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Perceived feasibility of soil health card recommendations: A multidimensional analysis of technical, economic and social aspects

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Abstract

The Soil Health Card (SHC) scheme, launched by the Government of India in 2015, represents one of the most ambitious precision nutrient management initiatives in the country's agricultural history. Despite the nationwide distribution of over 220 million cards, the on-ground adoption of SHC-based fertilizer recommendations remains inconsistent and considerably below expectations. This study investigates the perceived feasibility of SHC-based recommendations among 120 farmer respondents selected through multi-stage random sampling from erstwhile Karimnagar district, Telangana State. Employing an ex-post facto research design, the study measured technical, economic and social dimensions of feasibility across three principal crops rice, maize and cotton. Results indicate that while nitrogen application commanded the highest feasibility (>60% rated 'high'), micronutrient application exhibited the lowest, particularly for maize (54.17% rated 'low'). Application of farmyard manure (FYM) and phosphorus presented intermediate challenges driven by cost and availability constraints. Overall, 40.83% of respondents perceived medium feasibility, 30.00% high and 29.17% low feasibility for SHC-based recommendations. Profile analysis revealed that middle-aged, small-farm holders with medium extension contact dominated the sample. The study identifies key bottlenecks cost of fertilizers, access to micronutrients, inadequate follow-up extension support and low scientific orientation and recommends targeted extension education, input subsidy restructuring and technology-mediated advisory services to enhance SHC compliance.

Keywords: Soil health card, perceived feasibility, nutrient management, extension contact, fertilizer recommendations

Introduction

Sustainable agricultural production is increasingly contingent on the judicious management of soil nutrients, which forms the cornerstone of both food security and environmental stewardship. Soil degradation, driven by overuse of chemical inputs, imbalanced fertilization and neglect of organic matter replenishment, has emerged as a critical challenge for Indian agriculture, particularly in intensively farmed states such as Telangana (FAO, 2015; Singh *et al.*, 2023) [8, 25]. The National Academy of Agricultural Sciences has highlighted that nearly 60% of Indian soils are deficient in at least two essential macronutrients and over 48% show multi-nutrient deficiencies compounded by secondary and micronutrient limitations. Against this backdrop, the Government of India introduced the Soil Health Card (SHC) scheme in February 2015 under the National Mission for Sustainable Agriculture (NMSA), with the ambitious objective of providing every farmer household with a card containing information on 12 soil parameters pH, electrical conductivity, organic carbon, nitrogen, phosphorus, potassium,

sulfur, zinc, boron, iron, manganese and copper along with crop-specific fertilizer recommendations (GoI, 2015; Reddy, 2017) [12, 21]. The SHC scheme has been described as the world's largest precision agriculture initiative in terms of geographic and beneficiary coverage, with more than 220 million cards distributed across two cycles by 2021 (Timilsina *et al.*, 2025; Ohlan *et al.*, 2025) [26, 18].

Despite this massive institutional investment, field-level evidence suggests a considerable gap between card distribution and actual adoption of SHC-based recommendations (Chouhan *et al.*, 2017; Ghaswa *et al.*, 2019) [5, 10]. Farmers' decisions to adopt or reject SHC recommendations are influenced by a complex interplay of technical comprehensibility, economic affordability and social acceptability dimensions that constitute the construct of 'perceived feasibility' (Rogers, 2003; Saravanan, 2010) [22, 24]. The feasibility of implementing soil test-based nutrient management is not merely a question of technical correctness but is embedded in the farmer's resource base, access to inputs, extension contacts and peer norms.

Several studies have reported that while farmers acknowledge the informational value of SHCs, barriers such as the high cost of recommended inputs, non-availability of site-specific fertilizers, low comprehension of card content and inadequate post-distribution extension follow-up significantly constrain recommendation compliance (Jayalakshmi *et al.*, 2021; Sahay *et al.*, 2019; Ankhila *et al.*, 2023) [14, 23, 2]. Moreover, the psychological attributes of farmers scientific orientation, innovativeness and economic motivation have been shown to mediate the relationship between information exposure and actual behavioral change (Bandura, 1977; Feder *et al.*, 1985) [3, 9].

Studies on technology adoption in Indian agriculture have consistently identified education, farm size, extension contact and access to credit as determinants of farmer responsiveness to new recommendations. Specifically in Telangana, the erstwhile Karimnagar district presents an agronomically significant study locale, characterized by diverse soil types (red sandy loams, black cotton soils and mixed red and black soils), a range of cropping systems including paddy, maize and cotton and an active network of soil testing laboratories established under the SHC program (Telangana State Government, 2020) [27]. Despite the existence of individual studies on SHC awareness, knowledge and adoption, there is a relative paucity of research that simultaneously examines the technical, economic and social dimensions of feasibility and specifically measures these across multiple crops and farmer profiles in a single integrated framework. The present investigation addresses this gap by offering a multidimensional feasibility analysis of SHC-based recommendations, with implications for policy, extension programming and input delivery systems.

The study was undertaken with the following specific objectives

- To assess the personal, socio-economic and psychological profile of respondent farmers in erstwhile Karimnagar district, Telangana.
- To examine the technical, economic and social feasibility of Soil Health Card-based recommendations across rice, maize and cotton crops.

Materials and Methods

Study Area and Research Design

The study was conducted in the erstwhile Karimnagar district of Telangana State, India. This district was purposively selected owing to its agronomic significance (a major producer of rice, maize and cotton), its varied soil types (ranging from red sandy loams in the upland areas to black cotton soils in the alluvial plains) and the presence of an active soil testing laboratory network under the SHC scheme. The district spans an area of approximately 11,823 km² and recorded a gross cultivated area of 4.26 lakh hectares in 2019–20 (Telangana State Government, 2020) [27].

An ex-post facto research design was adopted, as the study aimed to investigate an existing phenomenon farmers' perceived feasibility of soil health management without any experimental manipulation or intervention (Kerlinger, 1986) [15]. This design is appropriate for social science investigations where the researcher examines variations in an outcome variable (feasibility) in relation to antecedent conditions (farmer profile characteristics) that have already occurred in the natural setting.

Sample Size and Sampling Procedure

A multi-stage random sampling technique was employed for the selection of respondents. In the first stage, six mandals were randomly selected from the erstwhile Karimnagar district using

simple random sampling without replacement. In the second stage, four villages were randomly chosen from each selected mandal, yielding a total of 24 villages. In the final stage, from each village, five farmers who had received SHCs in the most recent distribution cycle were randomly selected from the beneficiary lists maintained at the village-level Rythu Seva Kendra. This yielded a total sample size of 120 respondents (6 mandals × 4 villages × 5 farmers). The sample size satisfies the minimum requirement for reliable Pearson correlation analysis at the 5% level of significance (Cochran, 1977; Krejcie and Morgan, 1970) [7, 16].

Data Collection

Primary data were collected through personal interview method using a pre-tested, structured interview schedule. The interview schedule was developed in Telugu (the local language) and back-translated to English to ensure conceptual equivalence. A pilot study was conducted with 15 farmers (not included in the final sample) to assess clarity, comprehensiveness and appropriateness of questions. The schedule was refined based on pilot feedback before the main survey.

Measurement of Variables

Farmer profile characteristics measured included age (in years, categorized as young: up to 35; middle: 35–50; old: above 50), education (illiterate through post-graduation), farm size (following Indian Census categories from marginal to large), farming experience (categorized into low, medium, high by cumulative mean and standard deviation), training undergone (number of agricultural training programs attended), and extension contact (score on standardized contact scale). Psychological variables scientific orientation, economic motivation, achievement motivation, and innovativeness were measured using standardized scales adapted from Saravanan (2010) [24], with all scales demonstrating acceptable internal consistency (Cronbach's alpha > 0.70).

Perceived feasibility of SHC-based recommendations was operationalized as the degree to which farmers perceived specific SHC recommendations to be achievable given their existing resources, knowledge and social context. The feasibility scale comprised items related to: (i) soil sample collection, (ii) application of FYM, (iii) application of nitrogen fertilizers, (iv) application of phosphorus fertilizers, (v) application of potassium fertilizers and (vi) application of micronutrients. Each dimension was scored separately for rice, maize and cotton. Respondents rated feasibility on a three-point Likert-type scale (1=Low, 2=Medium, 3=High). Composite overall feasibility scores were computed by summing item scores and categorized by mean ± standard deviation into low, medium and high feasibility groups.

Statistical Analysis

Descriptive statistics (frequencies, percentages, means and standard deviations) were used to characterize the profile of respondents and the distribution of feasibility scores. Pearson product-moment correlation coefficients were computed to examine the association between farmer profile variables and overall feasibility scores. Chi-square tests were applied to assess the independence of categorical variables. All statistical analyses were performed using SPSS Version 25.0 (IBM Corp., 2017) [13]. Statistical significance was determined at $p \leq 0.05$ and $p \leq 0.01$ levels.

Results and Discussion

1. Profile Characteristics of Respondent Farmers

Table 1: Distribution of respondents based on their personal, socio-economic and psychological attributes of the farmers under the study n=120

S. No.	Variable	Category	Respondents	
			Frequency	Percentage (%)
1	Age			
		Young age (up to 35 years)	28	23.33
		Middle age (35 to 50 years)	62	51.67
		Old age (above 55 years)	30	25.00
2	Education			
		Illiterate	02	01.67
		Primary school	24	20.00
		High school	42	35.00
		Intermediate	32	26.67
		Under graduation	16	13.33
		Post-graduation and above	04	03.33
3	Farm size			
		Marginal (0.1- 1.0 ha)	24	20.00
		Small (1.1-2.0 ha)	44	36.67
		Semi- medium (2.1-4.0 ha)	32	26.67
		Medium (4.1-10.00 ha)	18	15.00
		Large (above 10.00 ha)	02	01.66
4.	Farming Experience			
		Low farming experience	28	23.34
		Medium farming experience	56	46.66
		High farming experience	36	30.00
5.	Training undergone			
		Low	33	27.50
		Medium	58	48.34
		High	29	24.16
6.	Extension Contact			
		Low	25	20.83
		Medium	63	52.50
		High	32	26.67
7.	Scientific Orientation			
		Low	38	31.67
		Medium	54	45.00
		High	28	23.33
8.	Economic Motivation			
		Low	32	26.67
		Medium	52	43.33
		High	36	30.00
9.	Achievement Motivation			
		Low	30	25.00
		Medium	53	44.17
		High	37	30.83
10.	Innovativeness			
		Low	34	28.33
		Medium	58	48.33
		High	28	23.34

With respect to age, more than half of the respondents (51.67%) were in the middle-age group (35–50 years), followed by the old-age group (25.00%) and the young-age group (23.33%). The predominance of middle-aged farmers in agricultural activities aligns with findings reported by Rani *et al.* (2022) ^[20] and Patel *et al.* (2019) ^[19], who attributed this trend to the sustained migration of younger rural populations toward non-farm employment in peri-urban and urban areas, a demographic shift documented across peninsular India.

Regarding educational status, the majority had studied up to high school level (35.00%), followed by intermediate level (26.67%), reflecting a gradual improvement in rural literacy rates in Telangana over the past two decades (Census of India, 2011) ^[4]. Only 1.67% were illiterate and 13.33% were

graduates, indicating a reasonably literate farming population capable of engaging with text-based SHC content. This educational profile carries positive implications for SHC comprehension, corroborating Ghaswa *et al.* (2019) ^[10] who demonstrated a significant positive association between educational level and SHC literacy scores.

Farm size distribution revealed that small farmers (1.1–2.0 ha) constituted the largest category (36.67%), consistent with the national trend of declining average land holdings reported by the Agricultural Census (2015–16). The combined prevalence of small and marginal landholdings (56.67%) underscores the critical importance of cost-effective, precision nutrient management approaches such as soil test-based fertilization, as larger fertilizer volumes per

unit area from unbalanced application represent a proportionally greater economic burden for these households. Chundru *et al.* (2024) ^[6] similarly emphasized that SHC adoption studies must be sensitive to the heterogeneous resource base of smallholders.

Concerning training undergone, approximately 48.34% had medium-level exposure to agricultural training, indicating partial penetration of formal extension training programs. Extension contact was medium for 52.50% of respondents. All four psychological attributes scientific orientation (45.00%), economic motivation (43.33%), achievement

motivation (44.17%) and innovativeness (48.33%) were predominantly at medium levels, indicating considerable untapped potential for behavioural change through targeted extension interventions that engage these psychological drivers, as theorized by Bandura (1977) ^[3] and empirically supported by Singh *et al.* (2023) ^[25].

2. Feasibility of Soil Health Card-Based Recommendations by Dimension

2.1. Feasibility of Soil Sample Collection

Table 2: Distribution of respondents according to their feasibility of collection of soil samples n=120

S. No.	Category	Rice		Maize		Cotton	
		F	%	F	%	F	%
01.	Low feasibility	27	22.50	28	23.33	26	21.67
02.	Medium feasibility	56	46.67	52	43.34	57	47.50
03.	High feasibility	37	30.83	40	33.33	37	30.83
Total:		120	100.00	120	100.00	120	100.00

Medium feasibility was the dominant category for soil sample collection across all three crops rice (46.67%), maize (43.34%) and cotton (47.50%). Approximately 30–33% of respondents rated the feasibility as high, while 21–23% rated it as low. The relatively favourable feasibility perceptions for soil sampling, compared to other SHC-related practices, may reflect the simplicity of the activity itself. However, barriers including distance to soil testing laboratories, delays in receiving test reports and uncertainty

about sampling protocols contribute to medium-level perception. These findings are consistent with Chouhan *et al.* (2017) ^[5] who noted that while farmers can physically collect samples, systemic delays in result communication undermine the perceived utility and therefore the feasibility of the entire process.

2.2. Feasibility of FYM Application

Table 3: Distribution of respondents according to their feasibility of application of FYM n=120

S. No.	Category	Rice		Maize		Cotton	
		F	%	F	%	F	%
01.	Low feasibility	41	34.16	44	36.67	41	34.17
02.	Medium feasibility	50	41.67	48	40.00	51	42.50
03.	High feasibility	29	24.16	28	23.33	28	23.33
Total:		120	100.00	120	100.00	120	100.00

FYM application recorded the highest proportion of ‘low feasibility’ responses among the macronutrient management practices, with 34.16% for rice, 36.67% for maize and 34.17% for cotton. Only about 23–24% of respondents rated FYM application as highly feasible. The declining availability of FYM due to reduction in livestock holdings, increased cost of transportation and labor for organic manure application, and the ready availability of subsidized chemical fertilizers have collectively diminished the feasibility of FYM application as perceived by smallholders.

These findings corroborate Jayalakshmi *et al.* (2021) ^[14] and Ghate and Kamble (2020) ^[11], who identified declining organic manure use as a key driver of soil organic carbon (SOC) deterioration in intensively farmed districts. Policy frameworks that incentivize organic matter recycling and FYM distribution infrastructure could address this constraint.

2.3. Feasibility of Nitrogen Application

Table 4: Distribution of respondents according to their feasibility of application of Nitrogen n=120

S. No.	Category	Rice		Maize		Cotton	
		F	%	F	%	F	%
01.	Low feasibility	16	13.33	16	13.33	20	16.67
02.	Medium feasibility	24	20.00	26	21.67	28	23.33
03.	High feasibility	80	66.67	78	65.00	72	60.00
Total:		120	100.00	120	100.00	120	100.00

Nitrogen application exhibited the highest feasibility perceptions across all three crops, with 66.67% (rice), 65.00% (maize) and 60.00% (cotton) of respondents rating it as highly feasible. This result is not surprising, given that nitrogenous fertilizers particularly urea are the most widely

used, heavily subsidized, and readily available inputs in the Indian fertilizer market. The price support and ubiquitous distribution network for urea ensure that nitrogen application remains the most economically accessible SHC recommendation for most farmers. However, SHC

recommendations often advocate for split application of nitrogen in multiple doses, which requires additional labour and timing discipline that some farmers find challenging (Patel *et al.*, 2019) ^[19]. The slightly lower feasibility for cotton (60%) compared to rice and maize may reflect the

more complex and extended crop cycle of cotton, which demands more precise nitrogen scheduling.

2.4. Feasibility of Phosphorus Application:

Table 5: Distribution of respondents according to their feasibility of application of Phosphorous n=120

S. No.	Category	Rice		Maize		Cotton	
		F	%	F	%	F	%
01.	Low feasibility	42	35.00	39	32.50	46	38.33
02.	Medium feasibility	51	42.50	56	46.67	53	44.17
03.	High feasibility	27	22.50	25	20.83	21	17.50
Total:		120	100.00	120	100.00	120	100.00

Phosphorus application presented a more constrained feasibility profile, with the majority of respondents in the medium feasibility category (42.50–46.67%) and a relatively high proportion in the low feasibility category (32.50–38.33%). High feasibility was reported by only 17.50–22.50% of respondents, with the lowest proportion observed for cotton. Phosphorus fertilizers particularly diammonium phosphate (DAP) and single-superphosphate (SSP) are generally less subsidized and more expensive than urea, and DAP in particular has been subject to periodic supply disruptions (Sahay *et al.*, 2019) ^[23]. SHC

recommendations for phosphorus often suggest quantities that deviate considerably from farmer practice (either recommending reductions where over-application is common, or increases where soils are deficient), which adds an economic risk perception dimension to feasibility. These findings align with Timilsina *et al.* (2025) ^[26] who identified phosphorus compliance as one of the weakest dimensions of SHC adoption nationally.

2.5. Feasibility of Potassium Application:

Table 6: Distribution of respondents according to their feasibility of application of Potassium n=120

S. No.	Category	Rice		Maize		Cotton	
		F	%	F	%	F	%
01.	Low feasibility	43	35.83	33	27.50	39	32.50
02.	Medium feasibility	52	43.33	55	45.83	48	40.00
03.	High feasibility	25	20.84	32	26.67	33	27.50
Total:		120	100.00	120	100.00	120	100.00

Potassium application followed a pattern broadly similar to phosphorus, with medium feasibility predominating. The low feasibility proportion was highest for rice (35.83%) and lower for maize (27.50%) and cotton (32.50%). Potassium fertilizers predominantly muriate of potash (MOP) are not subsidized under India's nutrient-based subsidy (NBS) scheme and have historically been underutilized in Telangana's rice systems, where farmers often substitute potassium with excess nitrogen. Ankhila *et al.* (2023) ^[2]

noted that potassium deficiency correction, while economically beneficial in the long run, requires an upfront investment that many smallholders are unwilling or unable to make in a single cropping season. The relatively higher feasibility perceptions for cotton and maize may reflect these crops' established potassium demand in farmer experience.

2.6. Feasibility of Micronutrient Application:

Table 7: Distribution of respondents according to their feasibility of application of micronutrients n=120

S. No.	Category	Rice		Maize		Cotton	
		F	%	F	%	F	%
01.	Low feasibility	44	36.67	65	54.17		45.97
02.	Medium feasibility	51	42.50	38	31.67		40.56
03.	High feasibility	25	20.83	17	14.16		13.47
Total:		120	100.00	120	100.00	120	100.00

Micronutrient application recorded the poorest feasibility perceptions across all three crops, representing the most significant compliance bottleneck in the SHC recommendation set. For maize, 54.17% rated micronutrient application as having low feasibility, the highest low-feasibility proportion observed for any practice–crop combination in this study. High feasibility was rated by only 20.83% for rice, 14.16% for maize and 13.52% for cotton. The multiple barriers to micronutrient adoption are well-documented in literature: unfamiliarity with zinc sulphate,

boron and iron sulphate formulations; lack of knowledge about application timing, method and rates; perceived high cost relative to visible short-term benefit and limited market availability in rural retail outlets (Jayalakshmi *et al.*, 2019; NAAS, 2019) ^[14,1]. The particularly low feasibility for maize and cotton may also reflect the fact that these crops are grown predominantly in upland areas with lighter soils where micronutrient deficiencies may be more severe and require larger corrective doses, amplifying the cost dimension of perceived feasibility.

3. Overall Feasibility of SHC-Based Recommendations

Table 8: Distribution of respondents according to their overall feasibility of soil health card-based recommendations n=120

S. No.	Category	Respondents	
		Frequency	Percentage (%)
01.	Low feasibility	35	29.17
02.	Medium feasibility	49	40.83
03.	High feasibility	36	30.00
Total:		120	100.00

Overall, 40.83% of respondents perceived medium feasibility for SHC-based recommendations, followed by 30.00% with high feasibility and 29.17% with low feasibility. The near-equal distribution across the three feasibility categories signals that SHC implementation is at a critical inflection point: while a significant proportion of farmers have internalized the value of soil-test-based management and find it feasible, a nearly equal proportion remains at the margins of effective adoption due to technical, economic or social constraints. The distribution indicates that targeted interventions addressing specific bottlenecks particularly micronutrient management, FYM availability and phosphorus affordability hold potential to shift a meaningful proportion of medium-feasibility farmers toward high compliance.

These findings are broadly consistent with Timilsina *et al.* (2025) ^[26] who reported national-level SHC compliance at around 43% in the medium-to-high range, and with Chouhan *et al.* (2017) ^[5] who documented similarly stratified feasibility perceptions in a multi-district study in Madhya Pradesh. The present study's contribution is the granular disaggregation by crop and nutrient dimension, which provides more actionable diagnostic information for extension planners and input delivery system managers.

Conclusions and Recommendations

The farmer profile is characterized by a predominance of middle-aged, high-school-educated, small-farm holders with medium levels of farming experience, extension contact, and psychological attributes, reflecting the typical demographic structure of Telangana's agrarian economy. Nitrogen application commands the highest feasibility across all three crops, driven by the wide availability and subsidized price of urea — but the uniformity of nitrogen favorability masks the need for split-application compliance that many farmers still do not follow. FYM application and phosphorus application represent moderate constraints, with over 30% of farmers rating each as having low feasibility due to declining livestock ownership, input cost, and complex soil-specific prescription variability. Micronutrient application represents the single largest bottleneck in SHC compliance, with more than half of maize farmers and nearly half of cotton farmers rating it as having low feasibility, driven by unfamiliarity, cost, and restricted market availability. Overall, 40.83% of respondents perceive medium feasibility, 30.00% high, and 29.17% low feasibility — a distribution that suggests the SHC program is at a pivotal stage where targeted interventions can produce meaningful compliance gains.

Extension agencies should design and deliver crop- and nutrient-specific training programs that go beyond SHC

distribution to focus on the 'how' of recommendation implementation — particularly for micronutrient and organic manure management. The nutrient-based subsidy (NBS) structure should be reviewed to include potassium and micronutrient fertilizers within the subsidized category, reducing the economic barrier to balanced fertilization. Mobile-based advisory services (e.g., mKisan, AgroStar, IFFCO Kisan) should be integrated with SHC data to provide real-time, personalized reminders and guidance during the input purchase and application windows, particularly targeting farmers with medium extension contact. Village-level demonstration plots showcasing the yield and income benefits of full SHC compliance should be established in collaboration with KVKs, FPOs, and Rythu Mitra Groups to leverage social learning and peer influence. Soil testing laboratory capacity and turnaround times should be improved to ensure that farmers receive their SHC reports well in advance of the sowing season, thereby enhancing the actionability of recommendations. Future research should investigate the mediating role of digital literacy and smartphone-based advisory access on SHC feasibility perceptions, and should extend feasibility analyses to rabi season crops and horticultural systems.

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