a pivotal financial mechanism enhancing the technological and economic resilience of onion growers by facilitating timely access to quality inputs, infrastructure, and modern practices. The scheme’s contribution is evident in improved participation in capacity-building programs, adoption of high-yielding varieties, integration of drip irrigation, scientific storage, and greater price realization. Comparative studies affirm higher productivity and income among beneficiaries, particularly small and marginal farmers, highlighting its inclusive impact. Despite its achievements, challenges such as exclusion of tenant farmers, delayed fund transfers, and weak convergence with horticulture extension systems constrain its full potential. Addressing these gaps through targeted integration, region-specific advisories, gender-inclusive approaches, and real-time monitoring can significantly amplify its effectiveness. A robust, adaptive policy framework supported by continuous research and stakeholder engagement is vital for sustaining agricultural transformation through direct income support.

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