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RESEARCH ARTICLE

Impact assessment of mobile agri support services on farmers' aspirations in aspirational districts of India: A difference-in-differences approach

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Abstract

The present study assesses the impact of Mobile Agri Support Services (MASS), a digital–physical agricultural extension initiative conceptualised and implemented by the Extension Education Institute (EEI), Professor Jayashankar Telangana Agricultural University (PJTAU), in collaboration with Evergreen Energy Enterprises Pvt. Ltd., on farmers' aspirations in three selected aspirational districts of Telangana. The MASS is a unique 'phygital' (physical + digital) platform tested for a period of one year (2nd June 2023 to 31st July, 2024) aimed at addressing critical gaps in agricultural extension by delivering real-time, hyperlocal and technology-enabled agricultural services. The study adopts an experimental research design involving 600 beneficiary farmers (experimental group) and 400 non-beneficiary farmers (control group) across 6 villages from each mandal. Employing the difference-in-difference (DID) technique, the study measures pre- and post-intervention changes in technological, economic, environmental and social aspirations of farmers. Data collection was conducted through structured interviews and analysed using statistical tools like frequency, percentage, arithmetic mean and Z-tests. A DID approach was employed to estimate the causal effect of the intervention on technological, economic, environmental and social aspirations. The results indicate a substantial positive shift in the aspirations of beneficiary farmers following the intervention. In the sample area, aspirations towards technological change increased from 19.52 to 48.41 units, reflecting a significant gain of 28.89 units, while no change was observed in the non-sample area (14.54 units before and after). Similarly, economic aspirations rose from 5.73 to 16.96 units in the sample area, showing an improvement of 9.85 units compared to a marginal increase in the non-sample area (5.53 to 6.64 units). Aspirations related to environmental change exhibited a marked rise from 15.65 to 94.45 units, indicating a substantial enhancement of 70.93 units relative to the non-sample area (8.20 to 16.16 units). Additionally, another dimension showed an increase from 11.65 to 35.20 units in the sample area, with a corresponding gain of 21.55 units, compared to only a slight change in the non-sample area (11.43 to 13.43 units). In contrast, non-beneficiary farmers in control areas exhibited static or marginal changes. Thus the MASS initiative demonstrated its potential in enhancing farmers' aspirations and capacities towards sustainable agricultural development, especially in backward regions, suggesting its scalability and relevance in similar agrarian contexts. The findings indicate significant post-intervention improvements among beneficiary farmers across all aspiration dimensions, while no meaningful changes were observed in control areas.

Keywords: aspirational districts; economic change; environmental change; phygital services; social change; technological change

Introduction

Farmers and rural communities need continuous awareness and handholding on the latest and futuristic technologies, better crop management practices, market linkage etc. Many organisations both well established and startups are innovating solutions which can help the farmers and rural communities to increase their earnings and have sustainable livelihoods. Access to this information and continuous handholding reaching the last mile user and bridging the gap between the solution providers and the rural communities is a big challenge.

In recent years, substantial technological advancements have been made in agriculture, ranging from improved seed varieties, precision farming tools, digital advisory services, to climate-smart agricultural practices. Yet the uptake of these innovations by smallholder farmers remains significantly low, primarily due to barriers in accessibility, affordability and lack of localised relevance. Traditional agricultural extension systems have struggled to meet the evolving demands of farmers, especially in remote and socio-economically backward regions, thereby widening the knowledge and service delivery gap. The effective extension systems must go beyond conventional models to integrate new technologies, improve outreach and enhance farmers' access to knowledge, thereby increasing productivity and bridging the knowledge-practice gap. Through a synthesis of country-level reform trajectories and case studies, there is a need for achieving more inclusive and responsive agricultural advisory services (1).

Recognising these pressing challenges, The Professor Jayashankar Telangana Agriculture University (PJTAU), Extension Education Institute and Evergreen Energy Enterprises Pvt. Ltd. are the institutions came forward with one phygital (physical + digital) solution called mobile agri support services (MASS) initiative to deliver hyper-localised, real-time agricultural services directly to farmers' doorsteps. These innovative organisations are working in the areas of last mile connectivity in agriculture and allied sectors. The initiative engaged farmers through MASS vehicle offering on-site soil testing, drone demonstrations, agri-input samples and digital advisory services through tele/video conferencing. There is a growing consensus on the need for modern, innovative and inclusive extension approaches that not only disseminate knowledge but also ensure timely, farmer-friendly and need-based solutions. Mobile agri support services introduces a transformative approach using a unique 'phygital' model in this context.

The primary goal of the MASS initiative is to bridge the last-mile gap in agricultural service delivery by providing expert advisories, facilitating capacity building and promoting technology adoption in a context-sensitive manner. Farmers use multiple information sources that may be complementary or substitutes to each other, implying that no single source satisfies all information needs of farmers. Understanding farmers' likelihood of choosing information sources can guide policy interventions to deliver targeted and effective agricultural information dissemination (2). This objective of the study is to determine the aspirations of the farmers towards MASS initiative. The study also deals with the aspirations of the farmers towards MASS concept in terms of bringing technological, economic, environmental and social changes in their farming situations. The findings of the study would be useful for implementing agencies like State Department of Agriculture and allied sectors of all the states of the country. The findings and suggestions would help policy makers, administrators and extension personnel for drawing effective strategies/plans for effective implementation of the project. The results of the study could be effectively used in other areas where similar conditions exist with necessary structural changes

Materials and Methods

Research design

The present study employed a quasi-experimental research design to assess the impact of the MASS intervention on the aspirations of farmers in selected aspirational districts of Telangana. Bennett's hierarchy model was used in the present study as it provides a systematic and logical framework for assessing the sequential effects of extension and development interventions, moving from inputs and activities to higher-order outcomes and impacts. The hierarchical structure of the model enables the assessment of intermediate outcomes, such as changes in farmers aspirations and perceptions, which are often overlooked when evaluations focus solely on final impacts. By adopting Bennett's Hierarchy Model, the study captures the pathway through which the MASS intervention influences farmers, allowing for a more comprehensive understanding of how technological, economic, environmental and social aspirations evolve because of the intervention. The research involved two groups of respondents:

An experimental group (beneficiaries of MASS intervention) and a control group (non-beneficiaries from non-intervention areas).

Data were collected through pre- and post-intervention surveys, allowing for comparative analysis over time. The study utilised the difference-in-difference (DID) method combined with Bennett's hierarchy of evaluation to measure changes in aspirations, among the farming community. The DID approach was adopted to rigorously estimate the causal impact of the MASS intervention by comparing changes in farmers' aspirations over time between intervention (sample) and non-intervention (non-sample) areas. The DID is particularly suitable in this context, as random assignment of the intervention was not feasible and the program was rolled out in selected villages based on administrative considerations. By exploiting temporal variation and cross-sectional differences, the DID framework effectively controls for unobserved time-invariant heterogeneity between the two groups, thereby strengthening causal inference.

The validity of the DID estimates rests on the parallel trends assumption that, in the absence of the intervention, aspiration levels in both sample and non-sample areas would have followed similar trajectories over time. This assumption was supported both theoretically and empirically. Theoretically, the sample and non-sample villages were comparable in terms of agro-ecological conditions, socio-economic characteristics, institutional access and baseline aspiration levels prior to the intervention. Empirically, baseline comparisons revealed no statistically significant differences in pre-intervention aspiration trends across the two groups, suggesting a common underlying trajectory. Additionally, the short time horizon and absence of other major policy interventions during the study period reduce the likelihood of differential external shocks affecting the two groups.

Sampling procedure

A multi-stage purposive and random sampling technique was used for the selection of state, districts, mandals, villages and respondents.

Selection of the state

The state of Telangana was selected purposively because the project is implemented in Telangana state.

Selection of districts

Three aspirational districts Kumurambheem Asifabad, Jayashankar Bhupalapally and Badradri Kothagudem were selected purposively based on the backwardness index of the districts.

Selection of mandals

Two mandals from each district namely Mutharam and Chityal mandals from Jayashankar Bhupalapally, Kagaznagar and Tiryani mandals from Kumurambheem Asifabad and Gundala and Annapureddypalli mandals from Bhadradri Kothgudem were selected randomly from each district.

Selection of villages

One village from each mandal namely Polaram (Mutharam manadal), Gunturpally (Chityal), Nazrulnagar (Kagaznagar), Nayakapuguda (Tiryani), Sayanapally (Gundala) and Abbugudem (Annapureddypalli) were selected for the project, thus constituting 6 villages.

Selection of respondents

The 600 farmers were selected randomly from intervention villages to form the experimental group and 400 farmers were selected from nearby non-intervention villages to serve as the control group.

The final sample comprised 1000 respondents, ensuring adequate power for statistical analysis. The same respondents were surveyed during both the pre- and post-intervention periods, thereby constituting a balanced panel dataset. This panel design strengthens the DID identification strategy by allowing the analysis to control for individual-specific, time-invariant unobserved characteristics, further improving the precision and reliability of the estimated treatment effects.

Variables and measurement

Dependent variables

In the present study, aspiration is operationally defined as the farmer's perceived and expressed level of desired improvement and positive change attributable to the MASS intervention across four dimensions technological, economic, environmental and social. The primary outcome measured was the aspiration levels of farmers, categorised under four key dimensions:

- Technological aspirations
- Economic aspirations
- Environmental aspirations
- Social aspirations

These were assessed using a structured interview schedule, specifically designed and pre-tested for this study. Each dimension comprised a set of sub-items capturing key aspects of perceived change due to the MASS intervention. Responses were recorded on a dichotomous scale (Yes = 1, No = 0) and composite scores were generated by summing item responses within each dimension. The internal consistency reliability of the aspiration scales was assessed using Cronbach's alpha (Kuder-Richardson Formula 20; KR-20), appropriate for dichotomous response items. The technological change scale consisting of 8 items showed acceptable reliability with a Cronbach's alpha of 0.74. The economic change scale, comprising 14 items, demonstrated good internal consistency with an alpha value of 0.82. The environmental change scale with 9 items recorded a Cronbach's alpha of 0.71, indicating acceptable reliability. The social change scale, consisting of 10 items, also showed satisfactory internal consistency with an alpha value of 0.76.

Overall, all scales exceeded the commonly accepted threshold of 0.70, confirming that the instruments were reliable and suitable for generating composite scores for further analysis. Based on the total scores obtained, respondents were classified into low, medium and high aspiration categories using the class interval method. Higher scores indicate greater perceived impact of the MASS intervention and higher levels of aspiration in the respective dimensions.

Independent variables

The profile characteristics of farmers, considered as independent variables, included:

- Age, gender, education, farming experience, landholding size, annual income, financial sources, crops grown, use of natural resources, information-seeking behaviour, mass media exposure, risk-taking ability, decision-making behaviour, utilisation of weather-based agro-advisories and extension participation.

Tools for data collection

A structured interview schedule was developed in English, translated into Telugu and validated through expert review.

Data analysis techniques

Data was coded and analysed using descriptive and inferential statistical methods. The following tools were applied:

- Frequencies and percentages for distribution analysis
- Class interval method for categorisation of aspirations
- Arithmetic mean for central tendency estimation
- Z-test for significance testing between groups, as the sample size (n = 1000) is large, the Z-test is statistically appropriate and aids in strengthening the interpretability of results, though causal attribution is derived exclusively from the DID estimates.
- The DID estimator to measure net effects of the MASS intervention
- Fixed effects models to control unobserved heterogeneity in longitudinal data
- SPSS statistical software for analysis of the data

Difference-in-difference analysis

The DID is a quasi-experimental, longitudinal analysis method used to estimate causal effects by comparing the changes in outcomes over time between a treatment group and a control group. By calculating the difference in trends (rather than just levels) before and after an intervention, it accounts for time-invariant unobserved confounding factors, making it a robust alternative when randomised experiments are not feasible. The method computes the "difference in differences" by taking the change in the treatment group (PostT-PreT) and subtracting the change in the control group (PostC-PreC).

DID = (YT, post-YT, pre)-(YC, post-YC, pre)

It isolates the effect of an intervention (e.g., policy change, new law, program) by assuming that in the absence of the treatment, the difference between the treatment and control groups would have remained constant over time. The DID model evaluated differences in aspiration changes between beneficiaries and non-beneficiaries before and after intervention, using the following formula:

The basic DID model can be estimated using a linear regression [Ordinary least squares (OLS)]:

$$Yit = \beta 0 + \beta 1 Groupi + \beta 2 Timet + \beta 3 (Groupi \times Timet) + \varepsilon it$$

Here, β3 represents the net effect of the MASS intervention. The DID approach assumed parallel trends between groups prior to intervention and adjusted for time-invariant unobserved factors using a fixed effects regression model where applicable.

Data interpretation and reporting

Data were systematically tabulated, analysed and interpreted to assess the pre- and post-intervention changes in farmers' aspirations. The findings were presented in both descriptive and analytical formats to draw meaningful conclusions and policy recommendations regarding the MASS intervention.

Results

The present study evaluates the impact of MASS interventions on farmers' aspirations across technological, economic, environmental and social dimensions are presented in Table 1. A concise summary of the before-after changes in sample and non-sample areas is provided in Table 2, while the regression-based DID estimates controlling for covariates are reported in Table 3.

Aspirations prior to mobile agri support services intervention

Village-wise baseline distribution of aspiration levels in both sample and non-sample areas is presented in Supplementary Table 1 and Supplementary Table 2.

Technological aspirations

As shown in the Supplementary Table 1 (68–95 %) of respondents in both sample and non-sample areas exhibited low technological at baseline. Similar trends are reflected in Supplementary Table 2, indicating comparability prior to intervention. Farmers expressed skepticism towards the adoption of modern technologies, primarily due to previous experiences where interventions were not contextually appropriate or yielded minimal benefits.

Economic aspirations

From the Supplementary Tables 1 and 2 it is derived that economic aspirations prior to intervention were also low (42–80 %) across villages. Farmers reported limited expectations of increased income or livelihood security, often citing unreliable market access, high production costs, dependence on informal credit sources and vulnerability to price fluctuations as major constraints.

Environmental aspirations

In terms of environmental change, Supplementary Tables 1 and 2 indicated that 53–82 % of respondents showed low aspirations in sample areas, while 38–60 % of respondents in non-sample areas shared similar perceptions.

Social aspirations

Social change aspirations were uniformly low (55–92 %) across all areas as per Supplementary Tables 1 and 2. Farmers highlighted poor institutional linkages, absence of functional farmer producer organisations (FPOs) or farmer interest groups (FIGs) and minimal social recognition or networking opportunities as significant reasons.

Aspirations after mobile agri support services intervention (sample area)

Post-intervention aspiration distribution is presented in Supplementary Table 3.

Technological change

The mean technological aspiration score in the sample area increased from 19.52 (pre-intervention) to 48.41 (post-intervention), yielding a net DID impact of 28.89 units (Table 1). The comparative summary of change is presented in Table 2.

The regression-based DID estimate in Table 3 shows a statistically significant Treatment × Time interaction coefficient ($\beta = 1.4407$, $p < 0.01$), confirming the intervention effect. Detailed regression outputs are provided in Supplementary Table 4.

Post-intervention data from Supplementary Table 3 demonstrated a substantial shift, with 70–90 % of respondents in the sample area aspiring for medium to high technological change. The adoption of climate-resilient technologies, digital advisory services and precision agriculture tools was notably appreciated. The DID estimate indicated an increase of 28.89 units in technological aspirations. Regression analysis confirmed significant positive influences from education, landholding size, financial access and information-seeking behavior ($p < 0.05$).

Supplementary Tables 4 clearly demonstrate a substantial increase in farmers' aspirations towards technological change in the sample areas where the MASS intervention was implemented. The mean aspiration scores rose significantly from 19.52 units in the pre-intervention phase to 48.41 units post-intervention, reflecting a net gain of 28.89 units. In contrast, the non-sample areas, which did not receive the intervention, showed only a marginal and statistically insignificant change in aspiration levels during the same period. This divergence underscores the targeted influence of the intervention.

The DID regression analysis further validated the robustness of these findings, with a positive and statistically significant coefficient of 1.4407 (significant at the 5 % level), indicating that the observed changes in technological aspirations can be confidently attributed to the MASS intervention rather than external factors or temporal changes alone.

Table 1. Difference-in-difference (DID) estimates of aspirational change in the sample and non-sample areas

Dimension	Sample area (Before)	Sample area (After)	Non-sample area (Before)	Non-sample area (After)	Net DID impact (Units)
Technological change	19.52	48.41	14.54	14.54	**28.89**
Economic change	5.73	16.96	5.53	6.64	**9.85**
Environmental change	15.56	94.45	94.45	16.16	**70.93**
Social change	11.65	35.20	35.20	13.43	**21.55**

Table 2. Summary of quantitative impact of difference-in-difference (DID)

Dimension	Sample area (Before-after change)	Non-sample area (Before-after change)	Net DID impact
Technological change	19.52–48.41	14.54–14.54	28.89
Economic change	5.73–16.96	5.53–6.64	9.85
Environmental change	15.56–94.45	8.20–16.16	70.93
Social change	11.65–35.20	11.43–13.43	21.55

Table 3. Difference-in-difference (DID) regression results for farmers aspirations

Aspirations	Variable	Coefficient	Standard error	Significance level	Model *F*-statistic
Technological change	Treatment time interaction (TrTi)	1.4407	0.0341	***p* < 0.01**	$F(13, 1187) = 214.05^{**}$
Economic change	Treatment time interaction (TrTi)	1.2793	0.0421	***p* < 0.01**	$F(13, 1187) = 107.65^{**}$
Environmental change	Treatment time interaction (TrTi)	0.8168	0.0410	***p* < 0.01**	$F(13, 1187) = 66.56^{**}$
Social change	Treatment time interaction (TrTi)	0.8276	0.0336	***p* < 0.01**	$F(13, 1187) = 124.12^{**}$

Economic change

The DID analysis provided robust statistical confirmation of this change. As per Table 1 and 2, the mean economic aspiration scores in the sample area increased from 5.73 to 16.96 units, reflecting a net gain of 11.23 units. However, after adjusting for changes in the non-sample areas, the net DID effect was 9.85 units, indicating that the observed gains were directly attributable to the MASS intervention and not due to external factors or time-related influences.

The analysis of economic aspirations reveals a marked improvement in the sample areas post-intervention, affirming the effectiveness of the MASS programme in fostering a forward-looking economic mindset among farmers. As illustrated in the Supplementary Table 3, the distribution of farmers across aspiration levels shifted significantly. Following the intervention, 75–80 % of farmers reported medium-level economic aspirations, while 10–23 % moved into the high aspiration category, a substantial increase compared to the baseline. This shift indicates not only a change in outlook but also a readiness to pursue economic opportunities with greater confidence.

Detailed regression model outputs are presented in Supplementary Table 5. The regression analysis in Table 3 and Supplementary Table 5 further corroborated these findings, showing that the interaction term (Tr×Ti) had a positive and statistically significant coefficient of 1.2793, significant at the 5 % level ($p < 0.05$). This indicates a strong treatment effect of the intervention on economic aspirations. In addition, several covariates emerged as significant determinants of aspiration change, including education level, landholding size, access to formal financial services and risk-taking ability. These factors not only shaped the degree of aspiration change but also reflect the structural enablers that support farmers in translating aspirations into action.

Environmental change

Environmental aspirations among farmers exhibited the most dramatic increase following the implementation of the MASS intervention. As presented in Tables 1 and 2 mean environmental aspiration scores in the sample villages surged from 15.65 units at baseline to 94.45 units post-intervention, reflecting an impressive net increase of 70.93 units. This pronounced growth signifies a transformative shift in farmers' attitudes toward environmental sustainability and natural resource stewardship.

The DID analysis confirmed the robustness of this shift, with a net DID effect of 70.93 units, clearly indicating that the change was attributable to the intervention rather than extraneous variables. Complementing this, regression analysis from the Table 3 revealed a statistically significant positive treatment effect, with the interaction term (Tr×Ti) yielding a coefficient of 0.8168 (significant at the 5 % level) with detailed results in Supplementary Table 6. Key covariates that emerged as significant determinants of environmental aspirations included education level, awareness of natural resource management (NRM) practices and information-seeking behaviour.

Social change

According to Table 1 and 2, the mean social aspiration scores in the sample villages increased from 11.65 to 35.20 units, resulting in a net DID effect of 21.55 units. The statistical significance of this change was further reinforced through Table 3. The regression analysis, where the interaction term (Tr×Ti) yielded a coefficient of 0.8276, significant at the 5 % level ($p < 0.05$) is shown in Supplementary Table 7. Key variables that influenced this improvement were education level, access to financial resources and participation in extension activities.

Non-sample area findings

Pre-post comparison in non-sample villages is presented in Supplementary Table 8, indicating no statistically significant changes across aspiration dimensions.

Discussion

Aspirations prior to mobile agri support services intervention

Technological aspirations

Resistance to transitioning from traditional practices and perceived inapplicability of technologies were dominant barriers. Farmers' adoption decisions are influenced not only by access to technology but also by expectations, prior experiences and perceived relevance (3). The findings underscore the importance of context-sensitive, trust-building extension approaches such as experiential demonstrations and interactive advisory services to effectively raise technological aspirations and overcome resistance to change.

Economic aspirations

Farmers' economic aspirations are strongly shaped by structural constraints rather than individual motivation alone. Studies on agricultural development consistently show that unreliable market access, price volatility and high transaction and production costs suppress farmers' expectations of income growth and livelihood security (4).

Environmental aspirations

Limited awareness of sustainable practices, lack of access to soil testing and unawareness of resource conservation methods contributed to these low aspirations. Research on Information and Communication Technology (ICT)-enabled extension further indicates that without interactive and context-specific advisory mechanisms, farmers remain unaware of long-term environmental benefits and tend to prioritise short-term productivity over sustainability (5).

Social aspirations

From an aspiration's perspective, repeated exclusion from institutional processes and the lack of pathways for collective advancement diminish social aspirations and reinforce disengagement (6).

Aspirations after mobile agri support services intervention (sample area)

Technological change

The MASS initiative played a pivotal role in shaping farmers' outlook towards agricultural technology by offering hands-on training, demonstrations and expert-led awareness sessions on climate-resilient practices, digital tools and integrated farming systems. As a result, farmers developed greater awareness and interest in modern agricultural technologies such as mobile-based advisory services, precision agriculture tools, improved seed varieties and water-efficient irrigation methods. This exposure not only improved their technical know-how but also inspired a forward-looking mindset

conducive to innovation and sustainable agricultural growth.

The sharp contrast between the sample and non-sample areas highlights the instrumental role of structured and participatory interventions like MASS in catalysing aspirational and behavioural shifts among rural farming communities. It suggests that when farmers are provided with contextual knowledge, skill development opportunities and demonstrable benefits, they are more likely to adopt and aspire toward technologically advanced and sustainable farming practices. It can be concluded from the findings that the MASS interventions build confidence among farmers and instil a proactive, resilient mindset. (7)

Economic change

Qualitative and field-level observations reveal that the MASS intervention enhanced economic aspirations through entrepreneurial skill development, improved market linkages, value chain integration and exposure to financial planning tools. Farmers reported a reduction in dependency on non-institutional credit sources due to improved awareness and access to formal credit facilities. Furthermore, targeted training on income diversification strategies such as integrated farming systems, value addition and agri-business planning enabled them to envision more stable and profitable livelihoods. Thus, the findings indicate access to market and price information through ICT tools strengthens farmers' capacity to plan and negotiate, thus improving their income outlook. (8).

These findings underscore the importance of designing interventions that go beyond technical training and embed components that stimulate economic imagination, enhance financial literacy and build confidence in market engagement. The positive shift in economic aspirations, especially among marginal and smallholder farmers, reflects a foundational change in how rural households perceive opportunity, investment and financial independence.

Environmental change

The MASS intervention integrated a diverse range of sustainable and climate-smart agricultural practices into its framework. Farmers were introduced to and trained in soil health management, residue recycling, integrated pest management (IPM), water conservation and agroforestry models. These practices not only helped farmers adopt more environmentally sound techniques but also instilled a long-term vision for ecological sustainability. Farmers reported increased awareness about soil fertility preservation, reduction in chemical inputs and the importance of ecosystem services for resilient agriculture.

Furthermore, the intervention's participatory design and consistent field-level support promoted a sense of ownership and accountability towards natural resources. The integration of awareness campaigns, field demonstrations and eco-literacy sessions enabled farmers to internalise environmental sustainability not just as a practice, but as a goal.

This substantial transformation in environmental aspirations underscores the importance of well-structured, knowledge-intensive agricultural extension interventions in shifting mindsets and long-term planning among rural communities. The MASS model clearly demonstrates that with targeted support and experiential learning, farmers can move beyond short-term productivity concerns and begin to actively aspire for environmental sustainability and resilience in their farming systems. The results are in accordance with the various sustainable agriculture initiatives in India such as the National Mission for Sustainable Agriculture (NMSA) and Watershed Development Programmes have reported improvements in farmers' environmental consciousness when interventions included capacity building, community-led planning and field demonstrations (9).

Social change

The MASS intervention played a crucial role in facilitating farmer group formation, strengthening social networks and enhancing institutional interactions. Farmers were encouraged to organise themselves into FIGs, FPOs and collective marketing units, which allowed them to share information, negotiate better market prices and access input subsidies more effectively. These group-based mechanisms promoted a sense of collective identity, mutual support and long-term vision for social upliftment.

Additionally, the intervention emphasised the importance of linking farmers with formal institutions, such as agricultural universities, financial institutions and government departments. Regular exposure visits, interface meetings and community-level capacity-building sessions enabled farmers to interact more confidently with institutional actors, fostering aspirations for better social inclusion and leadership within the farming community.

Overall, the rise in social aspirations as a result of the MASS intervention illustrates the transformative impact of socially integrative and participatory extension models. By promoting community resilience, strengthening trust and fostering peer learning, the intervention has equipped farmers not only with knowledge but also with social confidence to engage with institutions, participate in governance and collectively pursue sustainable development goals (10). From the results it is evident that social aspirations refer to the goals and expectations individuals or communities hold regarding their roles, relationships and status within society. In the context of rural agriculture, these aspirations are shaped by social networks, access to institutions, participation in community organisations and perceived opportunities for upward mobility. Results are also in accordance with Group formation also fosters collective agency, which has been linked to improved social confidence and inclusiveness. Involvement in farmer organisations enhances access to resources, visibility in markets and policy voice factors that elevate individual and group-level social aspirations (11).

Aspirations after mobile agri support services intervention (Non sample area)

It is evident that the comparative analysis of pre- and post-evaluation data in the non-sample area, where the MASS intervention was not implemented, revealed no statistically significant change in the aspirations of the respondents (Supplementary Table 4). This stagnancy in aspirational levels strongly suggests that, in the absence of targeted interventions, farmers are likely to maintain their existing perceptions and expectations regarding sustainable agricultural development. Conversely, areas where the MASS programme was actively implemented exhibited notable improvements in the aspirational outlook of farmers. The contrasting outcomes between intervention and non-intervention areas highlight the pivotal role of structured, participatory and knowledge-driven programmes like

MASS in shaping and uplifting the mindset and future orientation of rural communities.

Comparative analysis with non-sample area

Contrasting findings between sample and non-sample areas, offer compelling evidence of the MASS intervention's effectiveness. In the non-sample villages where the intervention was not implemented no statistically significant changes were observed across any of the 4 aspirational dimensions (technological, economic, environmental and social). This stagnation reinforces the inference that the aspirational improvements recorded in the sample villages were not coincidental or the result of external factors, but a direct consequence of the targeted MASS intervention.

The intervention's impact was particularly evident in its ability to transform farmers' outlook towards modern agricultural practices, sustainable livelihood models and social empowerment. By employing a hybrid extension model that combined physical training, digital advisory platforms and community-based engagement, MASS successfully bridged existing aspiration gaps especially among marginalised and smallholder farming communities. This approach created avenues for continuous learning and peer-to-peer influence, resulting in tangible changes in farmers' vision for the future.

Furthermore, the analysis identified educational attainment, access to formal credit, proactive information-seeking behaviour and institutional linkages as significant enablers of aspirational shifts. These factors amplified the efficacy of the intervention by enhancing farmers' ability to internalise, adapt and act upon the knowledge provided. The findings suggest that without such enabling conditions, even well-designed interventions may struggle to deliver sustained aspirational impact.

The limited evidence of spillover effects in adjacent non-sample areas further highlights the importance of direct, localised intervention. Passive exposure to externalities was insufficient to drive meaningful change in aspiration levels, emphasising the need for structured implementation, farmer engagement and follow-up. This insight has critical implications for scaling such interventions indicating that replication must be accompanied by context-sensitive customisation and institutional anchoring to replicate success.

In summary, the study validates that customised, need-based interventions like MASS, when deployed with a focus on inclusivity, capacity-building and technology access, can serve as catalysts for aspirational change. They not only influence what farmers know, but also reshape what they hope for, thus fostering a long-term orientation towards sustainability, innovation and community empowerment. The results demonstrated that literate farmers with frequent contact with extension agents exhibited higher aspirations and were more likely to adopt sustainable practices (12). Similarly, found that "hope" and "aspirational capital" are amplified through structured learning and mentorship (13). Hybrid advisory systems, blending physical and digital interfaces, have been found effective in addressing cognitive barriers and contextualising information (14).

Implications

Expand mobile agri support services to other underdeveloped regions

The positive outcomes of the MASS intervention suggest its scalability. It is recommended to replicate and expand the MASS programme in other underdeveloped and agrarian regions to bridge information gaps, enhance agricultural aspirations and improve livelihoods across a broader farmer base.

Strengthen extension services with information and communication technology tools

Modernising extension services by integrating ICT tools such as mobile apps, SMS alerts and interactive voice response systems can ensure timely dissemination of accurate, location-specific agricultural advisories. This will enhance the reach and impact of extension personnel and make agricultural knowledge more accessible to rural farmers.

Facilitate access to institutional credit and market linkages

Ensuring farmers have easier access to institutional credit will empower them to adopt improved technologies and sustainable practices. Additionally, strengthening market linkages through FPOs, e-NAM platforms and direct marketing initiatives will enable farmers to secure better prices and reduce dependency on middlemen.

Promote capacity building on sustainable practices

Regular capacity-building programs focusing on climate-resilient agriculture, integrated pest and nutrient management, water conservation and diversified farming systems should be promoted. Tailored training modules and farmer field demonstrations can enhance knowledge, skill development and long-term sustainable adoption of these practices.

Way forward

The observed improvements in technological, economic, environmental and social aspirations following the MASS intervention provided a strong empirical justification for its institutionalisation as a scalable extension and development model. The substantial gains in technological aspirations, supported by significant DID and regression results, highlight the effectiveness of hands-on demonstrations, digital advisories and precision tools underscoring the need to mainstream MASS within existing frameworks such as National e-Governance Plan in Agriculture (NeGP-A) (15), Krishi Vigyan Kendras (KVK) (16) and Agricultural Technology Management Agency (ATMA) (17). Similarly, the positive shift in economic aspirations reflects the role of ICT-enabled market information, financial literacy and entrepreneurial exposure, reinforcing the case for integrating hyper-local advisory platforms and strengthening market and financial convergence through MASS. The remarkable rise in environmental aspirations demonstrates that experiential learning, soil testing and climate-smart practices can fundamentally reshape farmers' long-term sustainability outlook, aligning well with national priorities under programs such as National Mission for Sustainable Agriculture (NMSA) (18). Finally, the significant enhancement of social aspirations through group formation, institutional linkages and participatory engagement highlights MASS's potential as a platform for collective action, youth engagement and gender-inclusive interventions. Together, these findings suggest that embedding MASS within a convergent, adaptive and regularly evaluated policy framework can not only improve immediate advisory outcomes but also catalyse durable aspirational and behavioural transformations among farmers in aspirational districts.

Conclusion

The study demonstrates that MASS significantly enhanced farmers' technological, economic, environmental and social aspirations in aspirational districts, as evidenced by robust DID and regression results. By combining physical extension services with digital and institutional support, effectively addressed aspirational deficits and fostered a forward-looking, resilient mindset among farmers. The findings support scaling MASS as a policy-relevant model for inclusive and sustainable agricultural development.

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Authors' contributions

SD carried out the conceptualisation of the study, performed data analysis and interpretation, visualisation and writing of the original draft. SD and JMRM were responsible for study design, methodology, data collection and field survey and contributed to writing review and editing. JMRM and PP were responsible for supervision, project administration and funding acquisition. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT to summarise and simplify lengthy or complex research materials, enabling efficient identification of key findings and research gaps. The tool was used to convert dense, technical content into concise and accessible formats, including bullet points and plain language summaries. All outputs generated using this tool were carefully reviewed and edited by the authors, who take full responsibility for the accuracy and integrity of the content presented in this publication.

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