Impact Study of
Soil Health Card Scheme

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Foreword

Government of India has introduced Soil Health Card (SHC) Scheme to facilitate farmers for better understanding of soil and Integrated Nutrient Management (INM). It is a well known fact that soil is the basis for agriculture and protecting the soil is the basic responsibility of every farmer to sustain agriculture. Unfortunately, quality and yields of agriculture produce is not at expected level due to deficiency of various nutrients. At the same time, there is excessive usage of certain nutrients. All this is happening as farmer is not fully aware of various physical, chemical and microbial activities in soil and due to this, farmers are unable to apply fertilizers in balanced and required quantities.

The Department of Agriculture, Cooperation and Farmers Welfare assigned MANAGE to undertake study of Implementation of Soil Health Card Scheme. The study brought out important aspects of whole gamut of activities starting from collecting soil sample, analysis and interpretation of data.

I congratulate Dr. A. Amarender Reddy and his team for the hard work they have rendered by taking up this study. I hope the study will further strengthen the scheme and will have impact on the farmers' knowledge on soil and application of fertilizer in a balanced manner.

(V. Usha Rani)

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Dr. A. Amarender Reddy

Abbreviations

ASCI	Agriculture Skill Council of India
CACP	Commission for Agricultural Costs and Prices
DSS	Decision Support System
EC	Electrical conductivity
FAO	Food and Agriculture Organization
FC	Forward Class
FPCs	Farmer Produce Companies
GIS	Geographic Information System
GPS	Global Positioning System
ICAR	Indian Council for Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IISS	Indian Institute of Soil Science
IPCC	Intergovernmental Panel on Climate Change
ISRO	Indian Space Research Organization
ITPS	Intergovernmental Technical Panel on Soils
KVK	Krishi Vigyan Kendra
NABARD	National Bank for Agriculture and Rural Development
NAPCC	National Action Plan on Climate Change
NGO	Non-Governmental Organization
NMSA	National Mission for Sustainable Agriculture
OBC	Other Backward Caste
OC	Organic Carbon
PPP	Public Private Partnership
RAU	Rajendra Agricultural University
S&MF	Small and Marginal farmers
SAU	State Agriculture University
SC	Schedule Cast
SHC	Soil Health Card
ST	Schedule Tribes
STCR	Soil Test Based Crop Response
STL	Soil Testing Labs
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
WSC	World Soil Charter

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Impact of Soil Health Card Scheme in India

Executive Summary

Soil health and fertility is the basis for sustainable profitability of the farmers. Using optimal doses of fertilizers and cropping pattern as per the scientific recommendation is the first step towards sustainable farming. Soil testing is a science based and time-tested tool for assessment of soil fertility status and soil ailments and for nutrient amendment recommendations. Soil testing, as a tool for judicious fertilizer use, works on the principle of profitability, meaning if all other factors of production are at optimum and none of them limiting, there is all probability to obtain more profitable response to applied nutrients based on soil testing than those applied on adhoc basis.

In India, the current consumption of NPK ratio is 6.7:2.4:1, which is highly skewed towards nitrogen as against ideal ratio of 4:2:1. India is spending nearly Rupees Seventy thousand crore on fertilizer subsidy every year. According to the estimates, subsidy amount is about Rs.5000/ha of net cropped area and about Rs.5100/farmer resulting in excessive use of fertilizers, especially NPK at the cost of micro-nutrients and manure. Hence, there is a need for balanced use of fertilizers, keeping this government of India introduced Soil Health Card Scheme across India (GoI, 2017).

On 5th December 2015 the ministry of agriculture introduced the soil health card (SHC) scheme. The SHC scheme has been approved for implementation during the remaining period of 12th plan. SHC will be provided to all farmers in the country at an interval of 2 years to enable the farmers to apply recommended doses of nutrients based on soil test values to realize improved and sustainable soil health and fertility, low costs and higher profits.

Under SHC scheme, cropped area was divided in to grids of 10 ha for rainfed and 2.5 ha for irrigated. One soil sample from each grid will be taken and test results will be distributed to all the farmers whose lands fall under the grid. Based on the grid system, of the total 14.1 crore hectare of net cropped area, 73 lakh grid samples to be collected to cover 7.3 crore ha in rain-fed areas and 2.7 crore grid samples to be collected to cover 6.8 crore ha irrigated land. That is, a total of 3.46 crore grid samples in two years (1.73 crore grid samples per year). And, an average of 25000 grid samples per district/year or 29 grid samples per village/year. With this, all 11 crore farmers will be covered in two years. Every year 5.2 crore farmers need to be covered.

Under cycle-1, 2.54 crore samples were collected, 2.36 crore samples tested, 9.62 crore soil health cards printed, but only 9.33 crore SHCs distributed. It indicates that 100% target archived in sample collection, 93% of the target achieved in soil testing, but only 80% of the target achieved in SHC printing. 97% of the SHCs printed were distributed among the farmers as on 24th September 2017. The cycle-II is already started across many states and is under progress. Overall, the progress of SHC scheme in terms of coverage is satisfactory, now we have to give more focus on quality of soil sample collection and testing and timely distribution of SHCs to farmers. However, the progress is highly skewed. Some states like Karnataka, TN, Chhattisgarh, UP, Maharashtra, Telangana and AP were better performers compared to other states.

Objectives of the impact study

As the SHC scheme has completed more than 2 years of implementation, the ministry has initiated a nationwide impact assessment with the following objectives.

- To examine the design of the SHC scheme in terms of planning, implementation, inputs (staff, financial and other resources), activities (trainings, lab established and strengthened), outputs (SHC's printed and distributed to farmers).
- To assess the modalities of delivery of the SHC scheme regarding procurement, sample collection, testing, SHC printing and disbursal.
- To assess the level of utilization of SHC's by the farmers across farm size class, in irrigated and rain fed situations.
- To assess the impacts of SHC scheme on judicious use of fertilizers, bio fertilizers, organic fertilizers, soil health, cropping choice, cost reduction, farm profitability and sustainability.
- To provide recommendations for improvement of overall design of the programme.

Methodology

Both quantitative and qualitative approaches were adopted to achieve the objectives of the study. Qualitative information in the form of stakeholder interviews across the states under the study, expert opinion gathering at the national and state level workshops and interactions with the progressive farmers and agricultural officers were carried out. At the quantitative level, both secondary and primary data was collected at the national, state and farmer levels. Secondary data mostly pertain to financial and physical achievements of the SHC scheme over the years.

Infrastructure availability, coverage of SHCs across the states, etc., were collected and analysed. Besides, information at the international level was collected for some selected countries to see the best practices in the design of soil health cards.

The secondary data was analyzed for all the states, while primary data was analysed from 16 states of India representing all agro-climatic zones. A systematic sample was drawn for the impact assessment at the farmer level. Care was taken to represent the whole country and its agro climatic conditions. A structured questionnaire was canvassed among 3184 sample farmers across 199 villages in 16 states. In addition, focus group discussions were conducted in each village, to get the feedback from key-informants, farmers not covered for individual surveys and farmers who have not received soil health card. All the indicators collected from field survey were classified as inputs (financial and physical inputs under the project), activities (different activities organized under the scheme), outputs (actual outputs of the project), outcomes (whether generated outputs were utilized by the farmers) and impacts (what are the ultimate benefits to the farmers) and are listed below. The analysis was carried out across zones / states and by the date of receiving SHC by the farmers' i.e., those who received more than a year back and those who received recently. This would help to understand the long term impacts and also would provide insights into whether agriculture development helps better awareness and demand for SHC.

Main findings

It may be noted that the analysis is based on the representative, though limited, sample size across regions. It is too short a time for the scheme (only 2 years old) to carry out a full-fledged impact assessment. The present analysis provides insights about the direction and cautions about any short comings. While the following conclusions and recommendations are based on the analysis, the weakness of the assessment needs to be kept in mind.

- ✓ Given the short duration of the scheme, awareness levels are good. At the same time participation of farmers in meetings, exposure visits are not high. Awareness campaigns need to be organized on content of SHCs, use of recommended practices, reduction in fertilizer use and costs and increase in profitability.
- ✓ There is no apparent or significant bias against socio-economically vulnerable sections. In contrast, small and marginal farmers benefit more in some cases.
- ✓ There is some reduction in fertilizer use, especially nitrogen and increase in bio-fertilizers and other micro-nutrients use. This is a good sign as N: P: K ratio was highly skewed towards nitrogen. Costs were reduced due to low fertilizer use. Crop yields have also increased for majority of the crops, although only moderately.
- ✓ A significant impact is the increase in the use of gypsum and other micro nutrients to some extent.
- ✓ There is a need for strengthening the Soil Health Card related extension services to provide better advisories.
- ✓ Two-thirds of the sample farmers indicated that SHC is beneficial which is encouraging, given the short span of the programme.
- ✓ Main complaint from the farmers is the timeliness of providing the results. This, however, is linked to the infrastructure (soil testing labs) and human resources. However, after the introduction of the SHC scheme, the time lag is significantly reduced. Results needs to be disseminated before sowing season, so that farmers will practice recommended crop choice and fertilizers.
- ✓ It is important to address these issues to gain confidence of the farmers in adoption of the fertilizers as per the recommendation in the SHC.
- ✓ The scheme has a poor backing of infrastructure and human resources, with significant gaps. Although some southern and western states performed better, some states are even allocated resources are not being spent or utilized due to lack of capacities. This should be of high priority in the immediate future.
- ✓ Proactive regions seem to be better in this regard.
- ✓ Lack of capacities with regard to skilled personnel and STLs is affecting the quality of services, which in turn affects the credibility of the scheme, and needs immediate attention.
- ✓ Results need to be provided in time so that farmers can benefit better.

Level of utilization and Impact of the SHC scheme

1. About 66% of the farmers are able to understand the content of the SHC, about 57% mentioned that the recommendations are suitable for their farms and about 53% are able to follow recommendations.
2. The SHC scheme is inclusive in nature, small and marginal farmers are pro-active in adoption of recommendations based on SHC.
3. There was a reduction in use of urea and DAP by 20 to 30% in paddy and cotton in some states resulted in decreased cost of cultivation. The reduction in cost of cultivation ranged between Rs.1000 and Rs.4000 per acre.
4. The use of micro-nutrients (especially gypsum) was slightly increased after SHC distribution.
5. There was a significant increase in yield for farmers who practiced recommended practices as per the SHC.
6. With the decrease in cost of cultivation and increase in yields, net-incomes of the farmers increased between 30 and 40% after the SHC scheme.

Constraints of SHC Scheme

1. Some farmers complained that the soil test values are not representative of their fields and they also complained that the field staff are not collected soil samples in their presence. To build trust, samples to be collected in presence of GRID farmers.
2. Uniform soil GRIDS of 10 ha for rainfed and 2.5 ha for irrigated should be reexamined. The grid size should be determined based on the soil variability index (soil variogram). If variability was high, GRID size should be less and vice versa.
3. Soil variogram needs to be developed at each block level to determine the GRID size at block level.
4. Many farmers are unable to understand the content, hence unable to follow the recommended practices.
5. Only 44% of the farmers mentioned that the extension officers explained the content.
6. SHC distribution and awareness campaigns needs to be arranged before sowing season, so that farmers will practice recommended crop choice and fertilizers.
7. Awareness campaigns need to be organized the use of SHC in reduction in fertilizer use and costs and increase in yields.
8. Many farmers feel that SHC should also mention one or two physical and micro-biological indicators (such as soil texture, water holding capacity, and water quality and bacterial content).
9. There is a need to identify best practices in soil sample collection (pre-determined DRID apps practiced in Punjab and TN) and testing for scale-up.

10. Development of GIS based soil fertility maps at village/block level and wider publicity through wall-posters and display boards in village panchayats should be promoted.
11. Government should ensure availability of recommended fertilizers and bio-fertilizers at village level at reasonable prices.

Soil sampling related (SHC design) improvement

- There is a need to identify best practices in soil sample collection and testing by examining across countries and different state governments practices. There is also a need for coordination and cooperation.

- The existing uniform grid of 10 ha for dry lands and 2.5 ha for irrigated lands is not taking in to consideration local soil variability. Grid size should be variable based on the soil variability index. Grid size should be decided at least at block level based on soil heterogeneity, fertility maps, cropping pattern, irrigation facilities and remote sensing maps. If soil is more variable, grid size should be reduced and vice-versa. Sampling errors needs to be reduced by using variogram. There should be a separate cell to monitor and recommend grid size across the country. It will also reduce cost, money and manpower and increase relevance of recommendations to farmers. In order to gain credibility of the farmers, at least one sample from each farmer should be included where soil variability is high.
- Soil variograms needs to be developed at each block level. Based on the soil variability, grid size may be determined. Variogram gives information about spatial pattern of continuous soil attributes. The variogram may be used as a critical input to decide required soil samples to be collected based on the soil variability index. More soil samples should be collected if the block level soil variability index was high and vice versa. Variogram is a tool to investigate and quantify the spatial variability of soil properties. The geostatistical literature shows that the following soil quality indicators were found to be the most important for variogram analysis. Ministry may consider following soil quality indicators. The available data with Indian Institute of Soil Science, Satellite maps of remote sensing agency of ISRO and Land use planning data can be used to estimate block level soil variograms.

- The following soil indicators may be considered to construct block level soil variogram: (1) Soil Colour, (2) Slop, (3) Sand (%), (4) Silt (%), (5) Clay (%), (6) Nitrogen (N), (7) Phosphorus (P), (8) Potassium (K), (9)Organic Matter (OM), (10) Organic Carbon (OC), (11) pH, (12) Cation Exchange Capacity (CEC), (13) Electrical conductivity (EC), (14) C:N Ratio and

(15) percentage of irrigated area (16) Cropping Pattern. The ICAR-Indian Institute of Soil Science (IISC), Bhopal, ICAR-IISWC- Indian Institute of Soil and Water Conservation, National Remote Sensing Agency (NRSA), Hyderabad and land classification/atlas can be consulted for developing block level soil variogram.

- Evidence shows that sample collected from 20% to 30% of the farmers in a village is enough to get reasonable soil quality for advising farmers, hence there was no additional benefit in covering each grid of 10 ha in case of dry lands and 2.5 ha in case of irrigated land if the soil is fairly uniform. In some cases, only 20-30 samples/500 ha is sufficient as evident from ICRISAT experiments. This, however, needs to be explained to the farmers so that they would take the SHC recommendations seriously. One needs to be mindful of efforts and resources gone into ICRISAT experiments.

- Although, in some states, grids were pre-determined in the mobile app (like in Punjab), but in some cases the procedure followed in dividing the cultivated village land in to grids is not known to many agricultural officers and this needs to be widely disseminated for accurate sampling same should be mentioned in the guidelines. Interestingly Punjab state is adopting GIS-tablet grid identification and GPS-based soil sample collection application, which seems to be working well and likely to solve many field level sample collection problems. This model should be adopted across all the states after an in-depth understanding (study) of the model.

- High density soil maps need to be developed for increasing precision at village level.

- There is a need to give appropriate training, easy to use sampling tools and transport to Agricultural officers and agricultural extension officers'. Incentives need to be provided for scientific sample collection.

- Coordination of agricultural extension officers and farmers needs to be enhanced and extension officers should make sure that most of the grid farmers, if not all should be present at the time of soil sample collection. This will build confidence on the soil health cards by the farmers.

- It was observed by study team that in some of the block agricultural offices, soil samples were kept aside for many days and soils were exposed to moisture and weather. After soil sampling, drying should be done within 15-20 days, grinding, machine sieving and bottling should be done in time for proper test results. Sample test results should reach farmers before sowing season. It may be a good idea to limit sample to the capacities. There should be more focus on quality of soil sample collection, testing rather than coverage as we have already covered larger areas and farmers with SHCs. This would create demand for soil testing once the credibility of the testing is established.

Soil Health Indicators (SHC design) improvement

- The whole chain of soil health-plant health-human health should be taken in to account and there is a need for promotion of application of balanced application of soil (macro & micro) nutrients.

- Excess application of urea results in accumulation of nitrate in soil and water is becoming a huge environmental problem in India. Hence, water quality information need to be included in the SHC.

- The soil health card is more focused on chemical nutrient indicators; among physical and biological properties only soil color is included. Some more physical properties like slop of the land, etc needs to be incorporated.

- Microbial activity, moisture retention activity are essential but missing in SHC. Although soil organic matter is indicated, many soil testing labs are not equipped with latest tools to measure it.

- At least one or two physical and micro-biological indicators (such as soil texture, water holding capacity, water quality and bacterial content) need to be incorporated. Index of soil health needs to be developed and incorporated in to SHC which indicates overall health of the soil.

- Although basic structure of SHC should be uniform, states should adopt/change as per their agro-climatic zones and needs. Some of the indicators, which needs to be included in SHC are (i) cropping history, (ii) water resources (soil moisture), (iii) slope of soil, (iv) depth of soil, (v) color of soil, (vi) soil texture (bulk density) and (vii) Micro-biological activity.

Soil Testing Infrastructure (design and delivery)

- About 1454 labs exist in India, of which only 700 are equipped with micro-nutrient testing facilities. Although, recently agricultural departments procured about 7000 mobile kits, they are not as good as that of full-fledged labs. Very few of the labs could take up micro nutrient analysis. They are neither equipped with skilled personnel or chemicals nor functional equipment. This infrastructure is grossly inadequate by any standard, given that 11 crore farmers need to be covered.
- Under the current PPP model, investments in labs to be done by private companies with an element of subsidy. A competitive bidding process based on technical and financial bids to be called for and companies which quote reasonable cost (per sample) should be selected. Government will pay on per sample basis with the condition that they employ qualified and trained chemists. This model will be successful when there is no strong Government presence in soil testing. However, the quality of such reports should be checked at random by authentic agencies.

- About 45% of the sample farmers are inclined to go to private STLs. At the same time only 20 % of the farmers are willing to pay for the services. Hence, one must find ways to support farmers in this regard i.e., direct subsidy to the farmers or private STLs, etc. A competitive PPP model could be explored in this regard, while government should take up the monitoring of the functioning of these labs more seriously. At the same time, there should be special incentive for Farmer Produce Companies (FPCs) to establish soil testing labs. There is a need for encouraging competition among private companies in setting up and running the soil testing labs so that they maintain quality at reasonable cost. Institutional modalities could be worked out on how to equip and manage STL within the FPCs frame work.

- Some of the private soil testing labs indicated that the cost of sample collection and testing was up to Rs.1000 / sample. Some private companies are charging Rs.75 / element and accordingly for 12 elements the total cost will be Rs.900/sample. Government should be more realistic in fixing the prices for private parties. Instead it should focus on quality of the services at an acceptable (market) cost.

- Strengthening and upgrading at least one soil testing lab per district as state-of-the-art lab, this should be equipped with world class infrastructure and accredited by internationally recognized agencies either in public or by private sector. So nearly 700 state-of-the-art labs are needed to act as referral labs and also to give broad advice to farmers. The cost per unit will be about Rs.4-5 crore/unit, with a total of Rs. 2800 crores. However, if this resulted in Rs.1000/ha savings in fertilizer use even if we don't consider the yield increase resulted in a saving of Rs. 14, 500 crores in a year to the economy. This could be worthwhile investment rather than spending money and providing services that have little value to farmers year after year i.e., ending up spending more in the long run.

- State-of-the-art district level soil testing labs at direct level should be equipped with Inductively **Coupled Plasma Atomic Emission Spectrometry (ICP-AES)** which costs about Rs.40-50 lakhs. These labs should have 24 hour generator for uninterrupted power supply, computer labs with colour printing facility, Air Conditioned Laboratories. In addition the lab should have the following equipment for conducting soil testing in large scale.

  KEL PLUS automatic nitrogen determination distiller
  Automated Flame Photometer (for Potassium)
  Automated Spectrophotometer (for phosphorus)
  Atomic Absorption Spectrophotometer (for Zn, Fe, Mn, Cu)
  Water distillation still (20 lit/hour)
  All glass distillation unit (5 liter/hour)
  Auto-analyzer (N&P)
  Automated pH meter
  Automated EC meter
  Centrifuge
  Auto Burette

- Some soil scientists and agricultural officers are of the opinion that test results of mini-kits (mini-labs) are not accurate enough as that of full-fledged labs. Mini-kits need to be standardized and tested for errors in calibrations. A Mini-kit cost about Rs.94,800, with this per sample cost comes about Rs.170-200. Some block agricultural offices received 5-6 mini-kits, but they were not able to utilize them, as they are involved in multiple-activities. Mini-kit is useful for remote villages and tribal communities and to measure highly volatile elements like Nitrogen which needs more frequent measurement. Mini-kits may be used exclusively for Nitrogen estimation in all block/mandal level offices.

- Soil testing is a specialized and highly skill oriented job. Frequent transfers of soil testing staff adversely affect the skill development within labs and test results will affect badly. There is a need to build some permanent staff in the labs who are interested and specialized in soil testing. Field observations indicate that only women officers are interested in working with soil testing labs.

- Managing the state-of-the-art soil testing labs could be established under the purview of Farmer Producer Companies (FPCs) or a nodal FPCs at the district level. The governance responsibilities should be handed over to them to run them as business models. Back of the envelop indicates that establishing a state of the art lab with Rs. 5 to 6 crore as loan from NABARD in each district looks viable, given that an average of about 25000 samples need to be collected and processed every year. At the Rs. 1500-2000 per sample (at half the market price for a detailed soil analysis), the investments will be paid back in less than 2 years. State department can have a monitoring cell created especially for this purpose. And extension services needs to be geared up to deal with soil health advisories. FPCs should be encouraged to set up demonstration plots to increase demand for soil testing by the farmers.

Soil Health Card delivery issues

- SHC recommendations should be accompanied by block level recommendations. Find an intermediate solution (based on both village level soil maps and SHC recommendation) for reaching the farmer's level.

- There is a need for demonstration of benefits of SHC on an experimental basis in each block by adopting a comprehensive approach (systematic and scientific analysis of soil and water) and adoption of recommended doses. This would have much greater impact than the subsidized and less authentic information. General SHC scheme and model farm initiatives should go together.

- In many villages, agricultural officers are distributing SHCs in awareness campaigns through village presidents and Mandal/block democratically elected representatives. However, in some villages, village revenue assistant is distributing SHC and getting it signed, without explaining the content. Whenever SHC is distributed in awareness campaigns and meetings directly greater number of farmers feel that they are convinced to use recommended practices. There is a need for following standard protocol to inform farmers about the recommendations of the SHC, when it is handed over to farmers.

- A specialized body is needed both at central as well as at state level for the management of soils. They should be given responsibility of monitoring the quality of service by various agencies. This also provides continuity of the work by the department.

- Development of GIS based soil fertility maps at village/block level and wider publicity through wall-posters and display boards in village panchayats should be promoted. Advertisements, slogans, etc. should be developed in local languages to increase awareness. This should be taken up in a campaign mode i.e., in the lines of anti-smoking / tobacco campaign.

- Many farmers are not aware of SHC portal. SHC portal should be more farmer friendly and simplified. A professional body may be employed to design the portal in more farmer friendly and effective manner.

- A simple tool to assess the quantity of urea, DAP and MoP based on SHC needs to be displayed as wall posters in the villages.

- It should be mandatory to enter fertilizer purchases by the farmers on the soil health card by each fertilizer dealer along with signature. It will not only increase awareness, but also help in adoption as per the recommendation.

Policy recommendations for improvement

- Index of soil health needs to be developed and incorporated in to SHC which indicates overall health of the soil. Based on the index soils should be classified as grade-A, B and C. The grades can be updated every SHC cycle based on soil tests. This updating of soil health index may act as an incentive to farmers to put special efforts to upgrade soil health index say from Grade-C to Grade-A, as grade-A soils may fetch higher land rental value for agricultural purposes and also get higher land sale price, if the land is put for sale when compared to Soils with grade-C.
- All agricultural and rural development schemes should mandate to mention soil health index based on SHC along with Aadhar in their application forms for getting benefits. The SHC information should be linked to Aadhar and available to download at e-seva in public domain.

- If the SHC programme needs to be successful, the high fertilizer subsidy for NPK should be reduced. Prices should reflect true cost to economy, then only farmers will have incentives to use fertilizers judiciously accordingly to the recommendations of the SHC. At the same time, subsidy on use of recommended dose of micro-nutrients, bio-fertilizers and organic inputs should be encouraged. However, quality of these inputs supplied on subsidy needs to be monitored and stringent punishment needs to be enforced, if they don't maintain quality standards.

- Government should set up state of art labs to test quality of micro-nutrients supplied. Accreditation of such labs to National/international standard institutes should be initiated. Supply of phosphorous soluble bacteria should be mandatory along with phosphate fertilizers and rock phosphate like neem-coated urea. FPCs need to be encouraged to take up SHC scheme as a business model through setting up the state of the art labs at the district level. Since FPCs are already involved in selling fertilizers, they are in a better position to stock all the required (according to SHC recommendations) fertilizer and micro-nutrient compositions and supply to individual FPCs across the district.
- There should be some incentives/awards for the farmers who grow green manure, vermi-compost and whose soil fertility increased over the years based on Soil Health Card.
- Some incentives to be given to local bodies who encourage good practices like recycling crop residues, encourage common lands for corporates, etc.
- Similarly, incentives can be given to villages when they adopt crop rotation with legumes.
- Innovative techniques like neem coated urea (for slow release of fertilizer in to soil) needs to be promoted by the government. Provide 45 kg urea bags instead of 50 kg. This will reduce the loss/excessive use of fertilizers by about 10-20% especially by small and marginal farmers.
- Soil sample collection, testing and printing at district level is significantly positively influenced by fertilizer use, number of bank accounts, net sown area, number of soil testing labs and households having mobiles.
- Other policies like water exploitation, electricity, etc. should be in line so that crop diversity can protect soil health in the long run.

Chapter ~ I

Introduction

According to the latest estimates 96.40 Million Hectare (Mha) area of India is undergoing the process of land degradation i.e., 29.32% of the Total Geographic Area (TGA) of the country during 2011-13. It has increased from 94.53 Mha (28.76% of the TGA) in 2003-05 (GoI, 2016). The states of Rajasthan, Maharashtra, Gujarat, Jammu & Kashmir, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telangana contribute 24 percent of the degraded area in the country. Water Erosion is the highest contributor (10.98% in 2011-13 and 10.83% in 2003-05) followed by vegetation degradation (8.91% in 2011- 13 and 8.60% in 2003-05) and wind erosion (5.55 % in 2011- 13 and 5.58 % in 2003-05). The area under desertification (arid, semi-arid and dry sub-humid regions of the country) during 2011-13 is 82.64 Mha; whereas, during 2003-05 it is 81.48 Mha. Thus, there is a cumulative increase of 1.16 Mha area under desertification. The most significant processes of desertification in the arid region is observed to be wind erosion and in semi-arid and dry sub-humid regions vegetation degradation and water erosion (GoI, 2016). These estimates are much higher than the earlier assessment from the national remote sensing agency (NRSA) which estimated the extent of land degradation in India at about 35.5 million hectares in 1999 (Reddy, 2003). This is mainly due to changes in definitions and also due to the inclusion of forest degradation (vegetation degradation)[1].

The pace of degradation has gone up during the post-green revolution period due to intensive use of chemical inputs (Table 1). India has a long history of soil conservation interventions and programmes. From the early 20th century, though, soil conservation was not among the policy priorities until the 1980s. As the extent of degradation increased over the years, soil conservation has gained policy attention (see appendix table on Polices). However, a more focused approach to soil management has been adopted only after 2014-15. This has coincided with the declaration of the international year of soils by the UN. Soil Health is a holistic concept which includes chemical, physical, biological health of the soil (Figure 1). In line with the UN resolution, the ministry of agriculture

[1] The new estimates refer to process of degradation, which includes heavy degradation and degraded lands), while the earlier estimates included only degraded lands. Besides, the earlier estimates provided forest degradation assessment separates. If these definitional differences are taken into account the estimates become comparable.

has introduced the Soil Health Card (SHC) scheme on 5th December 2015. The scheme is an improvement over the earlier National project on Management of Soil Health and Fertility that was launched during 2008-09.

Fig1: Measure of Soil Health

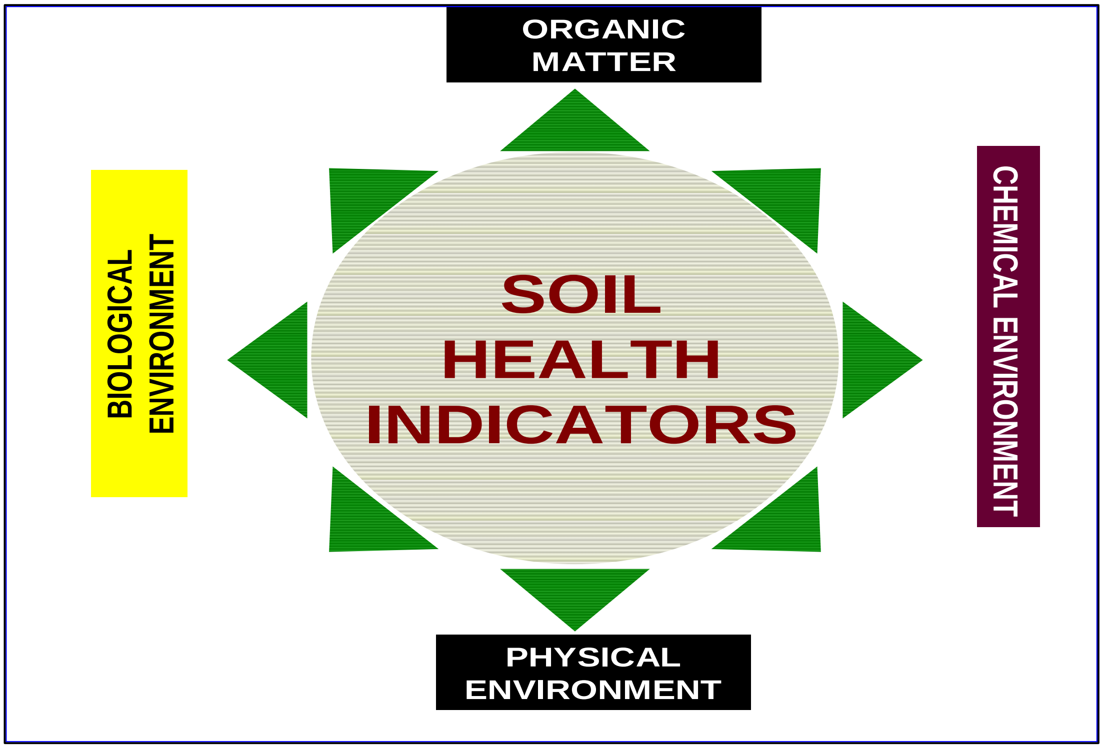
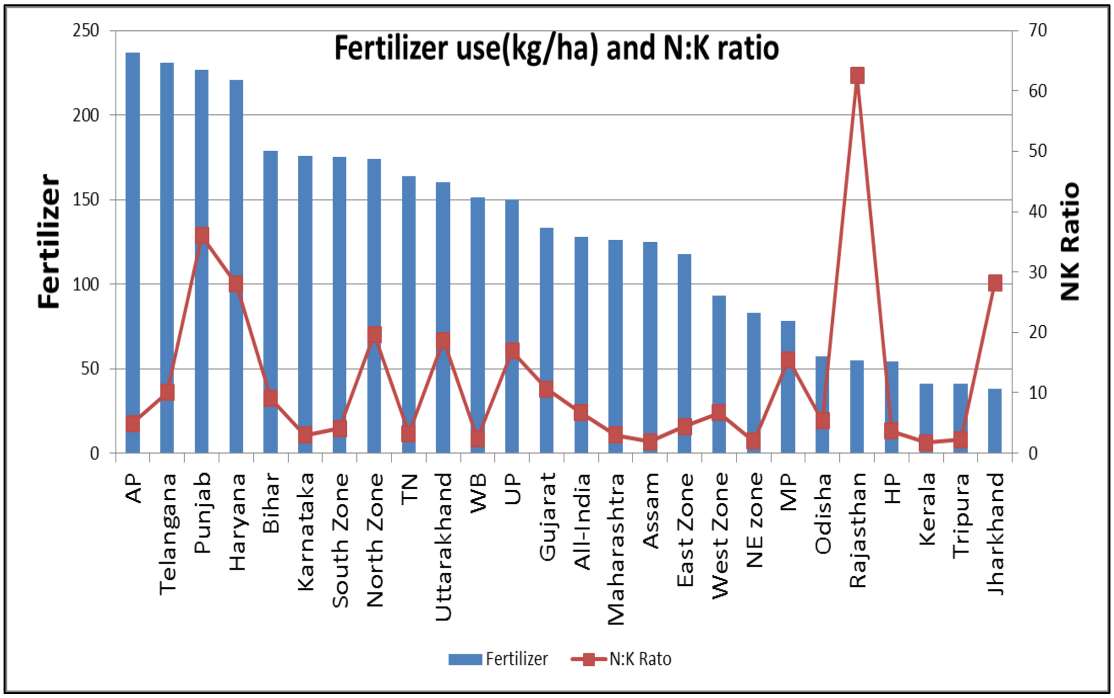


Table 1: Consumption of Fertilisers in million tonnes in India

	Million tonnes				NPK ratio		
Year	**N**	**P**	**K**	**Total**	**N**	**P**	**K**
1956	0.1	0.0	0.0	0.1	10.4	1.3	1
1981	3.7	1.2	0.6	5.5	5.9	1.9	1
1991	8.0	3.2	1.3	12.5	6.0	2.4	1
2001	10.9	4.2	1.6	16.7	7.0	2.7	1
2011	16.6	8.0	3.5	28.1	4.7	2.3	1
2015	16.9	6.1	2.5	25.6	6.7	2.4	1

India is consuming about 25.6 million tonnes of fertilizers, mostly Nitrogen (17 million tonnes) followed by Phosphorous (6 million tonnes) and Potassium (2.5 million tonnes). The current NPK ratio is 6.7:2.4:1, which is highly skewed towards Nitrogen as against ideal ratio of 4:2:1 (Table 1). There are wide variations across the states, in terms of fertilizer use per acre and NPK ratios (Fig. 2). India is spending about Rs. One lakh crore on fertilizer subsidy. It is estimated that subsidy amount is about Rs.6500/ha of the net cropped area and about Rs.7000/farmer resulting in excessive use of fertilizers especially Nitrogen at the cost of micro-nutrients and manure (Figure 3). As a result of the excessive and unbalanced use of fertilizers, the amount of food grain produced per kg of fertilizer applied declined from 13 kg in the 1970s to just 4 kg by 2010. In order to promote balanced use of fertilizers, government of India introduced has Soil Health Card Scheme across India.

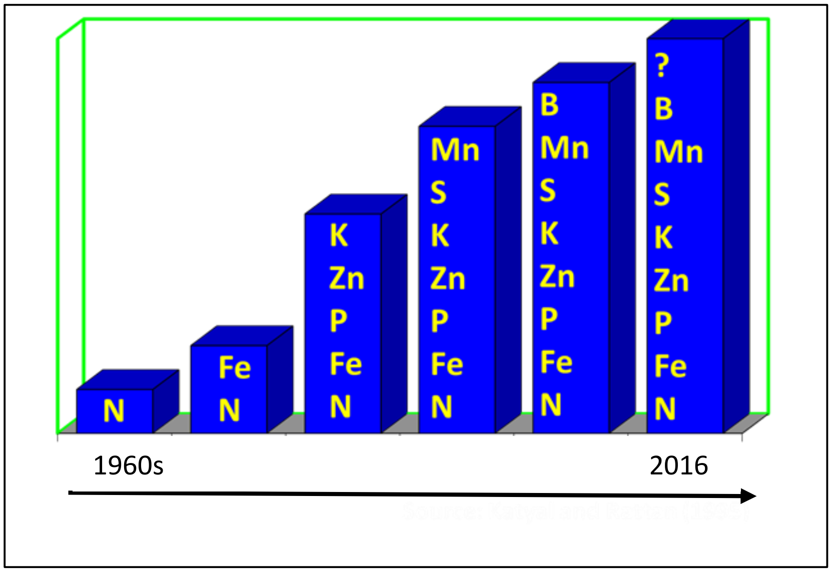
Fig. 2: State wise fertilizer use (kg/ha) and N:K Ratio



The SHC scheme has been approved for implementation during the remaining period of the 12th plan. The scheme aims to provide SHC to all farmers in the country at a regular interval of two years to enable the farmers to apply recommended dosages of nutrients to realize improved and sustainable soil health and fertility status and to reap higher profits. The scheme has the following objectives:

a) To improve soil quality and profitability of farmers.
b) Employment generation for rural youth.
c) To improve timelines in the analysis of soil samples.
d) Introduction of single window approach from collection to issue of SHC minimizing delays and maximize convenience to farmers.
e) Online delivery of SHC to the farmers using soil health card portal.
f) Provide soil testing facilities to farmers at their doorstep.

Fig 3: Progressive expansion in the occurrence of nutrient deficiency



Under SHC scheme, the cropped area was divided into grids of 10 ha for rainfed and 2.5 ha for irrigated and taken only one soil sample from each grid and test results will be distributed to all the farmers whose area was falling under the grid. Based on the grid system, the total 14.1 crore hectares of the net cropped area requires a total of 3.46 crore grid samples [with 52% of the area under rainfed (7.3 crore ha) with 73 lakh grid samples and with 48% area under irrigated (6.8 crore ha) with 2.72 crore grid samples]. The target is to cover 1.73 crores grid samples per year. This comes to on average 25000 grid samples per district/year and 29 grid samples per village/year. With this, all 10.39 crore farmers will be covered in two years. Every year 5.2 crore farmers need to be covered.

Under cycle-1, 2.54 crore samples were collected, 2.36 crore samples tested, 9.62 crore soil health cards printed, but only 9.33 crore SHCs distributed. It indicates that 100% target archived in sample collection, 93% of the target achieved in soil testing, but only 80% of the target achieved in SHC printing. 97% of the SHCs printed were distributed among the farmers as on 24th September 2017. However, the progress is highly skewed. Some states like Karnataka, Tamil Nadu, Chhattisgarh, Uttar Pradesh, Maharashtra, Telangana and Andhra Pradesh were better performers compared to other states.

Chapter –II

Soil Health in India: Review of Experience

Though there is a number of studies on the ill effects of poor soil quality across different states of India they mostly focus on micro situations. There are no all India studies on the impact of improved soil health. Of late, some studies have assessed the impact of soil health management programmes in Karnataka, Andhra Pradesh, Bihar, Gujarat, etc., where state governments have initiated the programmes viz., *Bhoochetana* in Karnataka and *Krishi Mahostav* in Gujarat. Here, the experiences of these initiatives are reviewed briefly (Details of the studies are presented in appendix table 2).

Studies have clearly shown that farmers do adopt soil management strategies (Reddy, 2011). Most of these practices are based on their long experience and rich knowledge of location-specific conditions. Combination of chemical fertilizers and FYM was a predominant practice along with mixed cropping and legume cultivation. This shows that farmers understand the role of FYM and other organic manure. The analysis also showed a positive sign of the emerging organic markets. The availability of FYM is limited and promotion of fertilizer use (advertisements) and also huge subsidy force the farmers to use more of chemical fertilizers. Farmers indicated that recommendations given by the scientists without proper soil testing do not hold well for the conditions they are working in.

A study of impact assessment of SHC in 3 districts of Bihar observed that there is a large gap between recommended and actual application of fertilizer, especially in the case of urea. Despite the recommendations provided in SHC farmers fail to adopt them (Fishman, *et al.,* 2016). Main reasons for this include: i) farmers didn't understand the contents of the SHC; ii) farmers didn't find the soil analysis and fertilizer recommendations to be reliable or compelling; iii) other factors such as cost, liquidity or timely availability of specific fertilizers was an added constraint.

On the other hand, studies have shown that when awareness programmes are followed up by supporting programmes like inputs, etc., soil improvements and increased crop yields were conspicuous. For instance, the *Bhoochetana* programme in Karnataka has introduced direct benefit transfer in fertilizer subsidy to increase efficiency and strengthening fertilizer supply chain along integrated nutrient management with emphasis on organic fertilizer. Under this programme, Karnataka government supplied micro-nutrients at 50% subsidy. The study estimated that total benefits with soil health mapping and soil test based fertilizer recommendations along with improved practices would be Rs.4.33 lakh crore, against the estimated cost of Rs 0.254 lakh crores (ICRISAT research report IDC-6). The benefit-cost ratio would be 17:1. Besides, economic benefits several environmental benefits, employment generation and several environmental benefits including enhancing the sustainability of Indian agriculture will be additional benefits.

Similarly, surface drainage technology for saline land reclamation was observed to be technically viable, economically feasible and socially acceptable. The study by Raju, *et al.,*(2015) clearly showed that land use was intensified, cropping patterns changed in favour of more remunerative crops and crop yields increased with the use of soil health cards. There was a significant reduction in the max and min salinity. Mean yield of all crops grown significantly increased to the extent of 186%. Increase in net income was largely related to the increase in crop yield due to soil improvements. A significant increase in net income from off seasonal crops was also observed. Benefit-cost ratio was more than one. Value of land also increased (Raju, *et.al.*, 2015).

In a study of on-farm trails in 8 districts of Andhra Pradesh, it is shown that balanced nutrient treatment in the widespread multi-nutrient (including micro-nutrients) deficient soils has resulted in significantly higher yields. Balanced nutrition while increasing crop yields maintained plant nutrient composition. Post-harvest soil testing in Nalgonda district showed higher contents of soil organic carbon and available nutrients like P, S, B and Zn in plots with balanced nutrition treatment. In the absence of balanced nutrition, farmers were losing 8% to 102% of current yields in season 1 and 15% to 24% in each of the succeeding 3 to 4 seasons (Chander, *et al.*, 2014)

2.1 Soil Health in India

According to "Degraded and Waste Lands of India" report by the Indian Council for Agricultural Research (ICAR) and the National Academy for Agricultural Sciences, of the 141 million hectares of total geographical area about 328.2 million hectares is under cultivation. Of this, about 100 million hectares — or 70% — is heading down a path where it will be incapable of supporting farming. Farmers are making the soil work more, growing two or more crops a year, instead of one without proper soil health management. This unplanned intensification is exacerbating nutrient shortages and changing soils' chemical composition. Levels of organic carbon in soil are dropping across the country, making soils more vulnerable to erosion and possibly resulting in the number of earthworms falling. Not only are these excesses and imbalances reducing the productivity and life of soils, they are now resulting in poor nutritional value of our food. For, if the soils are deficient in some nutrients, so are the food crops grown on them. Pharma companies have consequently started adding Zinc, Copper, Selenium, Chromium, etc., to fortify their vitamin tablets.

2.2 Soil Nutritional Status

Indian Institute of Soil Science, (IISS) data shows that large parts of India are deficient in two or more critical nutrients. Regions like the Indo-Gangetic plains – Punjab, Haryana, Uttar Pradesh and Bihar which produce nearly 50% of our grains and feed about 40% of our population are seeing multiple nutrient deficiencies. The reason being the imbalance use of organic and inorganic inputs. In the past, farmers used to plough the stalks left standing on the field after the harvest, cow dung, etc., back into the soil. This ensured that nutrients taken out of the soil were replenished. The green revolution, which started in the sixties, changed all that. High yielding crop varieties need more water and nutrients – which span from macro-nutrients like Nitrogen and Phosphorus to micro-nutrients like Copper and Boron. However, due to imbalanced fertilizer use, hardly any of these nutrient cycles are being completed. Farmers today use more of Urea (Nitrogen), some Potassium and Phosphorus, but not much else. Further, they choose fertilizers more by affordability and availability than what the soils need. Apart from retarding growth in yields, this unbalanced use has also damaged soils. Too much urea, for instance, turns soils acidic. The ICAR report estimates that 6.98 million hectares or 2% of India's total geographical area, have acidic soils. These are mostly in North East India, south Chhattisgarh and Kerala. Another 6.7 million hectares are salt-affected. In the absence of historical data on nutrients, the degree of decline cannot be ascertained. These soils are increasingly incapable of supporting agriculture.

2.3 Soil Organic Carbon

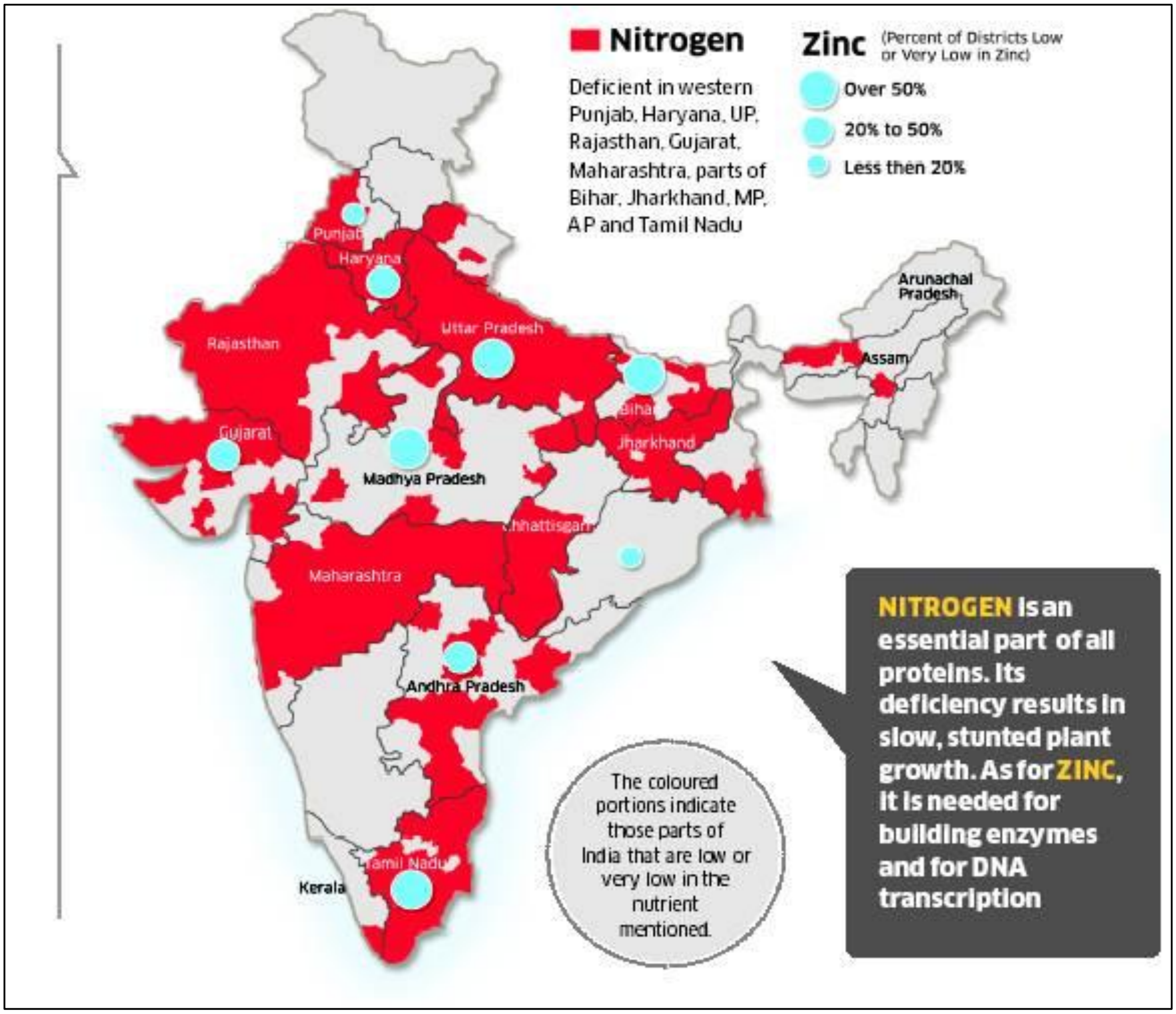
Soils are changing from fine to hard. In healthy soils, crop residues transformed by earthworms and other soil fauna into soft and spongy organic matter called humus (or organic carbon). This soaks up water, creates an environment where soil fauna like earthworms thrive, and binds the soil's three constituents: sand, silt and clay. Without humus, the soils compress and harden. Farmers, in a hurry to plant the next crop, burn their fields to clear stalks left standing after the harvest. Cow dung is scarcer. That's partly because, with mechanization, fewer households keep bullocks. The decline of grazing grounds has meant only households large enough to afford fodder can keep milch animals. The recommended amount of farmyard manure is 5-10 tonnes per hectare, whereas farmers add anywhere between zero to five tons. Poorer farmers sell manure instead of ploughing it into their fields. Or, they use dried dung as fuel. The outcomes are predictable. IISS estimated that humus depletion in the top 0-15 cm is nearly 50%, although it can be occasionally as high as 60-70% in some soil types. There is 10-20% loss in the 15-100 cm below that top layer. As humus falls, properties of the soil change. For example, its ability to absorb water reduces, resulting in erosion. The ICAR report estimates that a total of 126 M ha is suffering from various degrees of water erosion. Of this, 0.68 million hectares are seeing severe, very severe and extremely severe erosion. Another 0.2 million hectares is seeing "moderately severe" erosion. The report estimates that very severe and severe wind erosion occurs in 16% of India's total geographical area. Both these processes contribute to desertification — soil turning into a desert. About 81 million hectares, or 25% of it, is experiencing desertification, says a 2009 ISRO paper titled 'Desertification/land degradation status mapping of India'. Anecdotal information suggests that the number of earthworms and other soil insects is falling.

Fig. 4: Fields effected by alkalinity

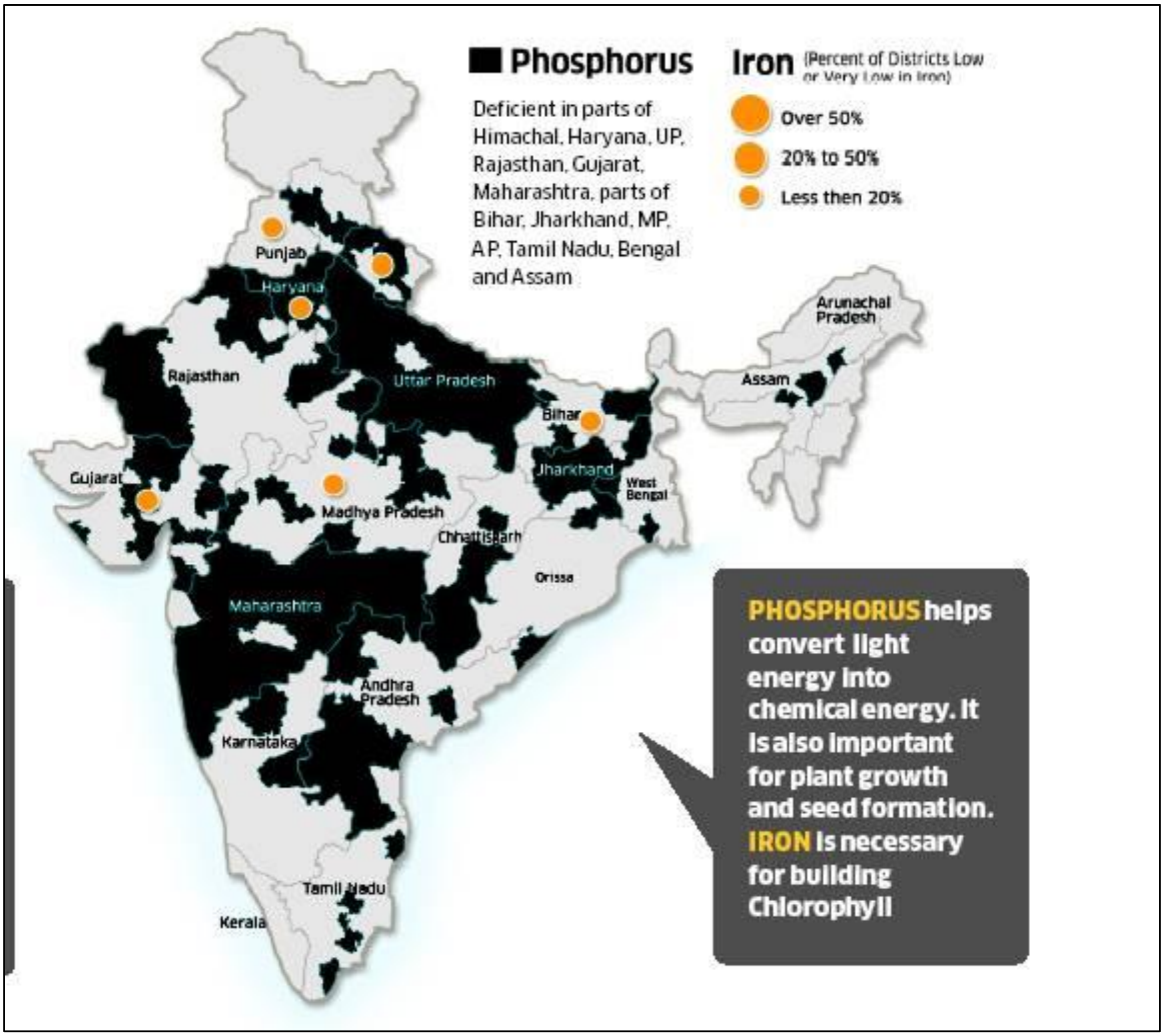
2.4 Soil Health Card to improve soil health

Soil Health Card programme is trying to address these problems. However, it is a crisis that we are just starting to deal with. One of the few exceptions is the government's switch to Nutrient-based Subsidy. As a response to growing micro-nutrient shortages, it falls short. Partly because the price signals it sends out about the nutrients to use are national while the shortages are local. Partly because the government has decontrolled prices of P and K while holding on to prices of N. As a result, every time P and K prices soar, farmers dump more urea than other fertilizers. And partly because it doesn't extend the subsidy to organic manure or to all 20 micronutrients – it only covers Boron and Zinc. We do not have pan-India authentic baseline data about soil nutrient concentrations. The Indian Institute of Soil Science (IISS) data as shown in (Map 1, Map 2, Map 3 and Map 4) was derived from samples collected by soil-testing labs. The quantum of deficiency in these maps has been calculated by gauging the minimum concentration of a nutrient required (for that soil type) for above normal yields. However, macro-nutrient deficiency has been mapped for only 18-odd states.

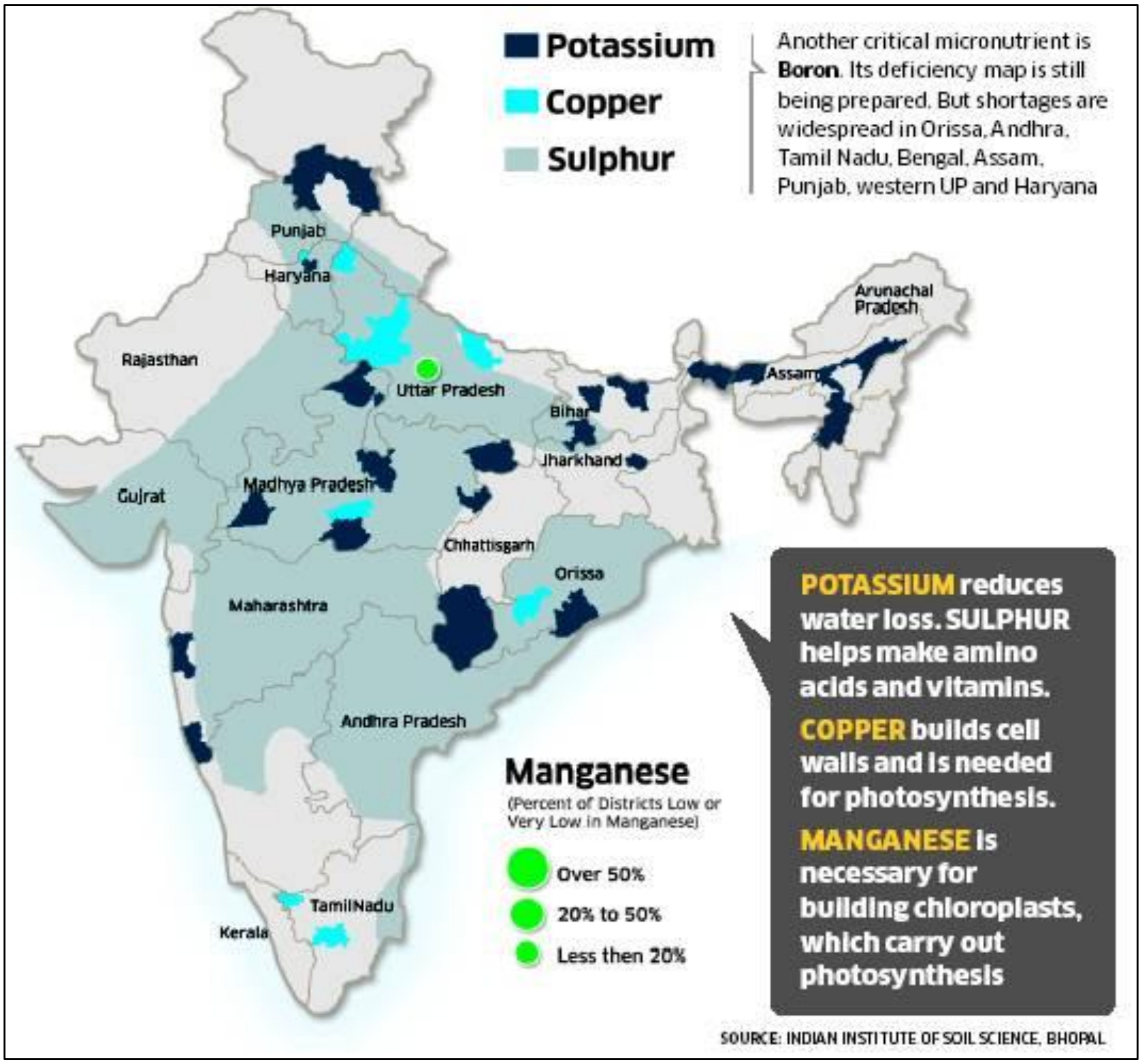
In the case of micro-nutrients, we know their concentration in even fewer states with a very limited sample. There was no authentic data on pan-India soil microbial population and activity. Tamil Nadu, Gujarat and Punjab are better in this regard than other states. India has 140 million farmers, but our labs cannot process more than 8 million soil samples in a year. It will take us 15 years, at this rate, to tell every farmer what his soil needs. The larger question is about the soils' physical condition – can they support the hydrological cycle? And for that, you need humus and soil biota. Earthworm populations, organic carbon levels and yields are the highest when a combination of balanced fertilization and farmyard manure is used. However, India doesn't have enough cow dung. Organic waste can be used instead of cow dung, but we need to figure out better ways to segregate organic and inorganic waste, and to get it across to fields. Various state governments are encouraging composting pits where agricultural and household wastes can decompose into manure that is then ploughed back into the soil.



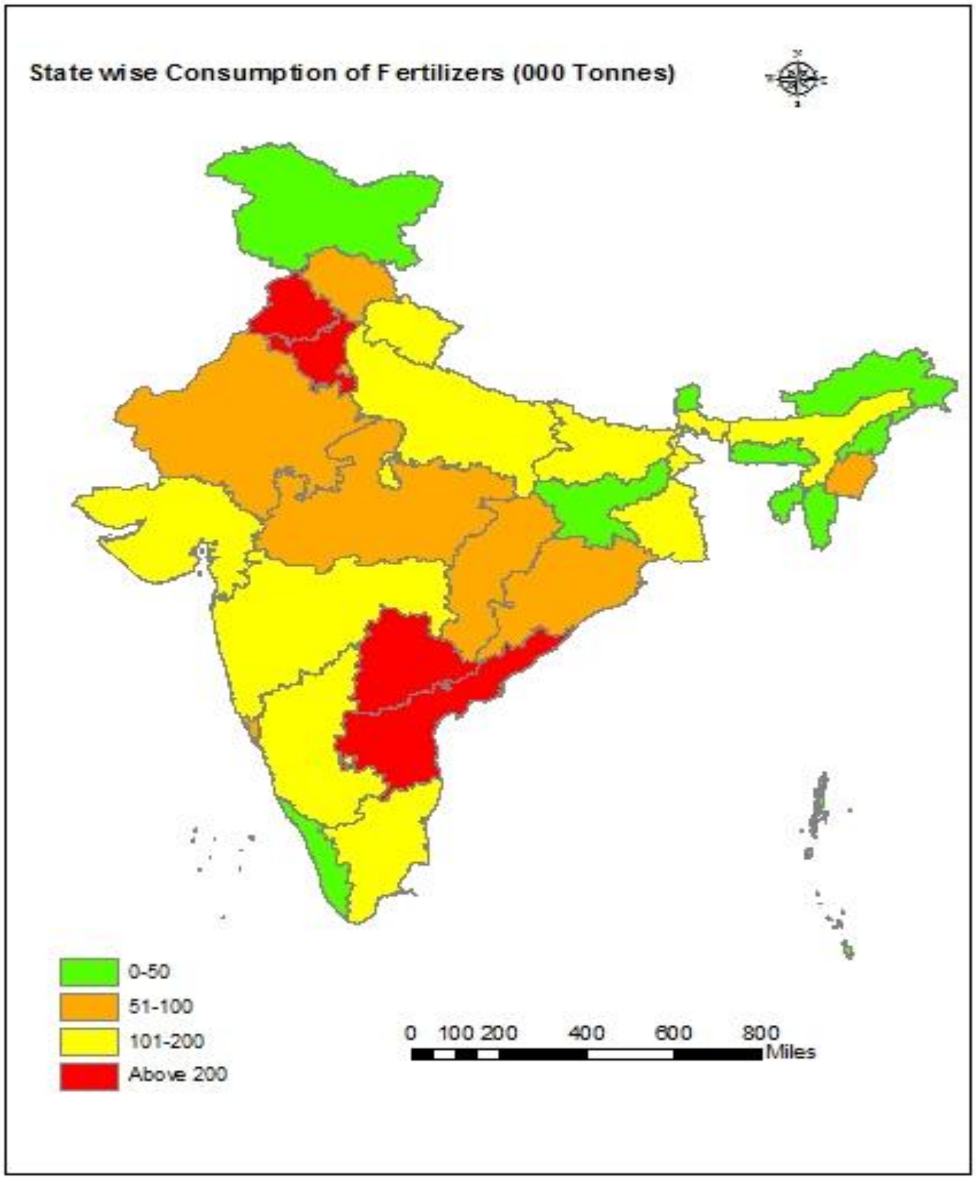
Map 1: Status of Nitrogen and Zinc availability in Indian soil (source: Economic Times)



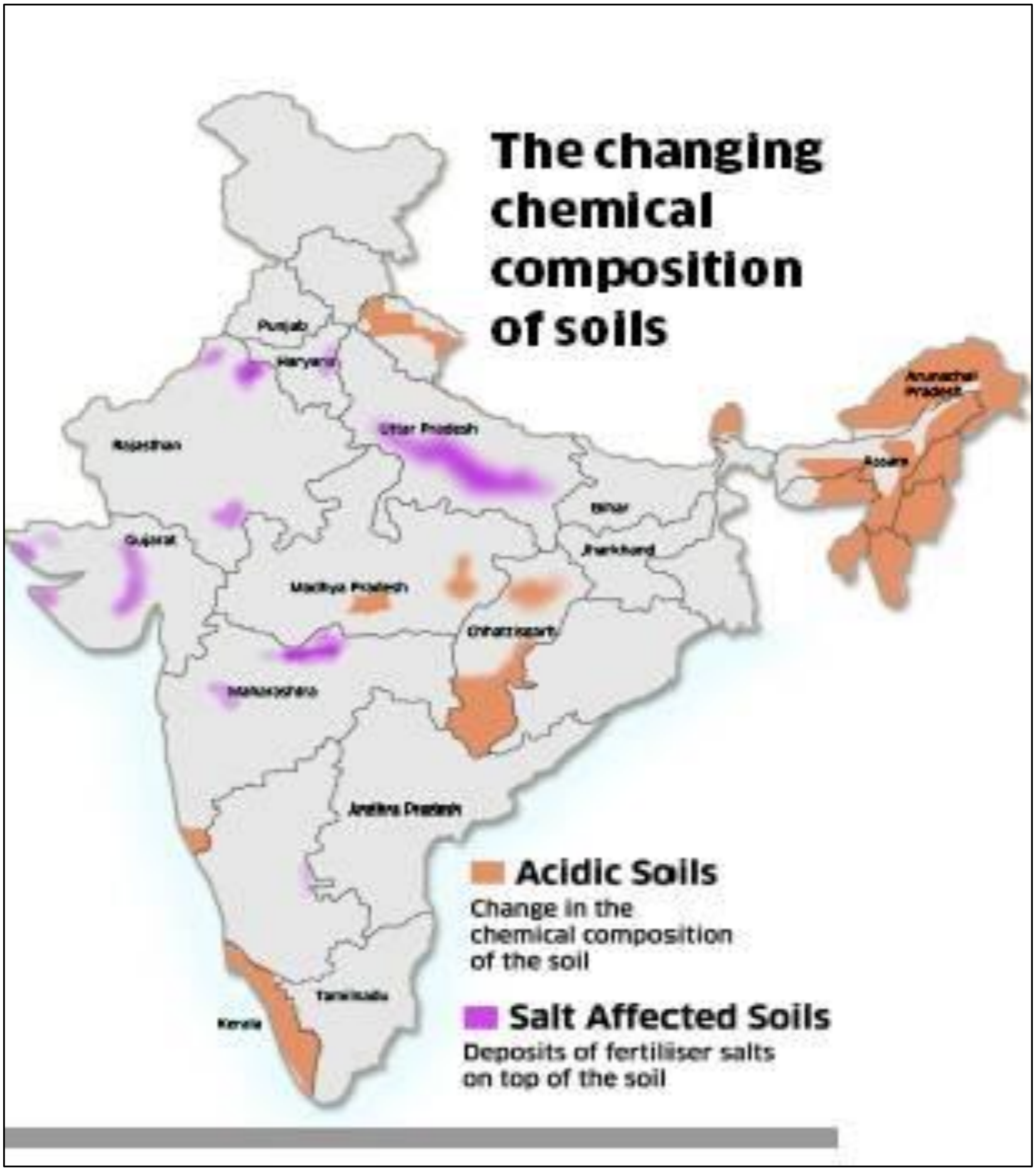
Map 2- Status of Phosphorus and Iron availability in Indian soil



Map 3: Status of Potassium, Copper and Manganese availability in Indian soil



Map 4: State Wise Consumption of Fertilizers



Map 5: Changing chemical composition of soils

Chapter III

Policy interventions over the years: International and National

Though soil management practices and policies are as old as agriculture, formal land management policies at the international level were initiated in the early 1980s with the first World Soil Charter (WSC) adopted by the FAO (Food and Agriculture Organization) member countries in 1982 under the global soil partnership. This was followed up by a number of international policy initiatives like Intergovernmental Panel on Climate Change (IPCC) in 1988. Soil management received a flip with UNCCD (United Nations Convention to Combat Desertification) focusing on drought mitigation and combat desertification. This was followed by Rio conference which has provided 27 principles to guide countries towards sustainable development. Following this number of conventions and protocols were initiated to help soil management at the global level. Important ones among them include:

3.1 Global policies

a. 1997- The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits State Parties to reduce greenhouse gas emissions, based on the scientific consensus that (a) global warming is occurring and (b) it is extremely likely that human-made CO_2 emissions have predominantly caused it.

b. 2000- MDG's - Soil management and prevention of desertification. Implementation of soil erosion control (by wind and water) by planting windbreaks and cover crops; improvements in soil fertility with agro-forestry systems, cover crops, and conservation of ground and surface water.

c. 2005- The Millennium Ecosystem Assessment looked at the consequences of ecosystem change for human well-being. From 2001 to 2005, the MEA involved the work of more than 1,360 experts worldwide. Their findings provide a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide, as well as the scientific basis for action to conserve and use them sustainability.

d. 2008- This UNCCD policy brief "A Sustainable Development Goal for Rio+20: Zero Net Land Degradation" provides a snapshot of the world's land, explains causes and impacts of land degradation and suggests pathways to land-degradation neutrality. The brief reveals that sustainable land-use is a prerequisite for ensuring future water, food and energy security. Given the increasing pressure on land from agriculture, forestry, pasture, energy production and urbanization, urgent action is needed to halt land degradation.

e. 2011- The Global Soil Partnership for Food Security and Climate Change Mitigation and Adaptation (GSP) brings together international, regional and national organizations that are working in the area of soil protection and sustainable management. Launched by the Food and Agriculture Organization of the United Nations in Rome on 7th September 2011, the partnership aims to implement the provisions of the 1982 World Soil Charter, and to raise awareness and motivate action by decision-makers on the importance of soils for food security and climate change adaptation and mitigation.

f. 2012- Sustainable Development Goal 15 of the 2030 Agenda aims to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainable forest management, combat desertification, and halt and reverse land degradation and halt biodiversity loss".

g. 2013- The Intergovernmental Technical Panel on Soils (ITPS) was established at the first Plenary Assembly of the Global Soil Partnership held at FAO Headquarters on 11th and 12th of June, 2013. The ITPS is composed of 27 top soil experts representing all the regions of the world. The main function of the ITPS is to provide scientific and technical advice and guidance on global soil issues to the Global Soil Partnership primarily and to specific requests submitted by global or regional institutions. The ITPS will advocate for addressing sustainable soil management in the different sustainable development agendas.

h. 2015- The International Year of Soils, 2015 (IYS 2015) was declared by the Sixty-eighth session of the United Nations General Assembly on December 20th, 2013 after recognizing December 5th as World Soil Day. The purpose of the IYS is to raise awareness worldwide of the importance of soils for food security, agriculture, as well as in mitigation of climate change, poverty alleviation, and sustainable development.

3.2 National Policies

In India, formal soil and water interventions were under way since 1900 under the British Rule. Post-independence, soil management has become part of five year plans from the first plan onwards (see appendix Table). A number of initiatives have been taken up at the national level over the years. Apart from the soil reclamation programmes during the 1970s and 80s and soil and water conservation programmes going on over the years (mainly watershed development programme), no specific soil management programme was initiated at the national level. For the first time during the 11^{th} plan, National Mission for Sustainable Agriculture (NMSA) was introduced as a part of the National Action Plan on Climate Change (NAPCC). The National Project on Management of Soil Health and Fertility and the Rain fed Areas Development Programme (RADP) was also introduced. It is recommended that conservation agriculture, integrated nutrient management, carbon sequestration, erosion control, saline and alkaline soils management, legislation for soil protection, development of remote sensing and GPS (Global Positioning System) - based Decision Support System (DSS) and amelioration of polluted soil to rejuvenate deteriorated soils. This was followed up in the 12th plan by introducing a new scheme: 'National Project on Management of Soil Health & Fertility' (NPMSH&F). Under this scheme, soil health cards were introduced along with strengthening of soil testing labs and expanding their testing capacity. Further, Nutrient-Based Subsidy (NBS) system was introduced. During the recent years, some of the states like Karnataka, Gujarat, etc., have introduced soil management programmes like *Bhoochetana* and *Krishi Mahotsav* programmes. These programmes have provided insights and learnings for the central schemes.

Table 2: Soil quality and quantity indicators

Indicator	Poor	Medium	Good
Earthworms	0-1 worms in shovelful of top foot of soil. No casts or holes	2-10 in shovelful few casts, kholes or worms	10+ in top foot of soil. Lots of casts and holes in tiled clods. Birds behind tillage
Organic matter colour	Top – soil colour similar to sub-soil colour	Surface colour closer to sub-soil colour	Top-soil clearly defined, darker than sub-soil
Roots/residue	No visible residue or roots	Some residue, few roots	Visible residues and roots
Surface compaction	Wire breaks or bends when inserting surveyors flag	Have to push hard, need fist to push flag in	Flag goes in easily with fingers to twice the depth of plow layer
Soil tilth mellowness friability	Looks dead. Like brick or concrete cloddy. Either blows apart or hard to pull drill through	Somewhat cloddy. Balls up, rough pulling seedbed.	Soil crumbles well, can slice through, like cutting butter. Spongy when you walk on it
Erosion	Large gullies over 2 inches deep joined to others, thin or no top-soil, rapid run-off the colour of the soil	Few rills or gullies, gullies up to two inches deep. Some swift runoff, colored water	No gullies or rills. Clear or no runoff
Water holding capacity	Plant stress two day after a good rain	Water stress after a week	Holds water for a long period of time without puddling.
Drainage infiltration	Water lays for a long time evaporates more than drains, always very wet aground	Water lays for short period of the time eventually drains.	No ponding run off water moves through soil steadily. Soil not too wet, not too dry.
Crop condition	Problem growing throughout season, poor growth, yellow or purple color	Fair growth, medium green colour	Normal, healthy dark green color, excellent growth all season across field
pH nutrient holding capacity	Hard to correct for desired crop Soil test values dropping with more fertiliser applied than crops use	Little or slow change	Proper pH for crop Fair growth, spots in field different, medium green color.

Chapter IV

Objectives and Methodology

4.1 Objectives:

As the SHC scheme has completed more than 2 years of implementation, the ministry has initiated a nationwide impact assessment with the following objectives.

- To examine the design of the SHM/ SHC scheme in terms of planning, implementation (role of state/ JDA/ADA/AO), inputs (staff, financial and other resources), activities (training, lab established and strengthened), outputs (SHC's printed and distributed to farmers).
- To assess the modalities of delivery of the SHM / SHC scheme in terms of procurement, sample collection, testing, SHC printing and disbursal.
- To assess the level of utilization of SHC's by the farmers across farm size class irrigated and rainfed situations.
- To assess the impacts of SHC scheme on judicious use of fertilizers, bio fertilizers, organic fertilizers, soil health, cropping choice, cost reduction, farm profitability and sustainability.
- To recommend for improvement of the overall design of the programme.

4.2 Methodology

Both qualitative and quantitative approaches were used to assess the impact of Soil Health Card Scheme. Qualitative information in the form of stakeholder interviews across the study states, expert opinion gathering at the national and state levels through workshops and interactions with the progressive farmers were carried out. At the quantitative level, both secondary and primary data were collected at the national, state and farmer levels. Secondary data mainly pertain to financial and physical achievements of the SHC scheme over the years, infrastructure availability, number and capacity of Soil Testing Laboratories and utilization capacity were collected and analyzed.

A systematic sample has been drawn for the impact assessment at the farmer level. Care was taken to represent the whole country and different agro-climatic conditions. The sampling details are presented below.

4.2.1 Selection of States, districts and blocks

For the secondary data, all the states were covered to understand the number of SHCs issued and farmers covered, financial and physical progress of the inputs, activities and outcomes of the SHC scheme. For primary data collection, all major states (25 major states) were divided into five zones for drawing the sample. From each zone, 2-4 states were selected and a total of 16 states were selected for primary data collection. At the next level, two districts from each state (in case of large states three districts and one district in case of small state) were selected i. e, total of 29 districts. From each district, two blocks were selected randomly, i.e., total of 65 blocks. From each block, two to three villages were selected randomly i.e., total of 199 villages. From each village 16 households were selected for collecting detailed information with the help of a structured questionnaire (see appendix). Overall, 3184 households were covered at the national level (Table 2).

Due care was taken to represent at least a few farmers who received SHC at least a year before the survey date, to understand the impact. Hence, sample size varies little according to the availability of these oldest adopters in villages. Due care was taken to cover small and marginal farmers, SC/ST farmers, educated youth and also beneficiaries under demonstrations (Table 3). The impact of SHC was assessed by using before and after methodology and also by using with and without wherever possible. We have also classified respondents based on the period of holding SHC, oldest (received SHC more than one year ago), old (six months back), new (four months back) and recent (less than four months) for assessing the impacts over the period.

All the states were grouped in to zones based on standard classification. Northern Zone comprising Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, and Rajasthan; North-Eastern Zone comprising Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura; Central Zone comprising the States of Chhattisgarh, Madhya Pradesh, Uttarakhand and Uttar Pradesh; Eastern Zone comprising Bihar, Jharkhand, Odisha, and West Bengal; Western Zone comprising Dadra and Nagar Haveli, Daman and Diu, Goa, Gujarat, and Maharashtra; Southern Zone comprising Andhra Pradesh, Karnataka, Kerala, Lakshadweep, Puducherry, Tamil Nadu, and Telangana.

Table 3: Details of sampling Framework

Zone	States	Districts	Blocks	Villages	Total sample farmers
Central	2	3	6	20	320
East	2	3	7	15	240
North east	4	4	10	28	448
North	3	8	11	54	864
South	3	7	24	50	800
West	2	4	7	32	512
Total	16	29	65	199	3184

For the primary data collection following states covered under each zone:

- Central Zone
  - Chhattisgarh
  - Madhya Pradesh
  - Uttar Pradesh
- East Zone
  - Jharkhand
  - West Bengal
- North East Zone
  - Nagaland
  - Arunachal Pradesh
  - Assam
  - Sikkim
- North Zone
  - Haryana
  - Punjab
- South zone
  - Andhra Pradesh
  - Telangana
  - Karnataka
- West Zone
  - Gujarat
  - Maharashtra

Further, states were divided into developed and less developed states based on development indicators taken from planning commission. The developed states include Andhra Pradesh, Telangana, West Bengal, Haryana, Maharashtra and Gujarat. Less developed states include Uttar Pradesh, Nagaland, Sikkim, Arunachal Pradesh and Assam. This would help in understanding whether development has any role in the effectiveness of the SHC at the farmer level.

4.2.2 Structure of Data from farmers:

The structured questionnaire covering all the details pertaining to SHC were canvassed among the sample farmers. Besides, focus group discussions were conducted in the sample villages to get the feedback from the communities. These groups include key-informants and farmers not covered under individual survey and farmers who have not received soil health card.

All the indicators collected from field survey were classified as inputs (financial and physical inputs under the project), activities (different activities organised under the scheme), outputs (actual outputs of the project), outcomes (whether generated outputs used by the farmers) and impacts (what are the ultimate benefits to the farmers).

4.2.3 Indicators of inputs of SHC scheme

i. Procurement of maps (patwari / pahani maps), field instruments (with GPS) and deployment of staff for collection of samples from farmers' fields.
ii. Methodology of soil sample collection (is the 10 ha grid for rainfed and 2.5 ha for irrigated adequate? Or any improvements are needed).
iii. Status of soil testing facilities including soil testing labs and mobile soil testing labs (geographical distribution, adequacy, access, and reachable)
iv. Availability of equipment (color Photostat machine, standard paper for printing, and printing machines) and mechanism for distribution of soil health cards to farmers.
v. Time lag between the releases of funds to actual utilization.
vi. Annual action plan versus implementation.
vii. Effectiveness of partnerships (operationalization of Public Private Partnership mode).
viii. Technical help from agricultural officers and allied sectors
ix. Number of skilled staff engaged and is there any shortage of staff
x. Number of awareness camps and trainings and effectiveness of the campaign,
xi. Reaching to remote village (in terms of samples collected and SHCs distributed and used)

xii. Identifying problematic soils, recommendations and application of soil amendments

4.2.4 Indicators of activities under SHM

i. Number of AEOs/ ToTs trained under the scheme.
ii. Number of meetings, trainings, exposure visits and demonstrations conducted.
iii. Number of soil testing laboratories strengthened (analyzing capacity and utilization).
iv. Number of soil testing labs equipped with micro nutrient testing facilities.
v. Number of referral labs established.
vi. Number of STLs equipped with Soil Test Based Crop Response (STCR).
vii. Number of farmers covered, samples collected, tested and SHC printed.

4.2.5 Indicators of Outputs of the Scheme

i. Number of SHCs distributed among farmers.
ii. Number of SHCs distributed among small and marginal farmers and SC/ST farmers (whether main field located in their farm)

4.2.6 Indicators of Outcomes

i. Awareness about SHCs by the farmers
ii. Sources of information about soil health card and reliability
iii. Gain in knowledge through attending demonstrations
iv. Understanding of the content and recommendation on SHCs
v. SHC portal usefulness to farmers; rating from 1 to 5 (1 is bad; 5 is excellent)
vi. Use of fertilizers according to the recommendations on SHC
vii. Crops recommended in SHCs and actual crops sown by farmers
viii. Use of organic manure and bio-fertilizers by farmers
ix. Integrated Nutrient Management practices followed by farmers
x. Expectations of the farmers
xi. Overall opinion of farmers on SHC.

4.2.7 **Indicators of Socio-economic impacts**

i. Perceptions of the farmers towards soil health card
ii. Increase in crop yields, reduction in fertilizer use and cost and increase in profitability.
iii. Economic returns to farmers

4.2.8 **Information from key stakeholders and secondary data**

i. Scheme design (whether current grid of 10 ha for rainfed and 2.5 ha for irrigated is appropriate), components, activities and outputs suitable to local implementation.
ii. Time lag in fund allocation, release and utilization at different stages.
iii. Gaps in physical and financial progress.
iv. Comparative analysis of the best performing states and other states in actual utilization of SHCs by farmers.
v. The process monitoring and evaluation (institutional and administrative procedures, roles and responsibilities, maintenance of records) were analyzed for learning across states.

Chapter~ V

Soil Health Card Scheme: Design, Coverage and Impact

5.1 SHC Design and Status (inputs/activities and outputs):

Under SHC scheme, the cropped area was divided into grids of 10 ha for rainfed and 2.5 ha for irrigated and taken only one soil sample from each grid and test results will be distributed to all the farmers whose area was falling under the grid. Based on the grid system, out of the total 14.1 crore hectares of net cropped area, with 52% of area under rainfed (7.3 crore ha) with 73 lakh grid samples and with 48% area under irrigated (6.8 crore ha) with 2.72 crore grid samples with a total of 3.46 crore grid samples in two years will be the target. Per year 1.72 crore grid samples need to be covered. This comes to on average 25000 grid samples per district/year and 29 grid samples per village/year. With this, all 10.39 crore farmers will be covered in two years. Every year 5.2 crore farmers need to be covered. Until now, the total samples entered is 1.56 crore, a number of farmers covered is 4.82 crores, samples tested are 1.23 crore and SHCs printed are 3.05 crore. It indicates 46% of the total farmers covered under the scheme at a national level, but only 29.3% received SHCs.

Samples collected

State wise samples collected were presented in map 5. It is observed that highest number of samples collected was in Kerala with maximum of 969 samples collected per 1000 ha. Kerala is followed by Tamil Nadu, Gujarat, Uttar Pradesh and Bihar with 247 to 544 samples collected per 1000 ha. Northern states like Jammu & Kashmir, Himachal Pradesh, Haryana and southern states of Telangana, Andhra Pradesh, and Maharashtra showed a moderate number of sample collection ranging between 157-246 samples/1000 ha. Semi moderate number of samples, i.e. 27-156 samples per 1000 ha were collected from most of the central, eastern and north-eastern states like Orissa, Madhya Pradesh, Arunachal Pradesh, and Assam. Lowest number of samples i.e. 0- 26 samples per 1000 ha were collected in Manipur and NCT of Delhi.

State wise samples collected per 1000 cultivators (Map 6), shows that Andhra Pradesh, Telangana and Haryana came into green with higher samples collected per 1000 cultivators. But Himachal Pradesh and Bihar came into red with the lowest samples collected per 1000 cultivators. Uttar Pradesh and West Bengal turned from light green to yellow.

<table>
<tr>
<td>Map 6: Statewise samples collected per 1000 ha</td>
<td>Map 7: Statewise samples collected per 1000 cultivators</td>
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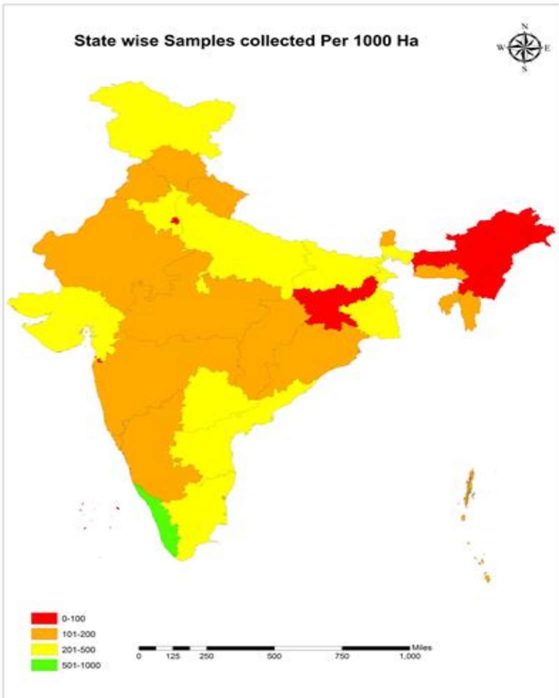
<tr>
<td>
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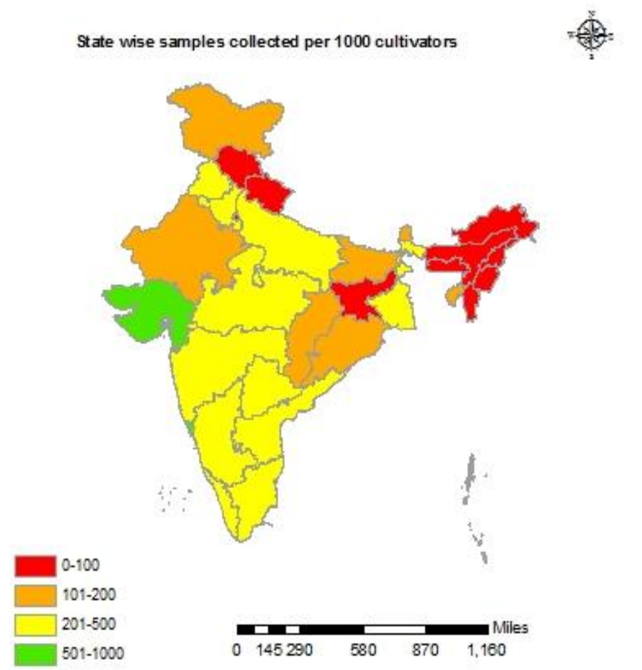
<td>
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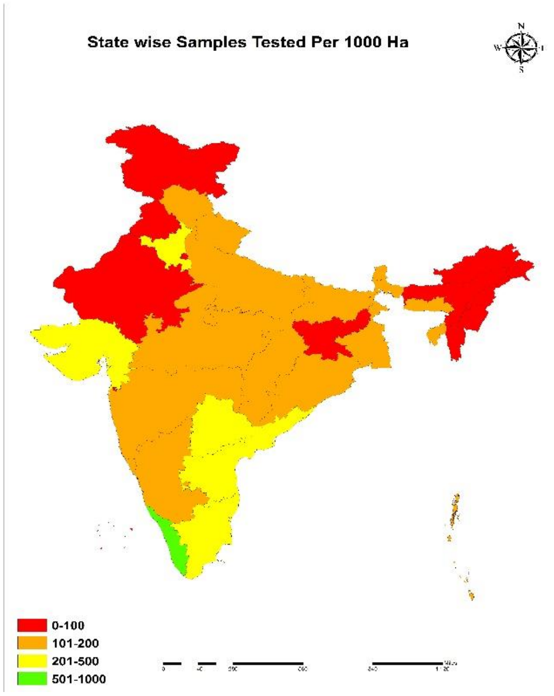
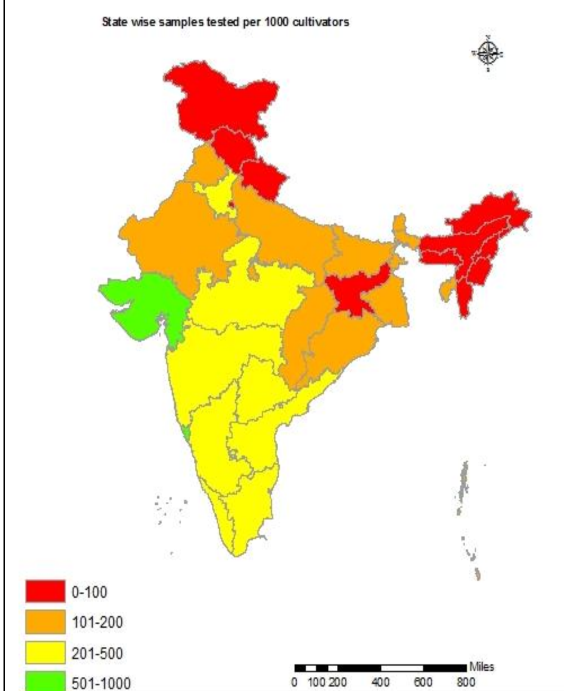
Samples tested

State wise samples tested per 1000 ha were presented in map 7. It is observed that the highest number of samples tested per 1000 ha was in Kerala (727 samples tested per 1000 ha). Kerala is followed by Tamil Nadu, Andhra Pradesh, Gujarat and Haryana with 206-316 samples tested per 1000 ha. It can be seen that in most of the states (Telangana, Maharashtra, Karnataka, Madhya Pradesh, Chhattisgarh, etc.) samples tested were in the range of 89-205 per 1000 ha. Rest of the states viz. Rajasthan, Punjab, Jharkhand and Jammu & Kashmir were showed only 24-88 samples tested per 1000 ha. Lowest number of samples tested i.e. 0-23 samples tested per 1000 ha is seen in the N.E states Assam and Manipur.

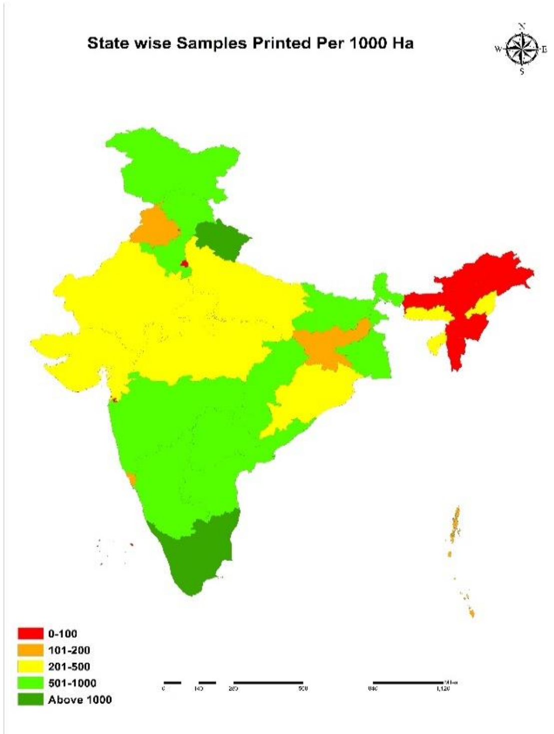
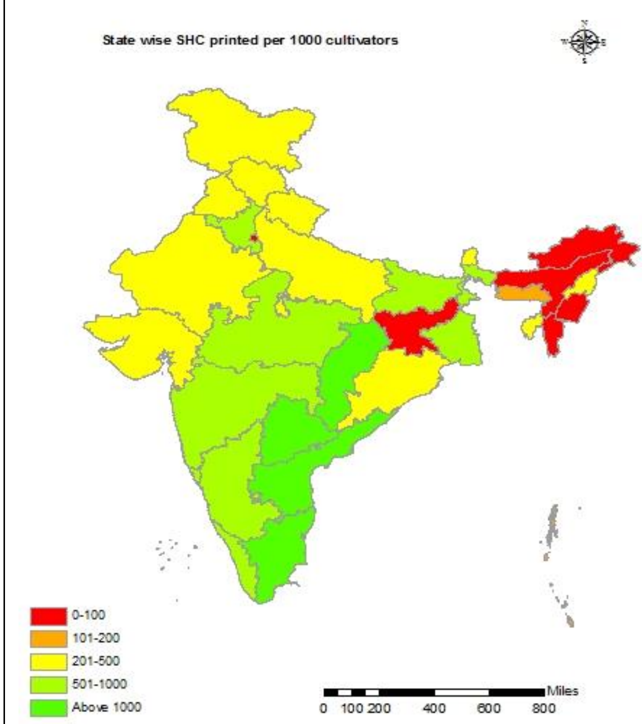
Soil samples tested per 1000 cultivators (Map 8), shows that Gujarat turned from light green (moderately high) to green (high). Karnataka, Telangana, Madhya Pradesh turned from yellow (medium) to light green (moderately high). On the other hand, Bihar turned from low to lowest (Map 8).

Map 8: State wise samples tested per 1000 ha	**Map 9:** Statewise samples tested per 1000 cultivators
	

SHC printed

State wise SHCs printed per 1000 ha depicted in map 9. It is observed that highest number of SHC printed was in Kerala and Tamil Nadu with above 1000 SHCs printed per 1000 ha. These two states are followed by Andhra Pradesh, Chhattisgarh, Himachal Pradesh, Uttarakhand, and Bihar with about 687-1002 SHCs printed in the states. Rest of the states like Telangana, Maharashtra, Orissa, West Bengal, Uttar Pradesh, and Parts of Jammu & Kashmir displayed a moderate range of SHCs printed per 1000 ha, i.e. in the range 361-686. The low number of SHCs (i.e. 73-360 numbers per 1000 ha) were seen in western states like Rajasthan, Gujarat, Madhya Pradesh and northern states like Punjab and also in Jharkhand. It is seen that Lowest number of SHCs printed, i.e., 0-72 SHCs printed per 1000 ha are in North-eastern states with exception of Tripura and Nagaland which showed about 361-686 SHCs printed per 1000 ha.

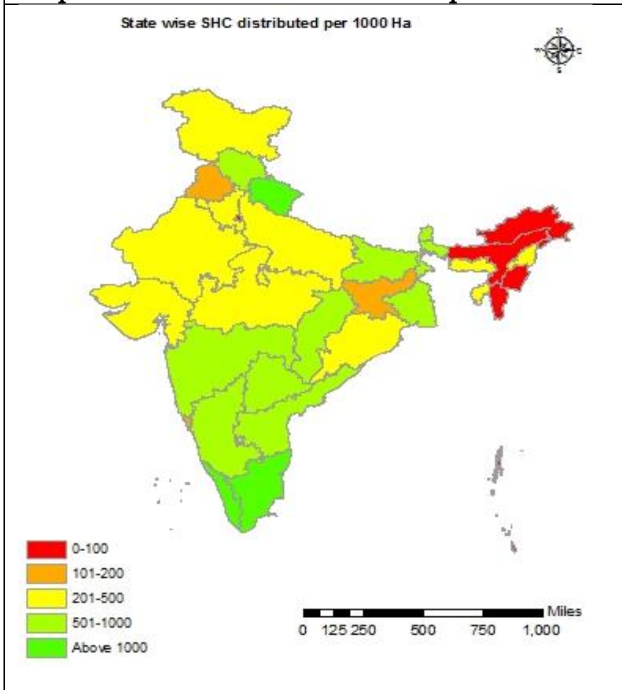
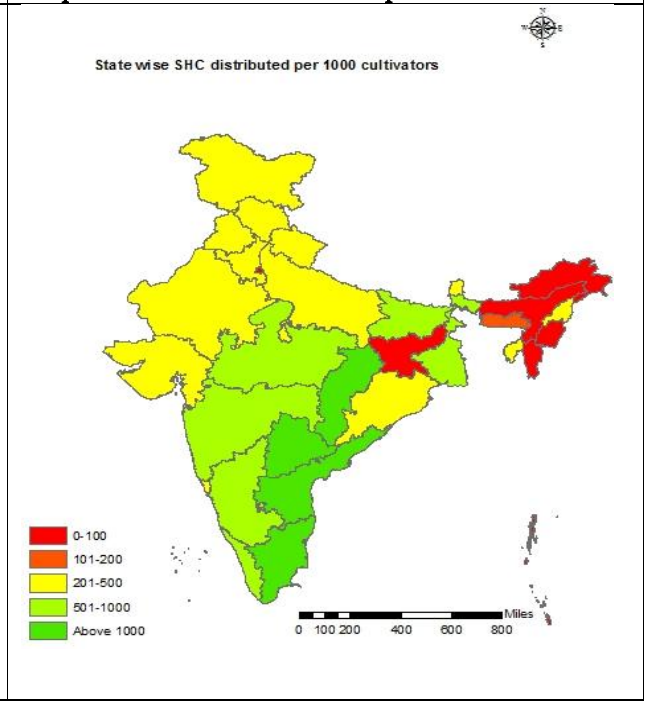
A comparison of Soil health cards printed per 1000 ha and per 1000 cultivators (Map 10) shows that there was a positive shift in Andhra Pradesh from light green (moderately high) to green (high), Telangana shifted from yellow (medium) to green (high). Gujarat and Madhya Pradesh shifted from low to medium, Haryana from medium to moderately high. Bihar has shifted from low to lowest (Map 9).

Map 10: State wise SHC printed per 1000 ha	Map 11: State wise SHC printed per 1000 cultivators
	

Soil Health Cards Distributed

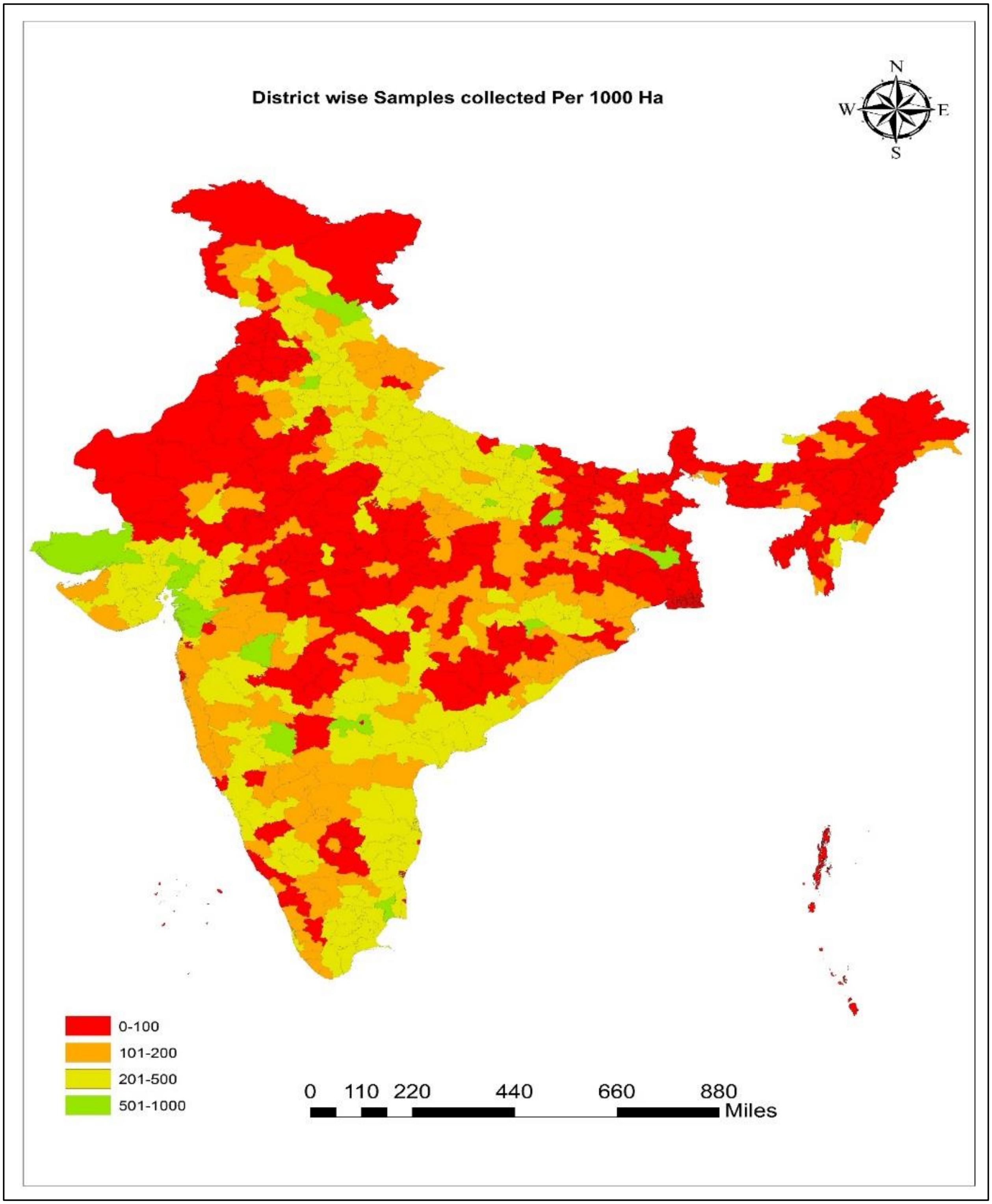
State wise SHCs distributed per 1000 ha can be seen from the map 11. It is observed that maximum number of SHCs distributed was in Kerala and Tamil Nadu (above 1000 SHCs distributed per 1000 ha). Andhra Pradesh, Chhattisgarh, Bihar, Himachal Pradesh and Uttarakhand also showed a positive result with 687-1001 SHCs distributed per 1000 ha. These states are followed by Karnataka, Telangana, Orissa, West Bengal, Uttar Pradesh., and North East states like Sikkim, Nagaland, and Tripura with 355-686 numbers of SHCs distributed per 1000 ha. Northern, Western and Northwestern states showed low range (74-354) of SHCs distributed per 1000 ha. Lowest number of SHCs i.e.0-70, were distributed in Assam, Arunachal Pradesh, Mizoram and Manipur.

When compared to SHCs distributed per 1000 ha, SHCs distributed per 1000 cultivators (Map 12) Maharashtra, Karnataka and Telangana shifted from yellow (medium) to light green (moderately high); Gujarat and Madhya Pradesh shifted from moderately low to medium; on the other hand, Kerala shifted from green (high) to yellow (medium), Bihar shifted from moderately low to low. Himachal Pradesh and Uttarakhand relative position also declined. Overall, the figures indicate that south India performed better followed by central and western India. The performance was poor in North East (Map 12).

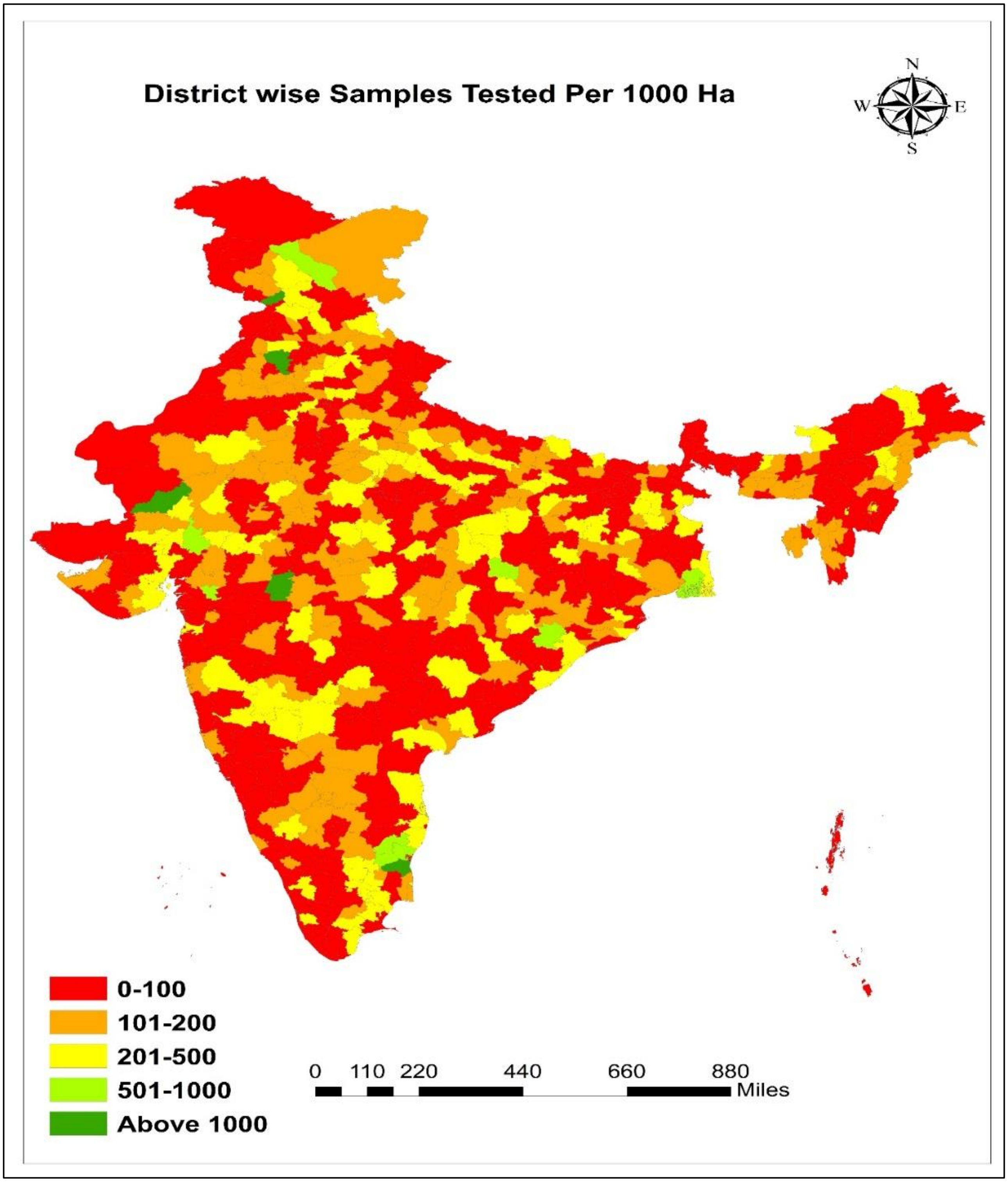
Map 12: State wise SHC distributed per 1000 ha	Map 13: state wise distributed per 1000 cultivators
	

District wise Samples collected, tested and printed

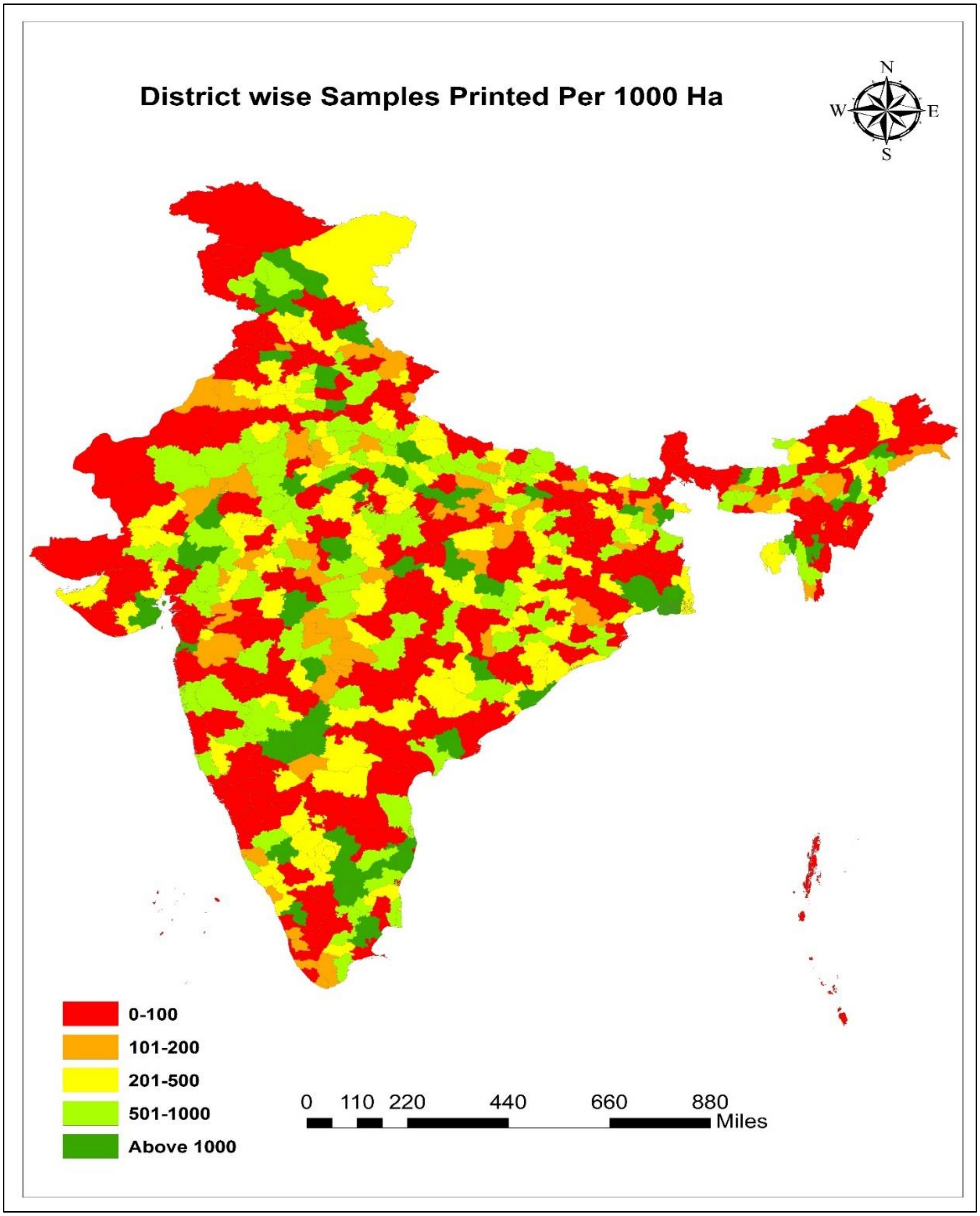
The district wise data on soil samples collected (Map 13), tested (Map 14) and printed (Map 15) shows that although south-central and western Indian districts performed better, there is much variation within states. Even some districts in most backward states like Bihar, Uttar Pradesh and North-East regions performed well, where as some districts in south India performed badly. It reflects the efficiency of district-level officers and other stakeholders. Besides, infrastructure also plays a greater role in the program.



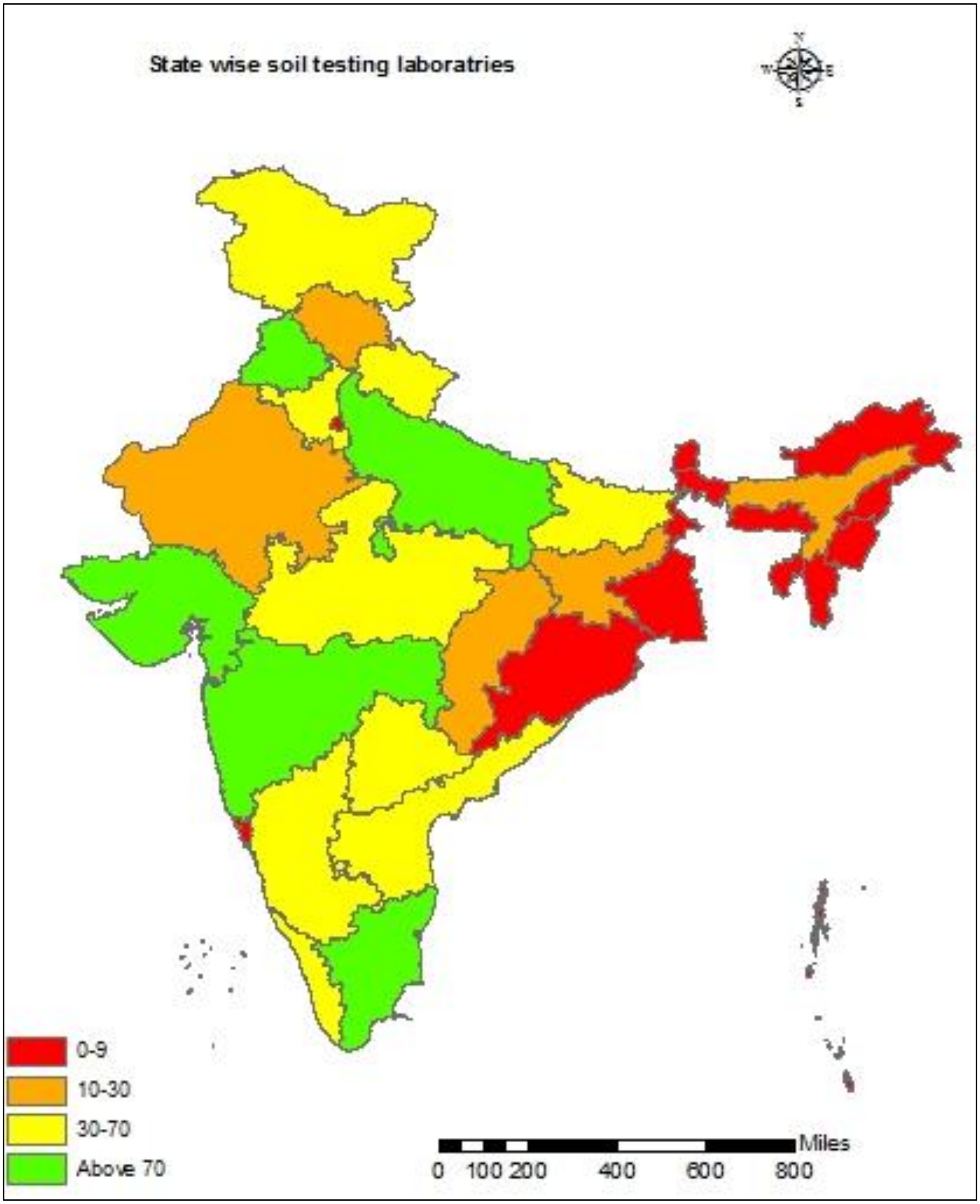
Map 14: District wise samples collected per 1000 ha



Map 15: District wise samples tested per 1000 ha



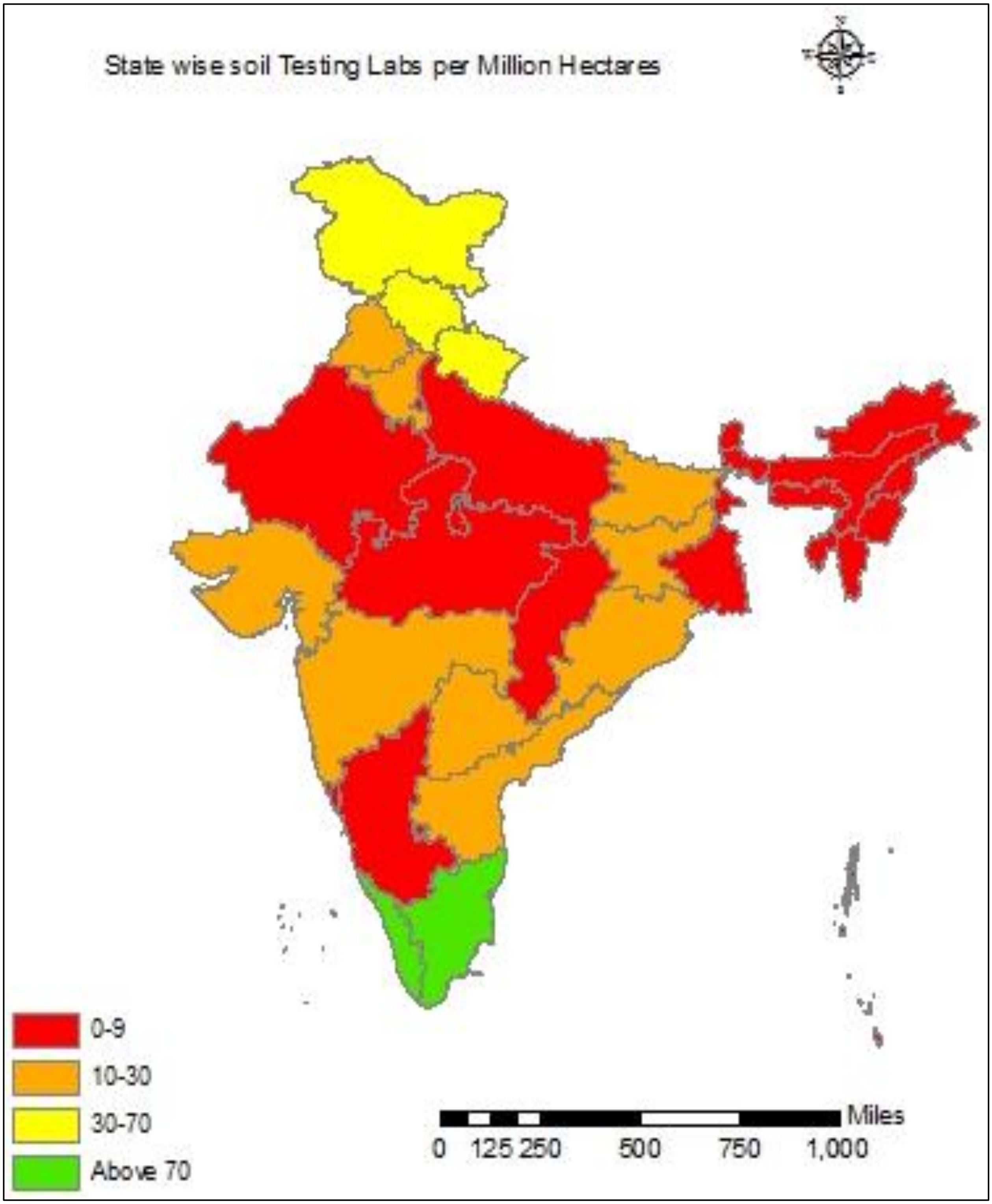
Map 16: District wise SHC printed per 1000 ha



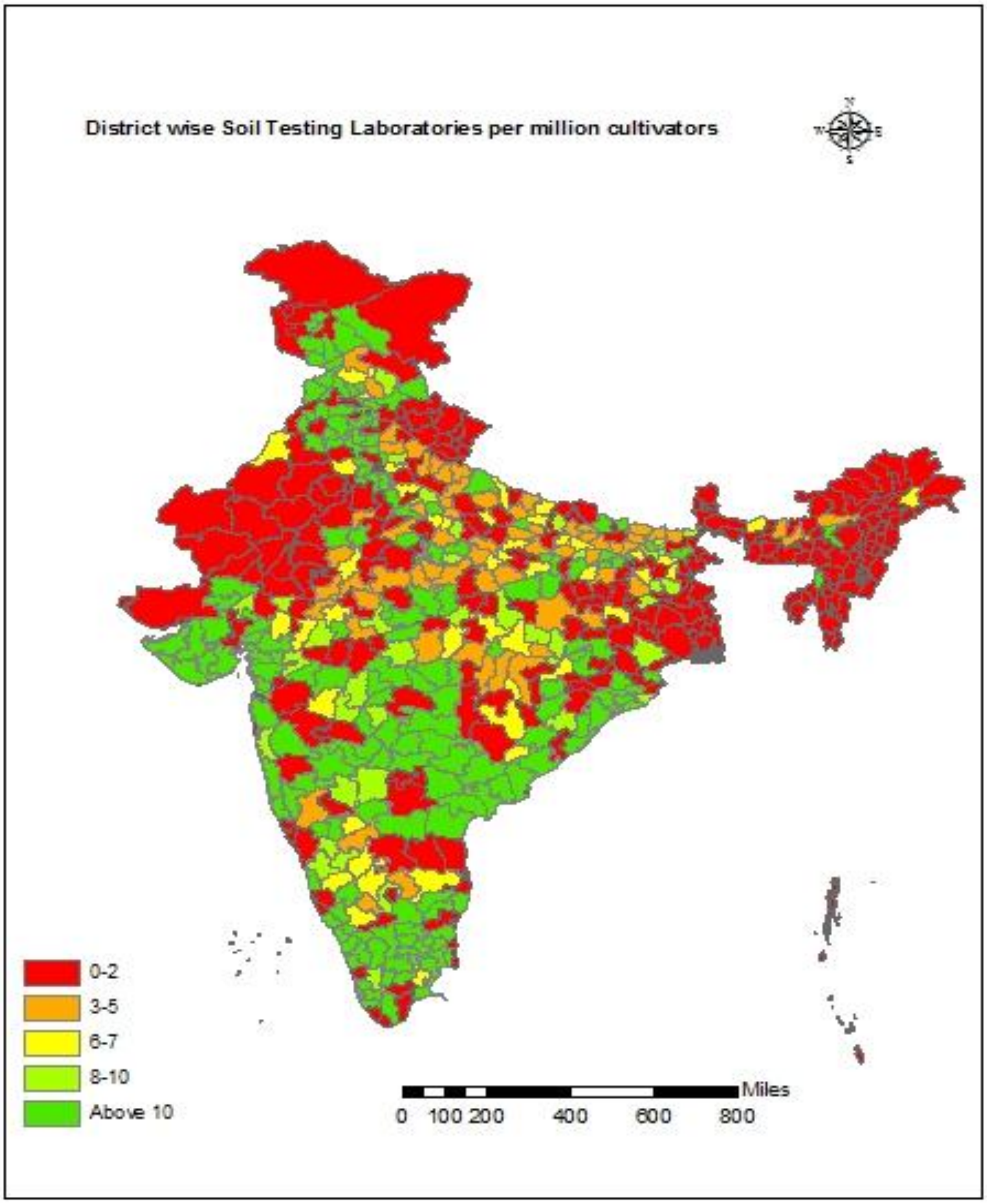
Map 17: State wise number of soil testing laboratories

State wise soil testing laboratories can be seen from the map 16. It is observed that highest number of soil testing labs are found in Maharashtra and Tamil Nadu with 156-344 number of labs. Gujarat and Uttar Pradesh stand second with 79-155 labs. Eastern (Chhattisgarh, Jharkhand and West Bengal) and North-Eastern states have the lowest number of (0-16 numbers) soil testing labs. Majority of the states like Telangana, Andhra Pradesh, Maharashtra, Karnataka, Orissa, Madhya Pradesh, Bihar, etc. have 42-78 labs (moderate range). Kerala, Himachal Pradesh, Uttarakhand and parts of Jammu & Kashmir have 17-48 labs (semi-moderate range).

A number of soil testing laboratories per million ha was given in map 17. It shows high density in Kerala, followed by Tamil Nadu, Himachal Pradesh, Jammu & Kashmir and Uttarakhand. Lowest density is in Rajasthan, West Bengal and North East. Density in Andhra Pradesh, Telangana, Maharashtra, Gujarat, Jharkhand, Bihar, Haryana and Punjab are medium. District wise labs are given in map 18. In a few districts of Tamil Nadu, Kerala, Gujarat, Andhra Pradesh, Himachal Pradesh, Punjab and Haryana soil testing lab density is high. However, many of the districts in north, central, eastern and north-eastern districts soil testing lab density are very low.



Map 18: State wise Soil Testing Labs per Million Hectares



Map 19: District wise STLs per million cultivators

5.2 Status of SHC (financial and human resource allocation)

In this section, the progress in implementing the SHC scheme is looked at from four important aspects viz., financial allocations, infrastructure, human resources and distribution of SHCs.

Allocations are increasing over the years. In 2014-15 allocation under the project was Rs.13.68 crores that were increased to Rs.88.53 crore in 2015-16 and reached Rs.169 crore in 2016-17. But the gap between allocation, release and expenditure is also increasing (Table 4A). North zone has the highest gap. This could be attributed to the low capacities to spend. It was observed during the field visits that the block and district level agricultural officers are involved in multiple-tasks assigned by state governments, hence there was a need to have separate staff for soil health card management, especially in setting up, up gradation and maintenance of soil testing labs. Field observations also indicated that there was the frequent transfer of staff in soil testing labs to field level and vice-versa. And postings in soil test laboratories is not a priority for many agricultural officers, although a few woman agricultural officers are interested in postings at STLs. To improve quality in soil testing there should be a separate cadre for working in soil testing labs. It was indicated that women agricultural officers are preferring working with STLs.

Table 4A: Financial Allocations and Expenditure

State-wise Funds Allocation, Released and Expenditure under Soil Health Cards Scheme in India (in lakhs)														
Zone	2014-2015			2015-2016					2016-2017*					
	Release	Expenditure	% Expenditure(Based on Release)	Allocation	Release	Expenditure	%Release(Based on Allocation)	%Expenditure(Based On Allocation)	Allocation	Release	Expenditure	%Release(Based on Allocation)	%Expenditure(Based on Allocation)
South	218	218	100	1250	811	811	64	64	2331	1165	697	50	29
North	389	371	95	2787	2005	492	71	17	5324	2442	0	45	0
West	440	396	90	3348	2424	1817	72	54	6235	3117	1544	50	24
East	234	219	93	1123	815	706	72	62	2274	407	88	17	3
North east	88	37	42	344	194	51	56	14	768	0	0	0	0
INDIA	1368	1241	91	8853	6248	3877	71	44	16932	7132	2329	42	14

Note:* until November 2016

Table 4B: Zone wise analysis of funds allocated, released and utilization

	2015-16			2016-17		
Zone	Allocation (Rs. Lakh)	Released as% of allocation	UC Pending as % of released	Allocation (Rs. Lakh)	Released as% of allocation	UC Pending as % of released
Central	2528	43	17	4593	98	78
Eastern	1094	77	58	2348	14	100
North	1844	48	35	3303	13	59
North-Eastern	292	64	0	1161	37	23
South	1996	56	4	3829	56	23
Western	1846	17	0	4056	42	32
Total	9600	46	23	19290	50	54

Source: Govt. of India letter dated 27th July 2017. There may be some mismatch between the table 4 and 4A, as 4A is updated one.

Table 4B shows that, overall only 46% of the fund allocated was released in year 2015016 and only 50% was released in year 2016-17. Utilization certificate was pending for 23% of the funds released in year 2015-16 and it is pending for 54% of the funds released in year 2016-17. In year 2015-16, fund release was better in eastern zone followed by north-east and north zones, while in year 2016-17 it was better in central and southern zones. The fund utilization needs to be increased across all the zones.

There are 1244 soil testing laboratories in India, of which 1048 are static and remaining 196 are mobile. About 90% are under state governments and the remaining are managed by the fertilizer industry. In addition, about 7000 mini-soil testing kits were distributed to block level agricultural offices across the states. The present analysing capacity is 1.78 crore samples per annum with a utilization of 75.8%. Number of Labs in India in 2016-17 is shown in Table 5.

While in terms of analyzing capacity (number of samples per annum), South zone is at the top with about 7.0 million samples per annum followed by North zone (5.4 million samples) and West zone (4.6 million samples). Among states, Tamil Nadu ranks first with 5.8 million samples followed by Uttar Pradesh (4.1 million samples), Maharashtra (4.1 million samples) and Gujarat (1.4 million samples).

Table 5: Infrastructure (number of Labs) in 2016-17

Zone/States/UTs	Number of Soil Testing Laboratories: State Govt.		Fertiliser Industry		Total			Analyzing Capacity	Number of Samples analyzed	Capacity % Utilisation
	Static	Mobile	Static	Mobile	Static	Mobile	Total	(`000 Nos.)	(`000 Nos.)	
East Zone	**105**	**37**	**1**	**2**	**106**	**39**	**145**	**959.4**	**769.2**	**80.2**
Arunachal Pradesh	5	3	-	-	5	3	8	9	7.9	87.3
Assam	7	4	-	-	7	4	11	84	60.8	72.3
Bihar	39	-	-	-	39	-	39	230	248.7	108.1
Jharkhand	8	-	-	-	8	-	8	40	10.7	26.7
Odisha	17	6	1	-	18	6	24	270	255.1	94.5
West Bengal	10	8	-	2	10	10	20	112	60.4	53.8
Manipur	4	4	-	-	4	4	8	40	1.4	3.4
Meghalaya	3	3	-	-	3	3	6	30	27.7	92.2
Nagaland	3	-	-	-	3	-	3	45	14.3	31.8
Sikkim	4	2	-	-	4	2	6	37	39.9	107.8
Tripura	2	4	-	-	2	4	6	35	17.5	50.1
Mizoram	3	3	-	-	3	3	6	27	25	92.6
North Zone	**377**	**45**	**9**	**6**	**386**	**51**	**437**	**5444**	**4198**	**77**
Haryana	35	3	2	-	37	3	40	365	247.9	67.9
Himachal Pradesh	11	4	-	-	11	4	15	125	124.4	99.5
Jammu and Kashmir	8	5	-	-	8	5	13	52	43.6	83.9
Punjab	54	12	2	3	56	15	71	631.5	282.1	44.7
Uttar Pradesh	255	18	5	3	260	21	281	4159.5	3404.6	81.9
Uttarakhand	13	3	-	-	13	3	16	106.5	95.2	89.4
Delhi	1	-	-	-	1	-	1	5	0.5	9.2
South Zone	**157**	**32**	**35**	**4**	**192**	**36**	**228**	**6727.4**	**5503.2**	**81.8**
Andhra Pradesh	55	5	27	1	82	6	88	413	345.8	83.7
Karnataka	56	-	6	2	62	2	64	295.7	194.8	65.9
Kerala	14	11	1	-	15	11	26	218	134.7	61.8
Tamil Nadu	30	16	1	1	31	17	48	5796.7	4823.5	83.2
Pondicherry	2	-	-	-	2	-	2	4	4.4	110.3
West Zone	**348**	**59**	**16**	**11**	**364**	**70**	**434**	**4695.4**	**3046.6**	**64.9**
Gujarat	132	2	4	1	136	3	139	1412	1199.1	84.9
Madhya Pradesh	50	7	2	4	52	11	63	378	346.5	91.7
Chhattisgarh	7	5	1	-	8	5	13	105	116	110.5
Maharashtra	123	23	8	4	131	27	158	2241.4	967.3	43.2
Rajasthan	34	22	1	2	35	24	59	536	402.7	75.1
Goa	2	-	-	-	2	-	2	23	15	65
India	**987**	**173**	**61**	**23**	**1048**	**196**	**1244**	**1,78,27**	**1,35,17**	**75.8**

Source: The Fertiliser Association of India. (16851); Andhra Pradesh Figures include Telangana

Capacity utilization is more than 90% in Chhattisgarh, Pondicherry, Bihar, Sikkim, Himachal Pradesh, Odisha, Mizoram, Meghalaya, Madhya Pradesh and Uttarakhand, but less than 50% in Manipur, Jharkhand, Nagaland, Maharashtra and Punjab. Low capacity utilization of funds and infrastructure could be due to lack of human resources. Since this is a new central scheme, state governments have taken time to streamline and coordinate the activities, especially in north and eastern zones. The performance is better in south and western zones. The better performance of southern and western zones is attributed to the efficient use of already existing skilled workers, labs and improvements in lab capacities especially setting up of mini-labs. Although focus group interactions reveal that the results of mini-labs are not as accurate as that of full-fledged labs.

Focus group interactions with local agriculture officers indicated that there was a severe shortage of infrastructure (labs) and skilled workers. Although, soil sample collection, testing and distribution of soil test values is done by multiple agencies (including KVKs, SAUs and ICAR and some private companies like Nagarjuna Fertilizers), under the SHC scheme burden is exclusively on state department of agriculture. Most of the soil sample collection work is being carried out by contractual agricultural extension officers who work under the block level agricultural officers. In developed states like Punjab, extension officers were provided with GPS-enabled tablets. There was no statistical database on the total staff involved in the soil sample collection and testing. As the soil sample collection was seasonal (only from April and May), all the staff below block level were engaged in the soil sample collection. Soil testing requires specialized labs and skills which are not widely available at the block level and hence sent to district level soil testing labs. Some estimates show that at the national level the gap between requirement and availability is -148 %. The gap is highest in South zone followed by west and north- east zones. The gap could be much higher if we include other activities as well i.e., after sample collection drying, grinding, sieving, etc. Soil sample collection should be done in a campaign mode, by involving the staff of all agricultural and allied department employees as it is exclusively done during April- May. While there is a need for developing separate soil testing cadre and strengthening district level soil testing labs with an estimated cost of Rs. 4-5 crore per district. Overall it requires Rs.2800 to set up one state-of-the-art lab in each of 700 districts in India. As field level observations indicated that the mini-lab results are not that reliable, takes a lot of time and they are also not suitable for large-scale testing. Mini-labs are more suitable in remote and tribal villages and also for analysis of highly volatile nitrogen and other major elements. They should complement rather than a substitute for full-fledged labs.

Under SHC scheme, the cropped area was divided into grids of 10 ha for rainfed and 2.5 ha for irrigated. One soil sample from each grid will be taken and test results will be distributed to all the farmers whose land falls under the grid. Based on the grid system, out of the total 14.1 crore hectare of net cropped area, 73 lakh grid samples to be collected to cover 7.3 crore ha area under rainfed situations and 2.7 crore grid samples to be covered to cover 6.8 crore ha irrigated land, with a total of 3.46 crore grid samples to be collected in two years i.e., 1.72 crore grid samples per year. On average this comes to 25000 grid samples per district/year or 29 grid samples per village/year. With this, all 14 crore farmers will be covered in two years.

Under cycle-1, 2.54 crore samples were collected, 2.36 crore samples tested, 9.62 crore soil health cards printed, but only 9.33 crore SHCs distributed. It indicates that 100% target archived in sample collection, 93% of the target achieved in soil testing, but only 80% of the target achieved in SHC printing. 97% of the SHCs printed were distributed among the farmers as on 24th September 2017 (Table 6A). The progress in samples collected, tested, printed and distributed in a short span is gigantic. However, the gap in number of farmers covered and number of SHC printed and distributed needs to be bridged with proper quality checks in all stages. The progress under cycle-II was given in table 6B.

Table 6A: Samples entered, farmers covered, samples tested and SHCs printed (Cycle-1)

(in Lakhs)

Sl.No.	State	Cumulative Target for Soil Samples Collection & Testing during Cycle-I (2015-16 & 2016-17)	No. of Samples Collected (Cycle-I)	% Progress of Soil Samples Collected (Cycle-I)	No. of Samples Tested (Cycle-I)	% Progress of Soil Samples Tested (Cycle-I)	Cumulative Target for Printing & Distribution of SHCs for Cycle-I (2015-16 & 2016-17)	No. of SHCs Printed (Cycle-I)	% Progress of SHCs Printed (Cycle-I)	No. of SHCs Distributed (Cycle-I)	% Progress of SHCs Distributed (Cycle-I)
Group - I											
1	Uttar Pradesh	47.7	47.7	100	39.34	82	233.25	106.24	46	106.24	100
2	Maharashtra	23.5	23.5	100	23.47	100	129.77	129.77	100	129.77	100
3	Madhya Pradesh	23.1	23.1	100	23.14	100	88.72	88.72	100	88.72	100
4	Rajasthan	23.1	23.1	100	23.08	100	68.86	69.56	101	68.67	99
Group - II											
1	Karnataka	16.7	16.7	100	16.66	100	78.32	78.32	100	78.32	100
2	Gujarat	15.9	15.9	100	15.89	100	51.09	48.61	95	48.61	100
3	Andhra Pradesh	13.5	13.5	100	13.48	100	74.55	74.55	100	74.55	100
4	Bihar	13.1	13.1	100	10.85	83	72.36	48.02	66	48.02	100
5	West Bengal	13.0	13.0	100	13.00	100	50.41	41.08	81	41.00	100
6	Tamil Nadu	12.7	12.7	100	12.75	100	70.00	70.00	100	70.00	100
7	Telangana	10.3	10.3	100	10.35	100	57.21	57.21	100	57.21	100
Group - III											
1	Punjab	8.4	8.4	100	4.11	49	46.20	8.59	19	8.52	99
2	Haryana	7.9	7.9	100	7.89	100	43.61	28.92	66	16.35	57
3	Chhattisgarh	7.0	7.0	100	7.04	100	38.91	41.14	106	38.91	95
4	Odisha	6.7	6.7	100	6.69	100	36.97	32.16	87	24.03	75
Group - IV											
1	Kerala	1.3	1.3	100	1.28	100	7.05	7.05	100	7.05	100
2	Goa	0.3	0.3	100	0.25	100	0.25	0.20	81	0.20	100
3	Uttarakhand	1.4	1.4	100	1.36	100	7.50	7.50	100	7.50	100
4	HP	0.7	0.7	100	0.70	100	3.85	5.43	141	3.85	71
5	J & K	1.7	1.7	100	1.40	85	9.14	5.11	56	2.50	49
6	Jharkhand	1.2	1.2	100	1.15	100	6.38	6.38	100	5.23	82
7	Arunachal Pradesh	0.2	0.2	100	0.19	93	1.14	0.14	12	0.11	80
8	Assam	2.8	2.8	100	0.85	30	15.41	1.74	11	1.58	91
9	Manipur	0.2	0.2	100	0.06	31	1.15	0.06	5	0.05	90
10	Meghalaya	0.4	0.4	100	0.39	100	2.10	2.10	100	2.10	100
11	Mizoram	0.1	0.1	100	0.10	86	0.12	0.08	69	0.08	100
12	Nagaland	0.3	0.3	100	0.33	100	1.85	1.85	100	1.85	100
13	Sikkim	0.1	0.1	100	0.13	100	0.46	0.46	100	0.46	100
14	Tripura	0.3	0.3	100	0.33	100	1.18	1.18	100	1.18	100
Union Territories											
1	Andaman & Nicobar	0.01	0.01	100	0.01	100	0.08	0.02	27	0.02	90
2	Dadra & Nagar Haveli	0.02	0.02	100	0.02	100	0.12	0.00	0	0.00	
3	Puducherry	0.04	0.04	100	0.04	100	0.20	0.20	100	0.20	100
Total		254	254	100	236	93	1198	962	80	933	97

Table 6B: Samples entered, farmers covered, samples tested and SHCs printed (Cycle-2)

(In Lakhs)

Sl.No.	State	Target for Soil Samples Collection & Testing during Cycle-II (2017-18)	No. of Samples Collected (Cycle-II)	% Progress of Soil Samples Collected (Cycle-II)	No. of Samples Tested (Cycle-II)	% Progress of Soil Samples Tested (Cycle-II)	Target for Printing & Distribution of SHCs for Cycle-II (2017-18)	No. of SHCs Printed (Cycle-II)	% Progress of SHCs Printed (Cycle-II)	No. of SHCs Distributed (Cycle-II)	% Progress of SHCs Distributed (Cycle-II)
Group - I											
1	Uttar Pradesh	23.85	12.67	53	3.44	14	116.63	1.96	2	1.96	2
2	Maharashtra	11.74	14.31	100	6.87	59	64.89	3.57	6	3.57	6
3	Madhya Pradesh	11.57	6.63	57	2.93	25	44.36	8.82	20	8.80	20
4	Rajasthan	11.54	6.40	55	0.00	0	34.43	0.00	0	0.00	0
Group - II											
1	Karnataka	8.33	4.27	51	3.21	39	39.16	5.81	15	2.32	6
2	Gujarat	7.95	8.14	100	0.18	2	25.54	0.00	0	0.00	0
3	Andhra Pradesh	6.74	2.54	38	2.54	38	37.28	10.12	27	10.12	27
4	Bihar	6.54	2.20	34	0.94	14	36.18	2.12	6	2.12	6
5	West Bengal	6.50	2.99	46	0.90	14	25.20	2.79	11	0.00	0
6	Tamil Nadu	6.37	6.40	100	3.09	48	35.00	0.00	0	0.00	0
7	Telangana	5.17	4.01	78	0.76	15	28.60	0.00	0	0.00	0
Group - III											
1	Punjab	4.18	1.15	27	0.00	0	23.10	0.00	0	0.00	0
2	Haryana	3.94	2.77	70	0.04	1	21.80	0.04	0	0.02	0
3	Chhattisgarh	3.52	3.10	88	1.90	54	19.45	4.56	23	4.08	21
4	Odisha	3.34	1.80	54	0.83	25	18.48	0.91	5	0.76	4
Group - IV											
1	Kerala	0.64	0.00	0	0.00	0	3.53	0.00	0	0.00	0
2	Goa	0.13	0.07	54	0.04	36	0.13	0.04	34	0.04	34
3	Uttarakhand	0.68	0.44	65	0.31	46	3.75	0.69	18	0.51	14
4	Himachal Pradesh	0.35	0.43	100	0.42	100	1.93	2.42	100	2.42	100
5	J & K	0.83	0.05	6	0.00	1	4.57	0.00	0	0.00	0
6	Jharkhand	0.58	0.47	81	0.34	58	3.19	0.55	17	0.55	17
7	Arunachal Pradesh	0.10	0.00	0	0.00	0	0.57	0.00	0	0.00	0
8	Assam	1.39	0.00	0	0.00	0	7.70	0.00	0	0.00	0
9	Manipur	0.10	0.00	0	0.00	0	0.57	0.00	0	0.00	0
10	Meghalaya	0.20	0.12	61	0.09	45	1.05	0.30	29	0.25	24
11	Mizoram	0.06	0.00	7	0.00	0	0.06	0.00	0	0.00	0
12	Nagaland	0.17	0.01	4	0.01	3	0.92	0.00	0	0.00	0
13	Sikkim	0.07	0.00	0	0.00	0	0.23	0.00	0	0.00	0
14	Tripura	0.16	0.07	43	0.05	31	0.59	0.02	3	0.02	3
Union Territories											
1	Andaman & Nicobar	0.01	0.01	81	0.00	47	0.04	0.00	0	0.00	0
2	Dadra & Nagar Haveli	0.01	0.00	0	0.00	0	0.06	0.00	0	0.00	0
3	Puducherry	0.02	0.03	100	0.01	79	0.10	0.00	0	0.00	0
Total		126.8	81.1	64	28.9	23	599.1	44.7	7	37.5	6

5.3 Farmers feedback on design

The design of SHCs needs to be looked at from the coverage and intensity of soil testing. Coverage means, at what scale the samples are taken and how representative they are in identifying the variations in soil quality. In the case of intensity, what are the parameters covered while testing the soils? While farmers would benefit more from a comprehensive SHC that is more representative of their plots and covers all the important aspects of soils, it could be time-consuming and expensive from the administrative side. More soil indicators mean more sophisticated STLs and better equipment and skilled personnel.

Soil experts and farmers feel that the present scale (2.5 ha grid for irrigated areas and 10 ha grid for the rainfed area) is not representative of all the soil types. Given the high fragmentation in India, each farmer may have number of fragments that too not at one place, farmers want more soil samples to be collected and tested so that they can rely on the recommendations. Number of soil samples per unit area should be based on soil variability. In most of the developed countries, soils are tested as per the requirement by crop.

It is also observed in the field that the norms prescribed in the SHC scheme are not followed due to various reasons. The timing of soil sampling and the methods of sampling are not adopted in number of cases. Moreover, the time taken for sample collection and its testing in the lab (although it improved after SHC scheme) is much longer than usually prescribed. This results in samples losing their characters due to exposure. Hence, the accuracy of the tests and the recommendations prescribed may not be reliable. In some areas, SHC are not provided to all the farmers. Besides, it is observed that SHCs are not provided in time. Lack of accuracy along with the absence of timely provision of recommendations has affected the credibility of the SHC among farmers. Lack of skilled staff, equipped laboratories and other infrastructure is the main reason for these shortcomings in the scheme (for details see appendix on soil health and soil testing and field observations and also opinion expressed by different stakeholders).

A comparison of indicators included in SHC in India with other countries like the USA (across its states) indicates that only nutrient availability along with some physical soil characters like PH and EC are included in India while number of states in USA use many other indicators like physical, topography, water, soil indicators, biological indicators and nutrient holding capacity (Table 7). Some of these indicators like water quality, soil erosion, slope, crop residue, etc., are very important for proper soil management. Experts feel that soil texture, direction of slope, water quality, irrigation source, cracks on soil surface, depth of the soil, crop residues can be included in the Soil Health Card. However, cost may be an issue, but in case of some aspects like irrigation source, depth of soil, etc. could be collected from general observation and through the farmer's knowledge about his farm. Importance of including water test in the SHC can be seen in Fig. 5.

Fig. 5: Importance of including water test in the SHC

Salt effected irrigation water | Normal irrigation water

Table 7A: Indicators mentioned in SHCs in different states of USA

	Indicators in soil health card		Countries/states/companies													
			India	USA states												
				Connecticut	Georgia	Idaho		Palouse & Nezpere prairies	North-eastern Illinois	Maryland	Mon Dak	Nebraska	Pennsylvania	Northern rivers area	Cornell university comprehensive assessment of soil health	(private company)
1	Nutrients availability															
A	Macro	N:P:K	Yes	-	-	Yes	Yes	-	-	-	-	-	-	-	Yes	yes
B	Secondary	Sulphur	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-
C	Micro	Zn, Fe, Cu, Mg, B	Yes	-	-	-	-	-	-	-	-	-	-	-	Yes	Yes
D	Physical characteristics	pH	Yes	-	Yes	-	Yes	-	-	Yes	-	-	-	Yes	Yes	Yes
		Ec	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-
		Soil structure	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	-
		Soil slacking	-	-	-	Yes	-	-	-	-	-	-	-	Yes	-	-
		Soil erosion	-	-	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
		Organic carbon	Yes	-	Yes	-	-	Yes	-	Yes	-	Yes	Yes	-	Yes	yes
2	Recommended NPK ratio crop wise		Yes	-	-	-	- -	-	-	-	-	-	-		-	Yes
3	General recommendations	Organic manure	Yes	-	-	-	Yes	-	-	-	-	-	-	-	-	Yes
		Bio fertilizer	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-
		Lime/gypsum	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Topography	Direction of slope	-	Yes	-	-	-	-	-	-	-	-	-	-	-	-
5	Water	Water quality	-	Yes	-	-	-	-	-	-	-	-	-	-	Yes	-
		Irrigation source	-	Yes	-	-	-	-	-	-	-	-	-	-		-
		Water holding capacity	-	Yes	-	-	yes	-	-	Yes	-	Yes	Yes	-	Yes	-
		Infiltration	-	-	-	-	-	Yes	-	-	Yes	Yes	-	Yes		-
6	Soil indicators	Cracks on soil surface	-	Yes	-	-	-	-	-	-	-	-	-	-	yes	-
		Depth of soil	-	Yes	-	-	-	-	-	-	-	-	-	-	yes	-
		Depth and colour of	-	Yes	-	-	-	-	-	-	-	-	-	-		-

		topsoil layer														
		Moisture of soil 2 days after heavy rain	-	**Yes**	-	-	-	-	-	-	-	-	-	-		-
		How moist soil particles hold together	-	**Yes**	-	-		-	-	-	-		-	-		-
		Rooting system	-	**Yes**	-	-	**yes**	**Yes**	**Yes**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	-
		Soil respiration	-	-	-	-	**yes**	-	-	-	-	-	-	-	**Yes**	-
7	Biological indicators	biological activity	-	**Yes**	**Yes**	**Yes**	-	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
		Crop residue	-	-	**Yes**	**Yes**	-	**Yes**	-	**Yes**	**Yes**	**Yes**	-	-		-
8	Nutrient holding capacity		-	-	-	-	-	-	-	**Yes**	-	-	-	-		**Yes**
	Autoclave-Citrate Extractable (ACE) Protein Test		-	-	-	-	-	-	-	-	-	-	-	-	**Yes**	-
	Cost		**free**				-								**$110/sample**	**$50/sample**

Table 7B: Indicators mentioned in SHCs in different countries

Indicators in soil health card			Australia				Bangladesh	China	Africa	Vietnam	
1	Nutrients availability		**Yes(only N)**	**Yes(only N)**	**Yes(only N)**	**Yes(only N)**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
A	Macro	N:P:K	-	-	-	-	**Yes**	-	-	**Yes**	
B	Secondary	Sulphur	**Yes**	**Yes**	**Yes**	**Yes**	-	-	-	-	
C	Micro	Zn, Fe, Cu, Mg, B					**Yes (only B)**	-	**Yes**	-	
			Yes	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
D	Physical characteristics	pH	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	-	-	**Yes**
		Ec	-	-	-	-	-	-	-	**Yes**	
		Soil structure	-	-	-	-	-	-	-	-	
		Soil slacking	-	-	-	-	-	-	-	**Yes**	
		Soil erosion	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
		Organic carbon	-		-	-	-	-	-	-	
2	Recommended NPK ratio crop wise					-	-	-	-	-	
			Yes	**Yes**	**Yes**	**Yes**	**Yes**	-	-	**Yes**	
3	General recommendations	Organic manure	-	-	-	-	-	-	-	-	
		Bio fertilizer	-	-	-	-	-	-	-	-	
		Lime/gypsum	-	-	-	-	-	-	-	-	
4	Topography	Direction of slope	-	-	-	-	-	-	-	-	

5	Water	Water quality	-	-	-	-	-	-	-	-	
		Irrigation source	**Yes**	**Yes**	**Yes**	**Yes**	-	-	-	**Yes**	
		Water holding capacity					-	-	-	-	
		Infiltration	-	-	-	-	-	-	-	-	
6	Soil indicators	Cracks on soil surface	-	-	-	-	-	-	-	-	
		Depth of soil	-	-	-	-	-	-	-	-	
		Depth and colour of topsoil layer	-	-	-	-	-	-	-	**Yes**	
		Moisture of soil 2 days after heavy rain	-	-	-	-	-	-	-	-	
		How moist soil particles hold together	-	-	-	-	-	-	-	-	**Yes**
		Rooting system	-	-	-	-	-	-	-	-	
		Soil respiration	**yes**	**yes**	**yes**	**yes**	-	-	-	**Yes**	
7	Biological indicators	biological activity	-	-	-	-	-	-	-	-	
		Crop residue	-	-	-	-	-	-	**Yes**	-	
8	Nutrient holding capacity		-	-	-	-	-	-	-	-	
	Autoclave-Citrate Extractable (ACE) Protein Test						-	-	-	-	
	Cost										

5.4 Design in different states.

Bhoochetana in Karnataka

The Government of Karnataka has initiated a novel mission mode project '*Bhoochetana*' from the year 2009-10 with the mission goal of increasing average productivity of soil by 20%. The consortium partners of the project are Karnataka State Department of Agriculture, Watershed Development Department, UAS, Bangalore/ Dharwad/Raichur while ICRISAT Hyderabad is the technical consultants.

Main strategies: Soil test based nutrient management with a major thrust to micro-nutrients, distribution of inputs at 50% subsidy at cluster village level, services of farmer facilitators for transfer of technology, farmer field schools, wide publicity through wall writings, posters, village meetings & mass media, effective project monitoring and feedback.

Under *Bhoochetana*, stratified soil sampling method was used. Districts were divided into three topo-sequences. At each topo-sequence location, samples were taken proportionately from small, medium and large farm-holding farmers' fields to represent different soil colour, texture, cropping system and agronomic management.

Soil sampling was not done for all the farmers in the village, but collected from only about 20% of the farmers and the soil sample size was based on the soil variability index with larger number of samples from higher variability index and fewer number from lower variability index to economize on costs without losing relevance of soil test results to farmers. Test procedures were done accurately and in a timely manner. In addition, they have supplied the micro-nutrients like S, Mg and B at 50% subsidy, if they are deficient in soils.

Project implementation started during *Kharif* 2009-10 in 6 districts covering 2.25 lakh hectares, 1440 villages and 2 lakh farmers. The *rabi* area coverage during 2009-10 was 0.59 lakh Ha. An enhancement in yields of 33-45% is observed in the treated areas. The project was extended to 16 districts during 2010-11 covering 12.0 lakh hectares during *Kharif* season, 5030 villages and 8.50 lakh farmers. The *rabi* area coverage during 2010-11 was 3.32 lakh Ha. An enhancement in yields of 21-41% was observed in the treated areas. During 2011-12 *Kharif*, *Bhoochetana* programme was implemented in all 30 districts covering 25.4 lakh hectares in 13800 villages covering 20 lakh farmers. The *rabi* area coverage during 2011-12 was 5.40 lakh Ha. An enhancement in yields of 29-41% was observed in the treated areas. The programme was extended to 50 lakh ha of a dry-land area and 5 lakh ha of a irrigated area during 2012-13. By the fourth year, the project reach was to 26,000 villages covering 42 lakh farmers. There was a considerable area coverage during *rabi* season also, i.e.,27 lakh ha during 2012-13. An enhancement in yields of 11- 37% is observed in the treated areas.

IFPRI Bihar randomized experiment of SHC design

International Food Policy Research Institute (IFPRI) conducted a randomized controlled trial in Bihar to understand the effectiveness of the soil health cards on farmers' incomes in an experimental basis before SHC scheme of government of India. They found no evidence of any impact of soil testing and customized fertilizer recommendations on actual fertilizer use or the willingness to pay for the soil testing services. The study was conducted by the Department of Soil Science of Rajendra Agricultural University (RAU), Bihar and IFPRI. The three possible explanations for the lack of response are:

a) Farmers simply did not understand the content of the SHC; we should not expect farmers to change their behavior on the basis of recommendations that they do not understand.

b) Farmers understood the contents of the SHC, but did not find the soil analysis and fertilizer recommendations to be reliable or compelling.
c) Farmers did in fact internalize recommendations, and the information did alter their preferred fertilizer mix, but other factors (such as cost, liquidity, or timely availability of specific fertilizers) prevented them from acting on these preferences by shifting their actual application.

5.5 Needed improvements in the design of SHC scheme

The Scheme

Soil health card is field-specific detailed report of soil fertility status and other important soil parameters that affect crop productivity. Besides soil health, it provides an advisory on soil test based use of fertilizers and amendments. As per the design, soil health assessment of farmer fields will be taken up once in two years and soil health cards are issued. Districts, blocks and villages within them will be selected in such a way that an action plan is in place to cover them every two years. The nodal soil test lab shall prepare timelines for scheduling the soil health cards in the district in phases. The year wise coverage of number of *talukas* / blocks may be prepared so that a continuous soil analysis takes place every two years.

Selection Process: The State Governments will prepare yearly action plan indicating number of districts to be covered, number of irrigated holdings and rainfed holdings in the selected districts, number of soil samples to be drawn from irrigated holdings and number of samples to be drawn from rain-fed holdings and finally total number of samples to be drawn and tested. Soil sample collection should be done during summer months, when there was no standing crop. In most of the cases, this window was open only in April and May, just 60 days. Hence, all the sample collection should be completed within these two to three months and the sample test results should reach farmers by July. But, generally it is taking six months to nine months to issue soil health cards. And one season will be over by the time the test results come in. This needs to be rectified and the soil test results should reach farmers before the onset of monsoon so that they can plan for cropping pattern and fertilizer use.

Agencies: a) Agriculture Department staff; b) Science Colleges and students and its soil testing/chemistry laboratory staff; c) State Agricultural Universities and its soil testing staff. Soil testing is to be outsourced to private agencies through tender wherever feasible (based on the technical and financial bids: price quoted for one sample test). Science Colleges could be nominated with a provision of providing equipment. Directly aiding for setting up soil testing laboratories is another option. Many farmers expressed faith in private soil testing laboratories as they maintain quality and timely distribution of test results. But only a few farmers are willing to pay for soil tests. Hence there was a need for promoting Public-Private Partnership mode of soil testing labs at different locations. In this, investments may be by private sector with subsidy component from government towards payments for testing (per sample basis). The rate per sample is determined in a competitive bidding process from the technically qualified labs that employ qualified and trained chemists. Though this system is currently working, there is need for increasing competitiveness among private institutions to maintain quality at reasonable cost. Farmer Producer Organizations need to be encouraged to participate in the bidding process through special incentives.

Sampling norms: The quality of soil testing results and fertilizer recommendations depend upon soil sampling. For this, following scientific norms are prescribed:

i. In the irrigated areas, samples will be drawn in a grid of 2.5 ha. In rainfed areas, sampling will be drawn in a 10ha grid.
ii. In irrigated areas, large, medium and semi-medium holdings will be sampled and tested holding-wise. In case of marginal and small holdings sampling in a 2.5 ha grid will be followed. However, field observations indicated that only one sample is taken and tested per grid and the same results are printed on SHCs of all grid farmers.
iii. In rainfed areas, all the large holdings will be sampled and tested. In case of medium, semi-medium, small & marginal holdings will be sampled and tested in a 10ha grid. Here also field observations indicated that only one sample per grid is taken and tested. Sample was collected from 3-4 locations in the grid and pooled for testing.
iv. The ideal time for collection of soil samples is between sowing/planting of other crop i.e., when fields are vacant. It is mostly in the months of March to June. In many locations this window was open just for two months, April and May. Many times samples were taken on buds, only road side plots are covered without following proper sampling framework. However, to meet the target, sample collection should be done in campaign mode by

involving agriculture and allied departments, science collages and village youth. Agricultural department should monitor the programme closely for maintaining quality of samples collected.

v. The sampling depth for field crops should be at 0 to 15 cm.

vi. Samples have to be collected preferably with the help of stainless steel tube augur, or with a *khurpi* / spade or *kassi*.

vii. A brief training to the soil sampling staff/students/farmers/field extension machinery would be necessary to ensure collection of representative soil sample, their labeling and transport to the STLs. Field observations indicated that samples collected were kept idle for months. They need to be properly dried, sieved, packed and labeled within time to avoid exposure to atmosphere.

viii. GPS co-ordinates have to be essentially recorded at the time of soil sampling which will be downloaded in the STL computer. It is also important to adopt a computerized pre-determined grid system with randomized sampling points as adopted by Punjab agricultural department. Punjab agricultural department distributed tablets with a software application, in which pre-determined grids mapped in a GPS-enabled software for identification of grids in the fields and taking random samples within the grid. This will reduce human error in sampling and collection.

ix. The target villages will use stratified sampling techniques. Samples will be collected from marginal, small and large farms to address variations that arise due to different management practices. Within each farm size class, samples will be chosen to represent all possible soil fertility variations.

x. The focus group discussions and key informant interviews indicated that the uniform gird size is not taking into account differences in variation in soil types and cropping pattern. The grid size should be larger if there is less variability in soils and vice-versa. This will not only represent soil types based on statistical principles and also reduce costs and workforce. Some studies show that covering 20-30% of the farmers or 20-30 samples per 500 ha is enough for reasonable soil test values, if sample is collected scientifically.

xi. There is a need for introducing flexible mechanism to grid sample size according to the variability in soil fertility index. In this regard soil fertility variability maps should be developed for each village. Based on this, grid size should be reduced in low variability villages and increased in high variability villages. In this way, the collected samples will represent the farmer’s actual soil conditions with little sampling error and work burden on the local staff can be reduced to some extent and representativeness of soil samples can be enhanced, which is crucial for increasing confidence of farmers in the SHC.

Soil analysis: Soil samples should be processed following standard procedures and analyzed for various parameters namely pH, electrical conductivity (EC), Organic Carbon(OC), available N, P, K, S and micronutrients (Zn, Cu, Fe, Mn & B). However, only a few soil testing laboratories were having facilities for micro-nutrient tests. In some laboratories instruments are outdated and take much time for analyzing N, P and K only. There were frequent power cuts and some are not in working condition. In some of the laboratories there was a shortage of chemical reagents to test for basic elements like NPK. In the recent years, state departments procured mini-soil testing kits. In some of the block agricultural offices/labs, five to six mini-kits were procured, but the agricultural extension officers are too busy with multiple-tasks and hardly have any time to test soil samples. It was observed that soil testing through mini-kits are time-consuming and test results are not as accurate as that of full-fledged-labs. Hence, in addition to the department soil testing labs, involving science colleges having soil testing laboratories were assigned the task of soil testing. This is a good decision for the timely and accurate dispatch of soil test results to farmers. The students are doing the work of soil testing under the guidance and supervision of professors. To overcome staff shortage with the state government agricultural department, private agencies were engaged with the competitive bidding process. Field observations indicated that, although some private companies are maintaining quality, some are not. There was a need for proper monitoring and evaluation of the work of private companies. Alternatively, contractual staff can be employed for testing of soil samples. The soil analysis has to be completed within 3 weeks of receipt of soil samples in the STL. It was observed in the field visits, that the process of drying, grinding of soil and bottling, etc. are not followed properly by many soil testing labs. There was an inordinate delay in sample testing up to six to nine months. This needs to be rectified to increase the confidence of the farmers in SHC.

There was a significant gap between farmers covered and SHCs distributed. The awareness camps, campaigns and *Kisan Melas* should be the main channel for the distribution of SHCs as it will achieve two goals of handing over the SHCs and explaining how to use SHC simultaneously. It was observed that SHCs were distributed by agricultural officers through village democratically elected president or block level elected representatives in campaigns and through village revenue assistant or by post/online. It was observed that whenever the SHC is distributed by elected representatives after explaining the content, farmers feel that they understood the utility of the cards and follow recommendations.

Soil Health Card*:* SHC contains information regarding soil fertility and provided recommendations on fertilizer application on crops and soil amendments required in the case of saline or alkaline soils. And suggestions are made regarding integrated nutrient management. Based on the soil analysis:

i. Fertilizer recommendations will be developed, considering the available infrastructure/financial resources for the small holders.
ii. The critical values for delineating deficiency levels will be tested and doses recommended for applications.
iii. Soil test based applications for removing deficiencies will be standardised as a component of agronomic practice for the selected crops.
iv. Time lines will be determined by nutrient status mapping based on soil fertility analysis and productivity enhancement through the application of deficient nutrients. Data will be developed for diagnostic soil analysis and deficient fields in each district. Nutrient recommendations will be prepared for *Kharif* and *rabi* crops separately. Block wise fertilizer dosage adjusted for soil test nutrient status for various crops will be developed.

Cross Checking*:* Mechanisms are put in place for random checking of 1 % of the total samples will be analyzed by external agencies for ensuring the quality of soil analysis. A team of Deputy Director of Agriculture (Ext.), District Agriculture Officer, Assistant Director of Agriculture (STL) and a Soil Scientist from SAU/ ICAR would jointly monitor, inspect and evaluate the functioning of STLs / other concerned agencies pertaining to the issue of soil health cards to the respective districts. The joint certificate will be issued from District Agriculture Officer, *Sarpanch* and *Gram Sevak* regarding satisfactory sample collection work. And, the list of farmers whose soil sample has been collected will be displayed at Gram Panchayat Office.

At district level, one state-of-the-art soil testing lab needs to be developed either by the public or private agency, which will be accredited by an international agency. This lab should act as referral lab and develop block wise soil fertility maps to determine the grid size in each block.

5.6 Socio-economic characteristics of the sample farmers

The basic socio-economic background of the sample farmers are given in Table 8. Overall, share of small and marginal farmers is 38.2%, SC/ST farmers is 22.1%. the region wise differences in the share of small and marginal framers is given in the table.

Table 8: Basic Features of the Sample Households (HH)

Region/ State	Sample Size (no.)	Coverage of social groups (% SC/ST)	Coverage of Economic Groups			Average Farm Size (acres)
			% of S&MF	% of Medium farmers	% of Large Farmers	
Central	320	12.7	20.9	43.9	35.2	7.5
East	240	51.4	78.7	21.3	0.0	1.7
North east	448	55.4	47.0	51.0	2.0	3.1
North	864	15.1	25.9	27.1	47.0	8.3
South	800	12.7	28.1	56.7	15.2	4.7
West	512	8.0	51.0	42.5	6.5	3.0
Total	3184	22.1	38.2	41.3	20.4	5.1

Note: S&MF= Small and Marginal farmers (<2.5 acres); Medium Farmers= 2.5 to 7.5 Acres; Large Farmers= > 7.5 acres

Table 9: Basic Features of the Sample Households (HH) by irrigation status

% irrigated group	Coverage of social groups (% SC/ST)	Coverage of Economic Groups			Average Farm Size (acres)
		% of S&MF	% of Medium farmers	% of Large Farmers	
Less irrigated	27.0	26.8	58.5	28.0	4.6
Medium irrigated	54.4	14.0	66.7	18.7	4.8
Mostly irrigated	17.9	56.8	34.4	42.8	6.0
All	22.1	49.0	41.3	38.2	5.1

Note: less irrigated (less than 50% of the total area irrigated); medium irrigated (50 to 80%); mostly irrigated (more than 80% of total area is irrigated).

The study grouped farmers based on share of irrigated area in total area (Table 9). Farmers who possess less than 50% of area under irrigation was classified as "less irrigated", farmers with 50% to 80% irrigated area was classified as "medium irrigated" and farmers with more than 80% irrigated area was classified as “mostly irrigated”. Average area of farmers was higher in “mostly irrigated” than “less irrigated” and “medium irrigated” group of farmers. Table 9 shows that, among SC/ST farmers, about 27.0% were having irrigation facilities for less than 50% of their total cultivated area, about 54.4% of the farmers were having irrigated area between 50% and 80% of their total land and the remaining 17.9% farmers were having land with more than 80% irrigated. Percentage of irrigated area was higher among small and marginal farmers compared to other farmers.

5.7 Awareness, utilization and outputs under SHC scheme

Farm level impacts are assessed in terms of awareness, participation in the activities, fertilizer use, and impact on crop yields, cost reduction and profitability. Analysis is carried out across farm size classes and social groups. The analysis is present by region (zone), development and time of card issued (old, recent, new, etc).

- **Awareness**

Awareness levels are quite good in South, West, Central and Eastern zones, with about 80% to 90% awareness. North east has the lowest awareness of 31.8 percent followed by north (78.4%). At the national level 82.2 % of the sample farmers are aware of SHC (Table 10). The high awareness in some zones could be attributed to the proactive nature of the state governments in the soil health card initiative. Very poor awareness in north east may be due to prolonged attachment to traditional ways of farming and less use of fertilizers. It is also to be noted that organic farming is practiced on a large scale here. So, the priority for SHC appears to be low at the official as well as farmer level.

Table 10: Zone wise awareness about SHC

Region/State	% of Sample Farmers			
	Awareness about SHC	Discussion of results	Awareness about Portal	Portal info Useful
Central	84.9	71.5	47.1	35.1
East	84.4	70.2	33.6	24.2
North east	31.8	10.9	3.5	2.1
North	78.4	30.4	4.5	1.2
South	89.8	72.8	33.4	23.1
West	88.5	69.4	15.2	12.2
All	82.1	58.6	18.1	16.8

Across the size classes (Table 11), the variations about awareness are not much though higher proportion of medium and large farmers are aware about the SHC is more among large farmers reflecting their better access to officials and other community members. Interestingly awareness about SHC portal is higher among small and marginal farmers, it may be due the reason that these farmers are not getting cards directly from the extension workers, and rather they depend on the portal for printing their cards. Cards were issued to large farmers at their door steps or in campaigns.

Table 11: Farm Size Class wise awareness about SHC

Farm size category	% of Sample Farmers are / saying			
	Awareness about SHC	Discussion of results	Awareness about Portal	Portal info Useful
Small & Marginal	79.4	57.3	21.6	21.4
Medium	81.1	61.5	12.6	11.1
Large	89.1	54.9	21.1	19.8
All	82.1	58.6	18.1	16.8

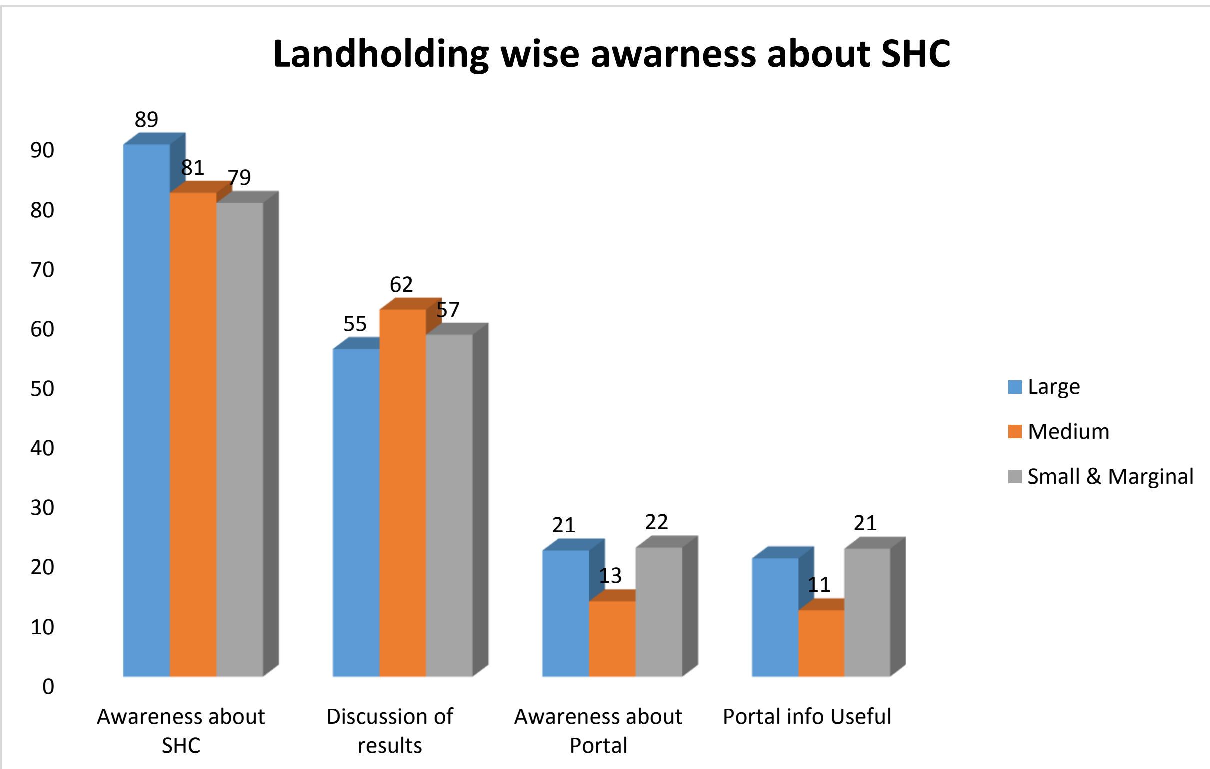


Fig. 6: Landholding wise awareness about SHC

The social class wise analysis indicates that Other Backward Caste (OBC) farmers are more aware of SHC (Table 12). This could be due to the reason that they own poor quality lands when compared to FC farmers. Moreover, of late these communities are showing more interest and attachment to farming (Reddy, 2016).

Table 12: Social group wise awareness about SHC

Region/State	% of Sample Farmers are / saying			
	Awareness about SHC	Discussion of results	Awareness about Portal	Portal info Useful
FCs	80.5	56.6	15.7	14.0
BCs	95.2	73.6	19.5	19.2
SC/STs	67.4	41.9	19.8	19.4
All	82.1	58.6	18.1	16.8

Fig. 7: Method of Soil Sample Collection

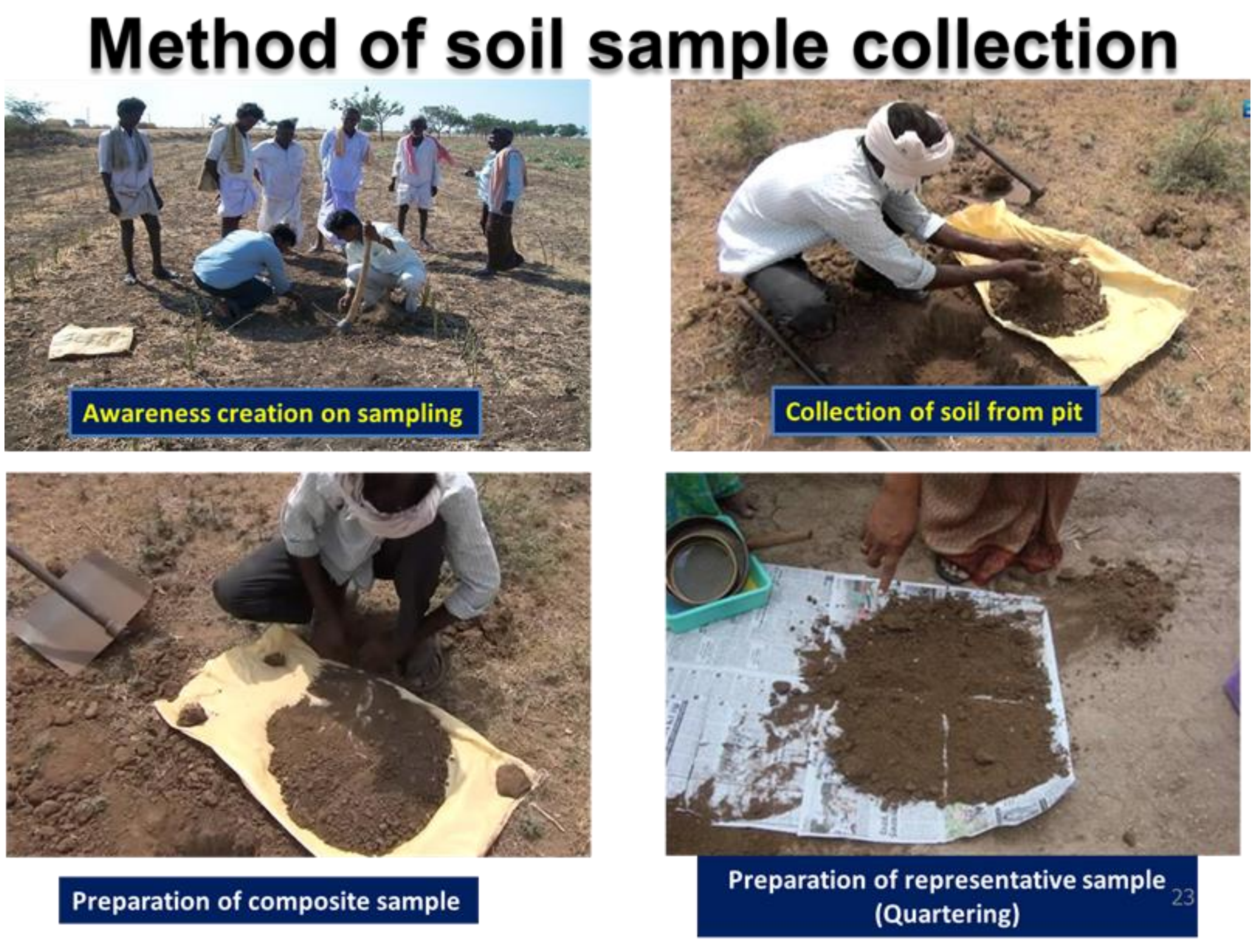
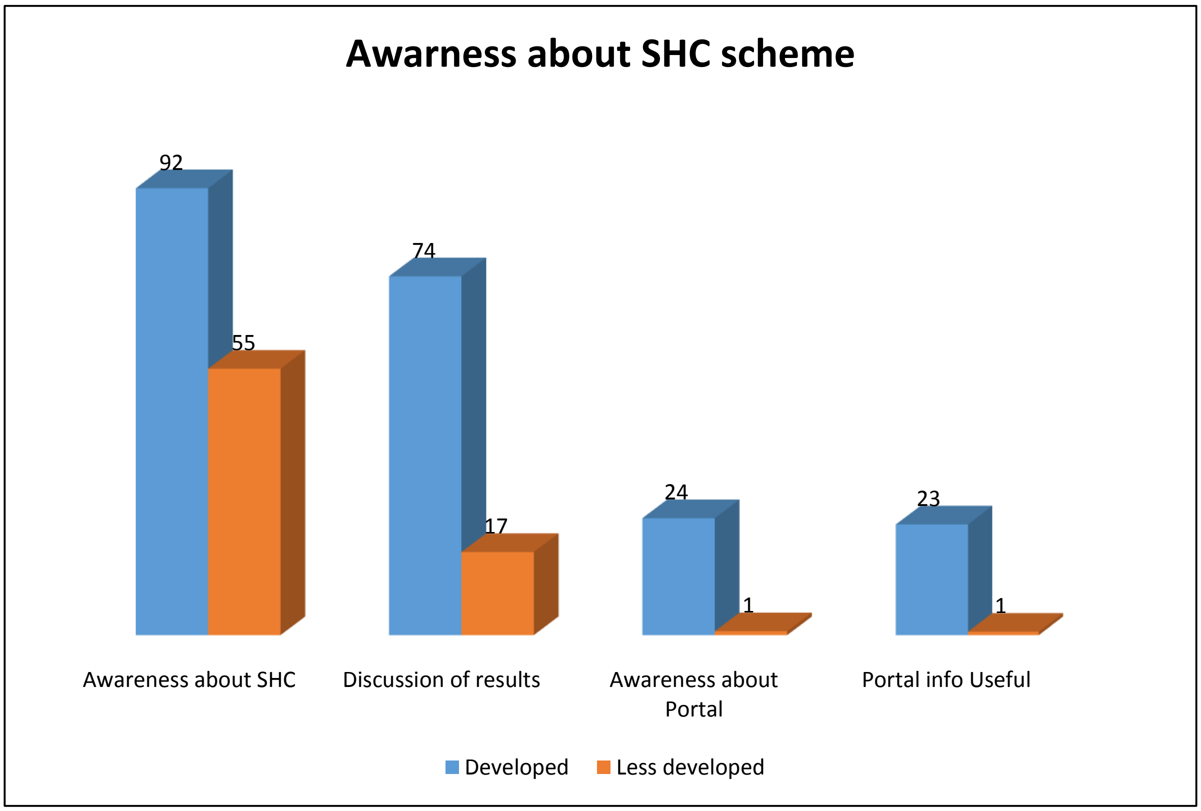


Table 13: Awareness about SHC in developed and less developed states

State group	% of Sample Farmers are / saying			
	Awareness about SHC	Discussion of results	Awareness about Portal	Portal info Useful
Developed	92.4	74.2	24.2	22.9
Less developed	55.1	17.2	0.8	0.7
All	82.1	58.6	18.1	16.8

Fig. 8: Awareness about SHC Scheme



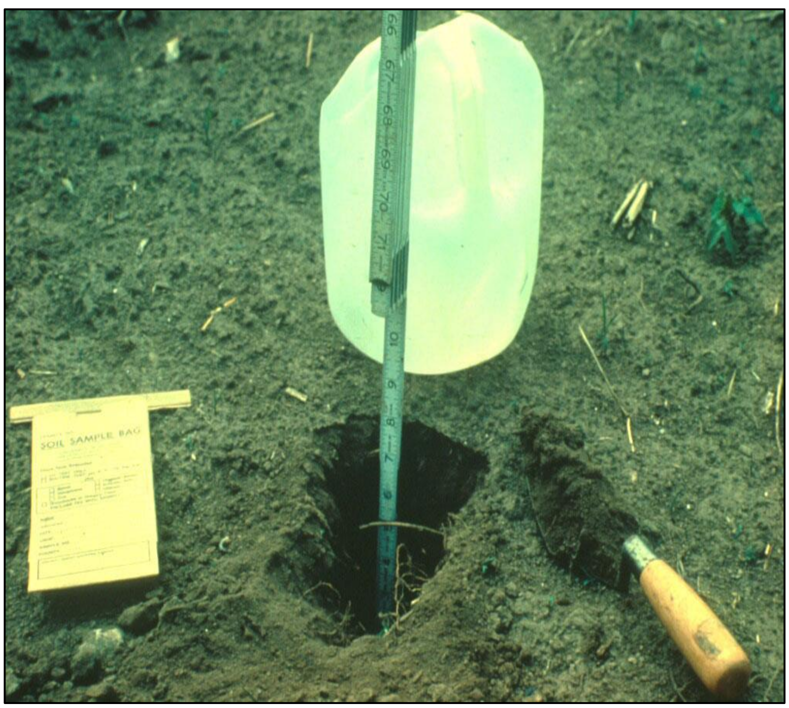
Most significant difference in awareness was between developed and less developed states (Table 13) rather than the zone wise. 92.4% of the farmers in developed states are aware about SHC compared to only 55.1% of farmers in case of less developed states. Awareness of SHC portal was about 22.9% among developed state farmers, compared to negligible farmers (0.7%) in case of less developed states.

Table 14. Awareness about SHC by irrigation status of the farmers

% irrigated group	% of Sample Farmers are / saying yes			
	Awareness about SHC	Discussion of results	Awareness about Portal	Portal info Useful
Less irrigated	84.6	59.1	4.5	3.4
Medium irrigated	76.1	49.2	5.8	4.2
Mostly irrigated	80.1	57.4	23.7	22.4
All	82.1	58.6	18.1	16.8

Awareness about SHC was high among "less irrigated" farmers (84.6 %), but awareness about SHC portal and usefulness of portal was higher among "mostly irrigated" farmers (22.4 %). Again discussion about the results were higher among "less irrigated" farmers (Table 14).

Fig 9: Soil sampling equipment



❖ Participation

Overall, 36.3% of the sample farmers are participating in meetings, 25.9% of the farmers are participating in exposure visits, and 26.3% of the farmers participating in the trainings conducted by agricultural officers. About 25 and 22% of the farmers said that they have benefited from the trainings and exposure visits, respectively. The participation of farmers from the Central and Eastern zones in SHC activities is the highest, whereas north-east and northern region was less than 10%. (Table 15).

Table 15: Participation of Farmers in SHC Activities across Regions

Region/State	% of Sample Farmers Participating in			% of Farmers benefiting from		
	Meetings	Exposure visits	Trainings	Meetings	Exposure visits	Trainings
Central	65.9	63.4	67.5	63.4	61.7	61.5
East	63.9	62.0	75.5	61.2	57.3	70.5
North east	10.3	9.4	5.1	5.8	2.8	2.0
North	16.3	10.2	5.6	5.0	3.4	5.1
South	51.5	27.6	27.5	47.8	26.4	26.7
West	35.1	13.4	3.7	29.9	6.2	0.7
All	36.3	25.9	26.3	33.6	21.8	24.8

Fig 10: % of farmers in SHC activities and perception

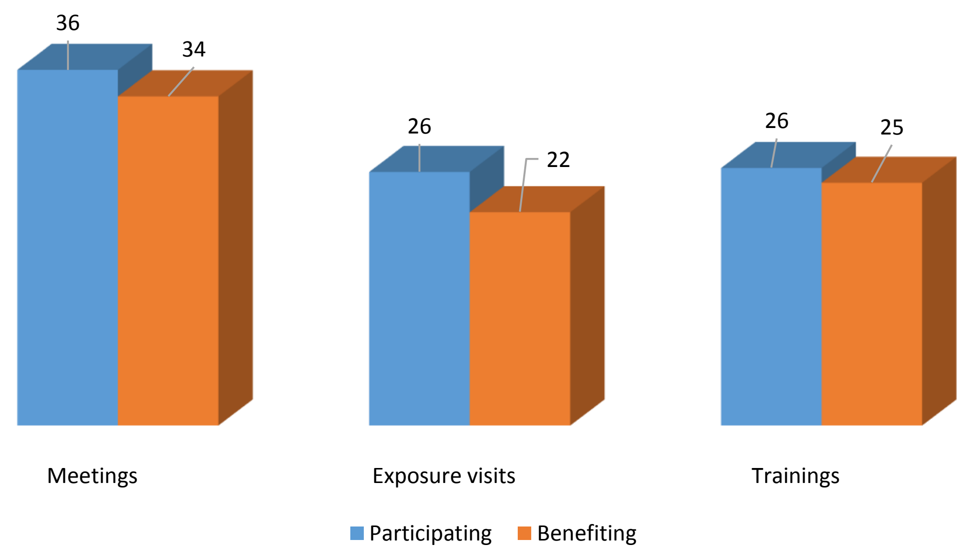


Table 16: Participation of Farmers in SHC Activities across States

State group	% of Sample Farmers Participating in			% of Farmers benefiting from		
	Meetings	Exposure visits	Trainings	Meetings	Exposure visits	Trainings
Developed	46.3	33.4	32.6	43.6	29.4	31.1
Less developed	9.7	6.1	9.8	7.1	1.8	8.2
All	36.3	25.9	26.3	33.6	21.8	24.8

As in the case of awareness, participation in different meetings, exposure visits and trainings is also significantly higher in developed (46.3%) compared to less-developed states (9.7%) (Table 16). Significant differences exist even in percentage of farmers benefiting from exposure visits and trainings.

Although there was no significant difference in participation different size class farmers, generally participation by small and marginal farmers is higher among all the size classes (Table 17). It is interesting to see that small and marginal farmers are more interested and getting benefits from government training programmes and exposure visits. Large farmers' participation maybe less due to other sources of information.

Table 17: Participation of Farmers in SHC Activities across Size Classes

Region/State	% of Sample Farmers Participating in			% of Farmers benefiting from		
	Meetings	Exposure visits	Trainings	Meetings	Exposure visits	Trainings
Large	33.4	26.1	26.9	30.9	25.7	26.6
Medium	38.7	23.4	23.2	35.6	19.8	21.9
Small & Marginal	35.1	28.4	29.4	32.9	22.0	27.0
All	36.3	25.9	26.3	33.6	21.8	24.8

Participation of farmers from the OBC group is the highest in all activities (Table 18). On the other hand, the percentage of farmers benefiting from these activities was the highest in SC/STs. As far as participation and related benefits are concerned lower socioeconomic groups (both small and marginal farmers and ST/SC farmers) are benefiting more when compared to others.

Table 18: Participation of Farmers in SHC Activities across Social Groups

Social group	% of Sample Farmers Participating in			% of Farmers benefiting from		
	Meetings	Exposure visits	Trainings	Meetings	Exposure visits	Trainings
FCs	30.1	21.9	19.9	28.7	17.1	18.0
OBCs	50.3	32.4	34.1	46.0	29.0	33.5
SC/STs	29.9	25.2	29.3	26.6	22.1	27.1
All	36.3	25.9	26.3	33.6	21.8	24.8

Table 19: Participation of Farmers in SHC Activities across irrigated area groups

% irrigated group	% of Sample Farmers Participating in			% of Farmers benefiting from		
	Meetings	Exposure visits	Trainings	Meetings	Exposure visits	Trainings
Less irrigated	38.0	21.4	20.9	33.8	20.5	20.3
Medium irrigated	26.9	21.6	21.1	25.7	14.0	17.0
Mostly irrigated	36.6	27.5	28.3	34.2	22.9	26.7
All	36.3	25.9	26.3	33.6	21.8	24.8

Again, figures in Table 19 indicated that the less irrigated farmers are participating more in meetings, while most irrigated farmers are participating in exposure visits and trainings when compared to less and medium irrigated farmers. In the case of benefits high proportion of most irrigated category farmers get the most in all the three activities. It is in line with our overall observations that the small and marginal farmers and resource-poor farmers are trying to participate in more government promotional programmes though the benefits are skewed in favour of resource rich within the groups. As their livelihoods are mostly depend on agriculture compared to large farmers who can also get income from other sources.

5.8: Farmers perception and source of information about SHC

Overall 57% of the sample farmers understand the SHC information. Farmers opine that, easy language and colors (green for sufficiency; yellow/brown for deficit; red for severely deficit) should be used to indicate the necessary information to the farmers (Table 20). About 62.8% of the farmers use fertilizers according to the recommendations on the SHC. This should be improved by imparting awareness about the need for soil management. 38.7% of the sample farmers received assistance from local agricultural extension staff regarding the adoption of recommendations as per the SHC. About 73.1% of the sample farmers said that recommendations are suitable for all plots of the land. About 78% of the sample farmers indicated that the samples represent all the soil types. However, it should be noted that the sample is little biased towards better performing districts within states. Proper sampling methods need to be used to increase coverage and relevance of the soil samples collected and tested to all plots. About 68% of the sample farmers said that the results are provided in time, indicating 32% of the sample farmers have not got SHC in time. It seems there was delay in sample testing and disbursal of SHCs after sample collection. Agricultural officers should take care that the SHC should reach the farmers in time. It is recommended that the SHCs should be distributed during the campaigns and *kisan melas* through elected representatives in the presence of local agricultural officers. Agricultural officers should display and demonstrate the utility of the content of SHC and how to adopt the recommended doses of fertilizers as per the SHC.

About 60% of the sample farmers reported that agricultural officers/agricultural extension officers explained the content of the SHC. About 67 % of the sample farmers find the recommendations practical. 46% of sample farmers reported difficulties in adopting practices. Most of the reasons sighted are (i) costly to purchase fertilizers, (ii) non-availability of micro-nutrients, (iii) perception that the traditional high doses of fertilizers will give more yields than the recommended lower doses, (iv) little difference in existing practice and SHC recommended practice, (v) for small farmers there was little reduction in fertilizer doses, as a result farmer generally prefer more fertilizers and (vi) agricultural officers are too busy to give proper advice. Agricultural officers are an important link between the farmers and the information they need. At block level, agricultural officers are burdened with multiple activities. Information dissemination and soil extension has become a least priority compared to distribution of seed, financial assistance under different government programmes. There is a need for pro-active PPP models, under which rural educated youth and entrepreneurs can actively participate in soil sample collection, testing and dissemination of SHCs for wider adoption of recommended practices by the farmers.

Table 20: Farmers perception about SHC across Regions

Region	% of sample farmers saying yes								
	1	2	3	4	5	6	7	8	9
Central	79.0	77.2	50.4	80.4	85.51	82.6	88.4	77.5	52.2
East	84.4	83.6	30.5	89.1	92.97	89.8	82.0	83.2	50.8
North east	32.3	21.0	14.9	57.6	76.52	80.3	20.2	39.9	59.6
North	49.0	63.1	0.8	71.3	78.90	39.0	58.8	63.5	36.5
South	71.0	68.3	51.2	73.1	77.21	76.7	78.1	76.4	31.9
West	75.6	90.0	96.3	90.3	92.54	81.5	91.0	77.6	73.6
All	62.8	65.7	38.7	75.3	82.34	71.2	68.2	68.8	47.8

1= understanding; 2=Using fertilisers and micronutrients according to SHC; 3= received financial assistance from govt.; 4 = Recommendations suitable to all plots; 5= Do samples represent all the soil types; 6= Results provided in time; 7= Do extension worker explain content; 8= Recommendations practical; 9= Difficulties in adopting practices.

Table 21: Farmers perception about SHC across Size Classes

Size class	% of sample farmers saying yes								
	1	2	3	4	5	6	7	8	9
Large	78.7	78.3	27.6	81.0	87.6	78.5	84.0	76.6	42.7
Medium	55.8	56.9	42.8	67.7	72.5	66.4	61.8	58.7	46.0
Small & Marginal	61.9	68.4	40.3	80.6	90.2	72.4	66.7	75.4	52.5
All	62.8	65.7	38.7	75.3	82.3	71.2	68.2	68.8	47.8

1= understanding; 2=Using fertilizers and micronutrients according to SHC; 3= received financial assistance from govt.; 4 = Recommendations suitable to all plots; 5= Do samples represent all the soil types; 6= Results provided in time; 7= Do extension worker explain content; 8= Recommendations practical; 9= Difficulties in adopting practices.

Zone wise farmers' opinion about the implementation of SHC scheme was given in Table 20. Overall, the perception index was higher in Eastern India, Western India and also Southern India. It was low in North and North-Eastern India. Hence there was a need for more intensive efforts in North and North-eastern zones. In many indicators of adoption SHC scheme, small and marginal farmers seem to be better compared to large farmers (Table 21). Farmers in more developed states and districts were having higher knowledge about soil health card and also practicing recommended practices (Table 22). In the developed states, farmers face fewer difficulties in adopting recommended practices.

Fig. 11: Methods for Evaluating Soil Nutrient Status

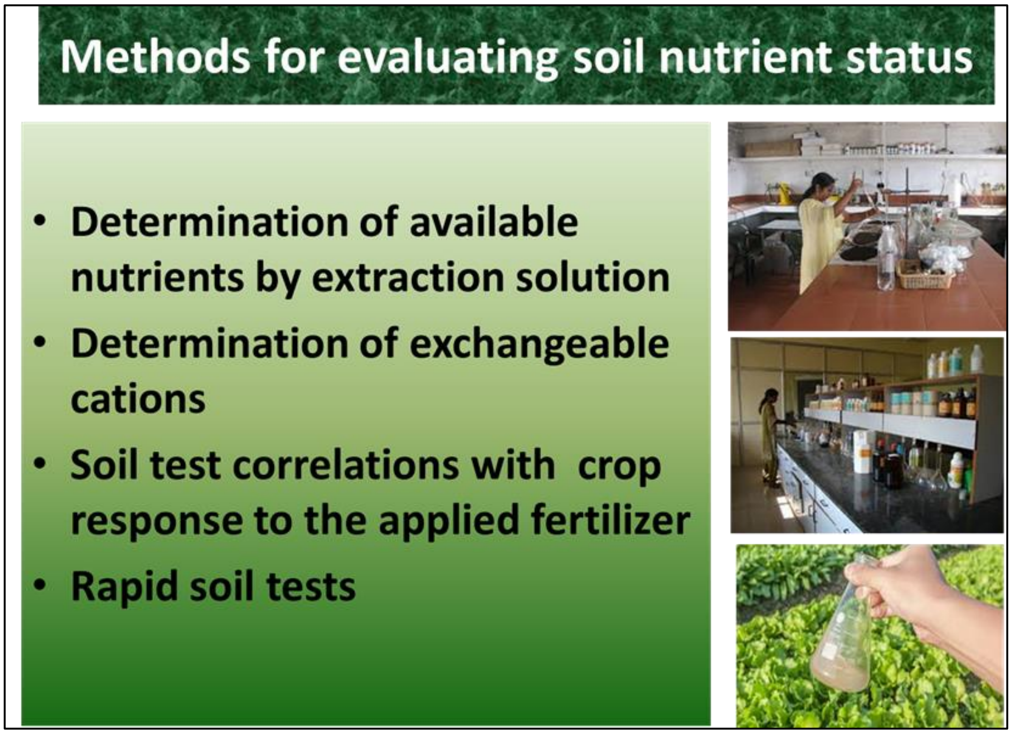


Table 22: Farmers opinion about SHC in developed and less developed states

State group	% of sample farmers saying yes								
	1	2	3	4	5	6	7	8	9
Developed	74.8	76.2	49.8	80.3	84.8	77.5	83.6	76.3	47.0
Less developed	31.1	37.9	9.3	62.2	76.0	54.3	27.4	48.9	49.9
All	62.8	65.7	38.7	75.3	82.3	71.2	68.2	68.8	47.8

1= understanding; 2=Using fertilisers and micronutrients according to SHC; 3= Financial assistance from govt.; 4 = Recommendations suitable to all plots; 5= do samples represent all the soil types; 6= Results provided in time; 7= do extension worker explain content; 8= recommendations practical; 9= Difficulties in adopting practices.

Table 23: Farmers opinion about SHC across Irrigation categories

% irrigated group	% of sample farmers saying yes								
	1	2	3	4	5	6	7	8	9
Less irrigated	57.9	57.4	47.7	76.4	88.6	70.8	76.3	66.0	45.4
Medium irrigated	49.7	37.4	15.2	66.7	76.6	78.4	41.5	54.4	54.4
Mostly irrigated	65.4	70.5	38.4	75.8	81.1	70.6	68.4	70.8	47.9
All	62.8	65.7	38.7	75.3	82.3	71.2	68.2	68.8	47.8

1= understanding; 2=Using fertilizers and micronutrients according to SHC; 3= received financial assistance from govt.; 4 = Recommendations suitable to all plots; 5= Do samples represent all the soil types; 6= Results provided in time; 7= Do extension worker explain content; 8= Recommendations practical; 9= Difficulties in adopting practices.

Table 23 reveals that, more percentage of the "less irrigated" farmers opine that they understand the SHC scheme, using fertilizers and micro-nutrients as per the SHC, getting assistance from agricultural officers, recommendations suitable to their soils, sample test values represent their soils, results provided in time, etc. It indicates that the SHC scheme is more pro-poor compared to other government programmes.

It is prescribed that in a grid of 10 hectare of dry land, soil sample should be collected from the land of all large and medium farmers falling in the grid and also should cover some plots of small farmers by random selection. However, in practice, most of the soil samplers collecting sub-samples from 3-4 locations of grid farmers and not covering small farmers' plots (Table 24). Field survey shows that most of the sub-samples are collected from only one plot of the grid (large) farmers. About 51% of the farmers told that sub-samples were taken from only one plot of the farmers, whereas about 28% of the farmers responded that, sub-samples were taken from a few plots of the farmers, while about 18% of the farmers told that the sub-sample was taken from all the plots. However, if the soil is homogenous, representativeness may not be lost with small number of sub-samples, but if the soil variability is higher, samplers must collect sample from each plot and test separately. Because of this reason, the study suggests grid size should vary with soil variability, so that soil test values represent soils correctly without sampling error. In North East and South India coverage is more compared to other states. A few also reported (2.5%) that they received SHCs without any sample taken from their fields. Many of the field extension officers don't know the exact procedure to be followed in soil sample collection, they said that they don't see the field manual on soil sample collection. Hence every block level office should have the soil sampling manual and the same is explained [properly to the soil sample collectors. There is a need for standard protocols for soil sample collection. The soil sample collection of different soil conditions and seasons needs to be standardized. The procedures should vary according to the variability of soil, i.e. the slope of the land, the water sources, etc.

Table 24: Number of plots covered in soil testing across zones

Zone	All (%)	Some (%)	One plot (%)	None (%)
Central	63.4	19.2	12.7	4.7
East	6.6	5.1	84.0	4.3
North east	18.9	55.6	23.0	2.5
North	1.5	54.3	41.0	3.2
South	42.8	20.3	36.3	0.6
West	25.6	21.6	45.5	7.2
All	25.4	32.2	39.0	3.3

According to farm size groups, 68% among small and marginal farmers indicated that only one plot of their land was covered for soil sample collection, about 19% mentioned that some of their plots were covered and only 14.5% mentioned that all their plots were covered for soil sampling (Table 25). While 17.5% of large farmers said that all their plots were covered for sampling, 26% said that only one plot was considered for sample collection and remaining 55% said that some of their plots were considered for sample collection. Farmers who have land with less irrigated area also mentioned that their soils are covered in the soil sampling, which is a good sign. There was no significant difference between developed and less developed states in the coverage of the samples (Tables 25 to 27).

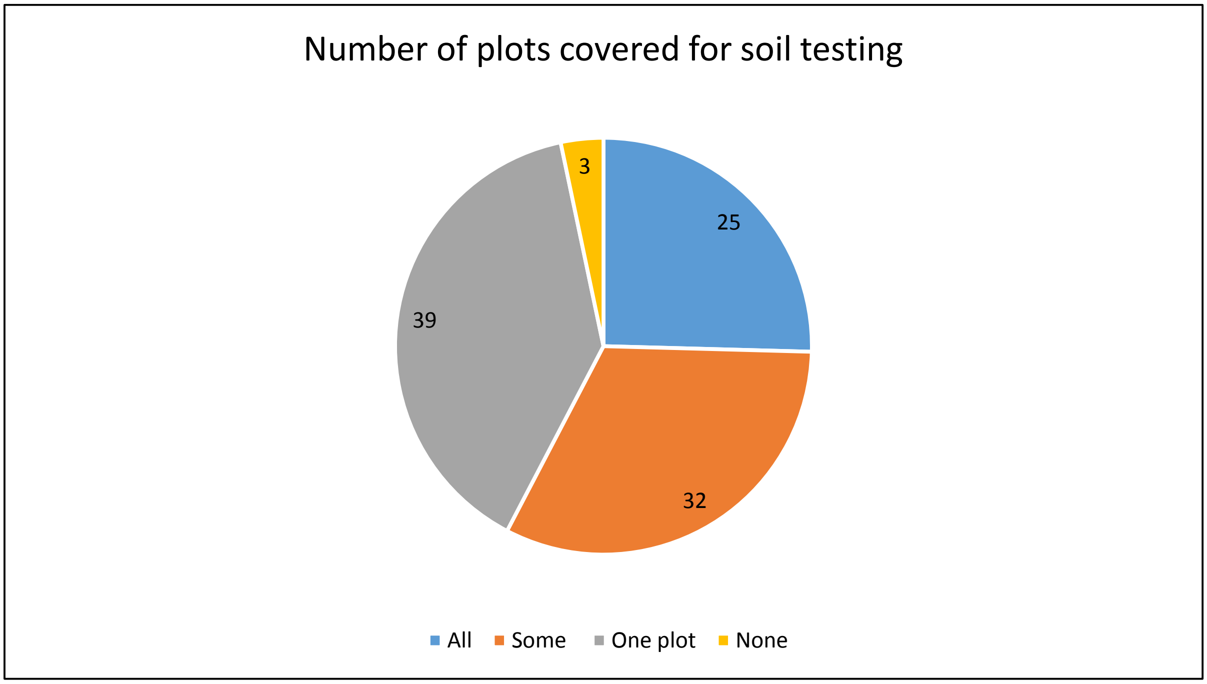


Fig. 12: Number of plots covered for soil testing

Table 25: No. of plot covered in soil testing across size classes.

Size class	All (%)	Some (%)	One (%)	None (%)
Large	18.9	37.1	42.4	1.6
Medium	35.6	21.8	36.6	6.1
Small & Marginal	25.1	36.5	35.1	3.3
All	25.4	32.2	39.0	3.3

Table 26: No. of plot covered in soil testing

State group	All (%)	Some (%)	One (%)	None (%)
Developed	29.8	32.5	35.0	2.7
Less developed	13.9	31.5	49.5	5.1
Total	25.4	32.2	39.0	3.3

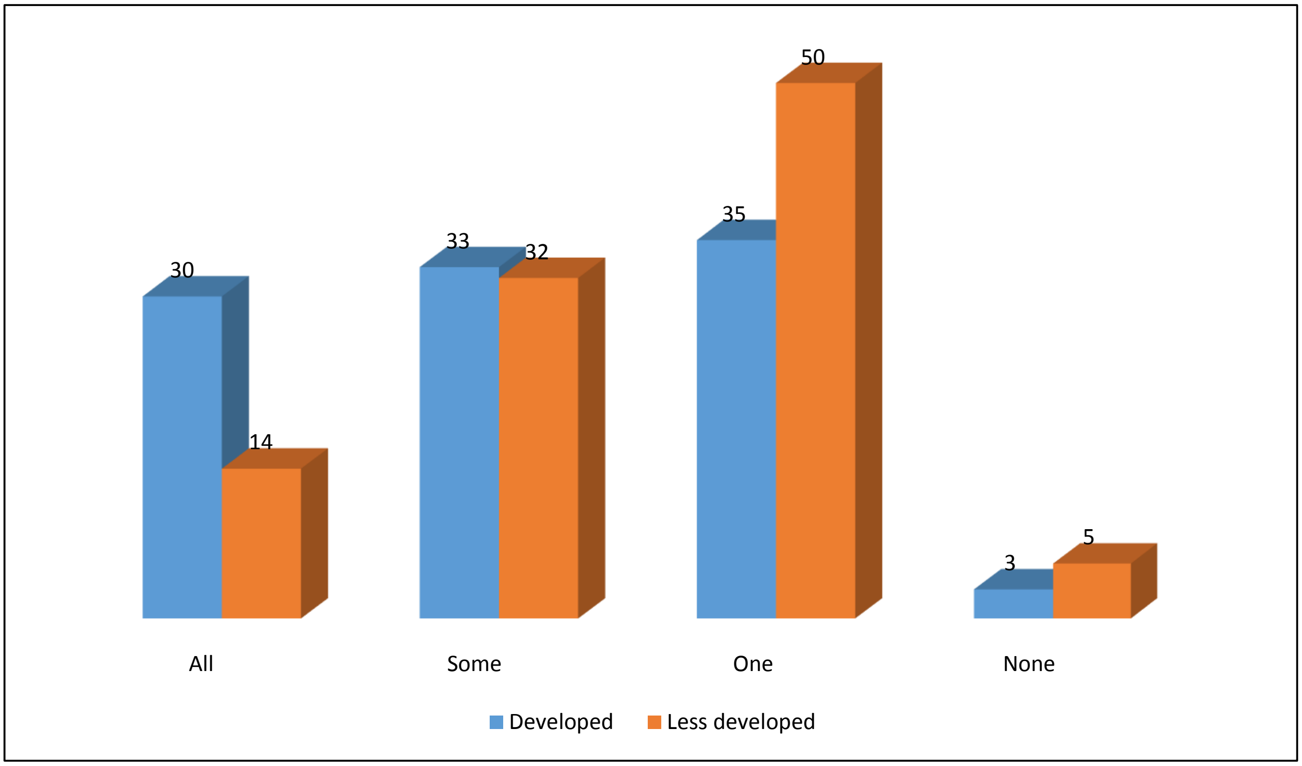


Fig. 13: Number of plots covered in developed and less developed states

Table 27: No. of plot covered in Irrigated Groups

% irrigated group	All (%)	Some (%)	One (%)	None (%)
Less irrigated	48.5	24.7	23.2	3.7
Medium irrigated	19.9	44.4	28.1	7.6
Mostly irrigated	19.6	33.2	44.3	2.9
All	25.4	32.2	39.0	3.3

Source of Information

Most of the information was provided by Agricultural extension officers and agricultural officers. KVKs and NGOs are active in north east and western India. The role of KVK's, NGO's should be encouraged by the government to disseminate information easily (Table 28).

Table 28: Zone wise source of information about SHC content

Region	% of the farmers received information from			
	KVK	AEO/AOs	Scientist of SAU/ICAR	NGO's
Central	39.3	58.8	1.5	0.4
East	5.4	87.4	4.8	2.4
North east	10.6	77.5	2.8	9.1
North	5.8	89.8	4.2	0.2
South	6.9	85.6	3	4.5
West	1.0	90.1	3.4	5.5
All	10.3	84.6	2.6	2.5

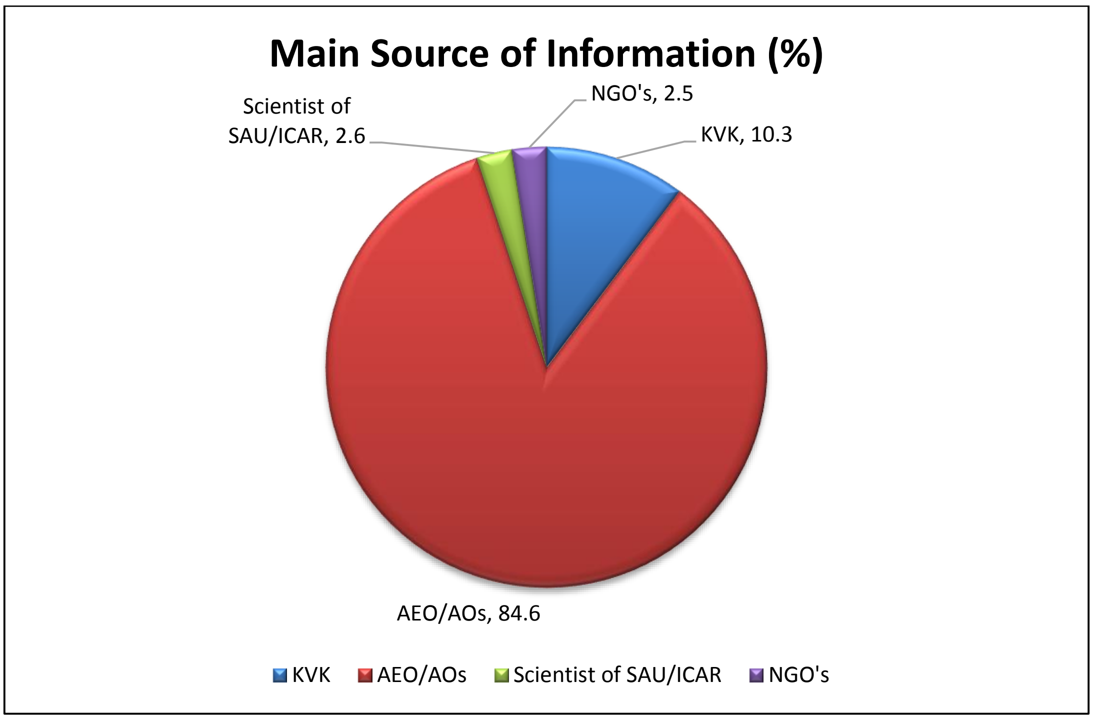


Fig. 14: Main Source of Information (%)

KVKs and NGOs are active in providing information in less developed states and also covering most of the small and marginal farmers (Table 29) as the extension system in the less developed states are not able to cover all the farmers, given the shortage of skilled workforce and infrastructure (Table 30 & 31). "Less irrigated" farmers were mostly got information from AEOs/AOs, while KVKs and NGOs are mostly providing information to medium and mostly irrigated farmers (Table 30).

Table 29: Source of information about SHC content across size classes

Size class	% of the farmers received information from			
	KVK	AEO/AOs	Scientist of SAU/ICAR	NGO's
Large	18.4	76.1	3.2	2.3
Medium	12.1	83.1	2.9	1.9
Small & Marginal	5.0	90.2	1.2	3.6
All	10.3	84.6	2.6	2.5

Table 30: Source of information about SHC content by state groups

State group	KVK	AEO/AOs	Scientist of SAU/ICAR	NGO's
Developed	8.8	86.6	3.1	1.5
Less developed	10.9	81.9	2.1	5.1
Total	10.3	84.6	2.6	2.5

Table 31: Source of information about SHC content by level of irrigation

% irrigated group	(% of the farmers received information from			
	KVK	AEO/AOs	Scientist of SAU/ICAR	NGO's
Less irrigated	5.3	89.7	1.5	3.5
Medium irrigated	4.5	88.9	2.6	4.0
Mostly irrigated	12.8	80.8	4.1	2.3
All	10.3	84.6	2.6	2.5

Perceptions about SHC benefits

On an average 70 % of the farmers indicated that they benefited from SHC, while the remaining suggested improvement (Table 32). Most regions, except north east, farmers feel that the benefits from the SHC scheme is huge in terms of reduction in fertilizer use and cost of cultivation and increased yields. About 45.5% of the farmers are inclined to go to private STLs. About 23.3 % of the sample farmers are willing to pay for the services. However, only in north and east farmers are willing to pay as in these zones government machinery is not meeting the expectations of the farmers. The zone wise, farm size category wise and social group wise farmers' perceptions were given in Table 32, Table 33 and table 34 respectively. It was observed that the farmers in less developed states are not benefiting as that of developed states (Table 35). A Majority of the farmers mentioned that they benefited through

- ✓ Reduction in fertilizer use
- ✓ Identification and application of micro-nutrients
- ✓ Increase in yield.
- ✓ Knowledge gain

- Farmers suggest that
  - ✓ They should get information in time
  - ✓ Need for more awareness camps
  - ✓ Provide the recommended inputs free/subsidy basis by government

Table 32: Farmers Perceptions about SHC across Zones

Zone	% of Sample Farmers				Type of benefits (by priority)	Nature of Improvement
	Benefiting	Need improvement	Willing to go to Private STL	Willing to pay		
Central	80.8	73.6	7.6	16.7	Reduce fertilizer use	Timely distribution of SHCs
East	84.8	83.7	47.8	13.6	Reduce fertilizer use	Sample to be taken from all fields
North east	15.9	13.6	42.9	13.1	Reduce cost	Subsidized micro-nutrient supply
North	63.3	12.5	31.9	22.4	Awareness about soil nutrition	Make farmers aware about SHC
South	86.6	24.7	12.1	10.7	Save fertilizer doses	Information of SHC in time
West	86.8	10.9	43.0	41.3	Increase of production	Recommended practices in more understandable way
All	73.6	29.1	32.4	19.5		

Table 33: Farmers Perceptions about SHC across Size Classes

Region/ State	% of Sample Farmers				Type of benefits (by priority)	Nature of Improvement
	Benefiting	Need improvement	Willing to go to Private STL	Willing to pay		
Large	82.9	26.4	19.2	17.1	Reduce fertilizer use	Give the SHC reports in time
Medium	73.8	26.7	27.5	19.4	Knowledge about SHC	Free nutrients from govt
Small & Marginal	68.4	33.1	44.6	20.9	Get knowledge	Free/subsidized micro-nutrients from govt
All	73.6	29.1	32.4	19.5		

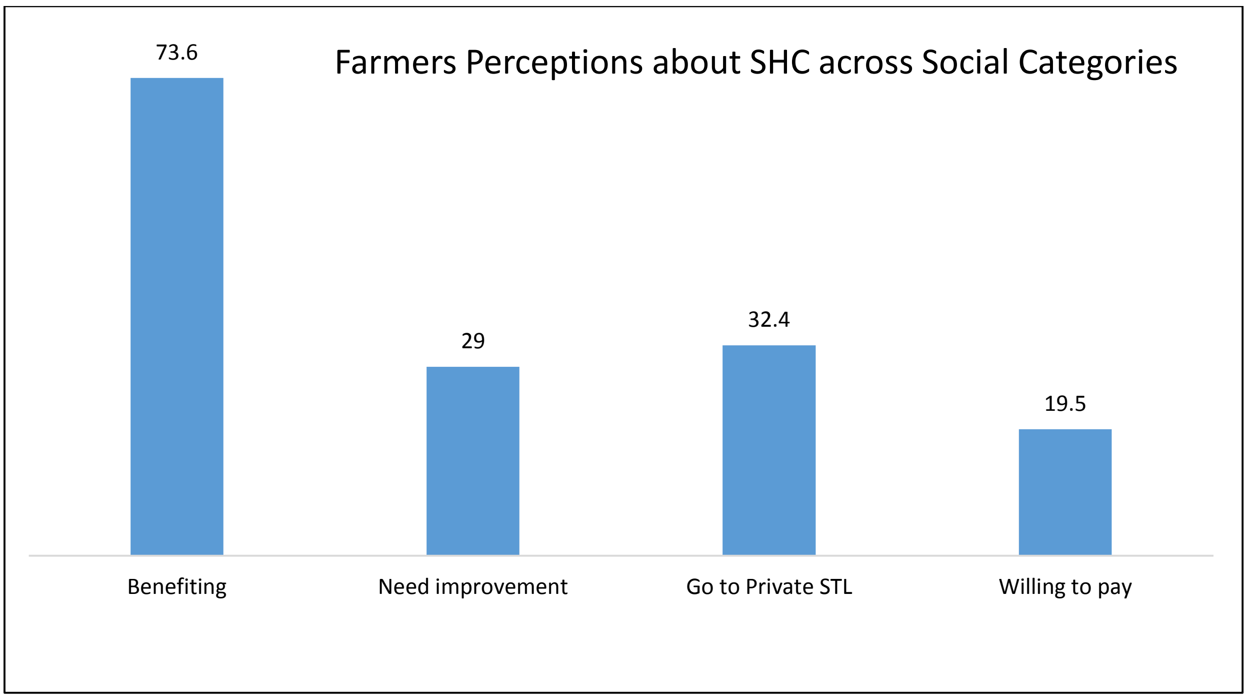


Fig. 15: Farmers perceptions about SHC across social categories

Table 34: Farmers Perceptions about SHC across Social Categories

Region/State	% of Sample Farmers				Type of benefits (by priority)*	Nature of Improvement *
	Benefiting	Need improvement	Willing to go to Private STL	Willing to pay		
OCs	78.3	23.5	37.1	21.3	Reduces fertilizers use	Give the SHC reports in time
BCs	82.8	33.5	18.5	19.5	Reduces cost	more trainings needed
SC/STs	50.8	34.9	41.3	15.8	Awareness about soils	free soil nutrients by govt.
All	73.6	29.1	32.4	19.5	Reduces fertilizers use	more trainings needed

Table 35: Farmers Perceptions about SHC across States

State group	% of Sample Farmers				Type of benefits (by priority)*	Nature of Improvement*
	Benefiting	Need improvement	Go to Private STL	Willing to pay		
Developed	91.6	32.9	32.2	21.8	Optimal dose of fertilizers	Give me information of SHC in time
Less developed	26.0	18.9	32.6	13.6	Awareness about SHC	Free inputs from agricultural dept
All	73.6	29.1	32.4	19.5		

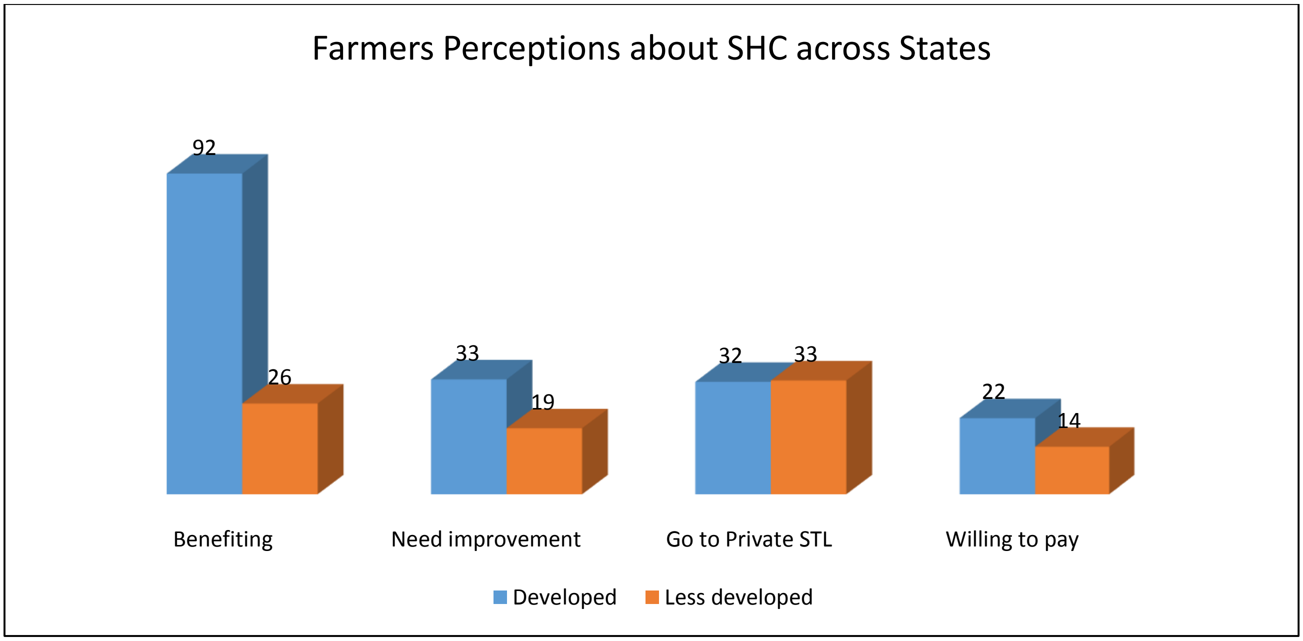


Fig. 16: Farmers perceptions about SHC across States

Table 36, shows that the "mostly irrigated" farmers are mentioning that there is a need for improvement in SHC scheme, about 50% of them are willing to go for private soil testing labs and about 25% of them are willing to pay.

Table 36: Farmers Perceptions about SHC Irrigated Groups

% irrigated group	% of Sample Farmers				Type of benefits (by priority)	Nature of Improvement
	Benefiting	Need improvement	Go to Private STL	Willing to pay		
Less irrigated	78.6	17.8	13.7	16.8	Awareness about SHC	Information of SHC in time
Medium irrigated	44.4	21.1	39.2	24.0	Save fertilizer doses	Free fertilizers from dept.
Mostly irrigated	74.9	32.9	36.8	19.9	Reduce fertilizer use	Make farmers aware about SHC
All	73.6	29.1	32.4	19.5	Reduce fertilizer use	Information of SHC in time

5.9: Outcomes (Input Use and Cost per hectare) of the SHC scheme

The impact of SHC was assessed for three important crops viz; paddy, cotton and soybean by comparing fertilizer use and yield before possessing SHC and after following the recommendations of SHC. The study has assessed change in the area under the crops, use of major fertilizers (Urea, DAP/SSP and MoP), cost of cultivation and yields. For above three crops farmers reported decline in area after SHC scheme, indicating that most of the farmers have diversified to less input-intensive crops from more input-intensive crops like paddy and cotton after the introduction of SHCs. Overall, paddy farmers reduced use of urea by about 13%, DAP/SSP by about 12 %, and Potassium by about 4 %. This is a healthy sign of moving towards balanced use of fertilizers. All the three crops showed a decline in costs per acre by about 8 to 10 per cent. There was substantial increase in se of manures especially in paddy resulted in decreased cost of cultivation per unit area. On the other hand, soybean farmers indicated an increase in fertilizer use although marginally (Table 37). Crop yields have increased slightly after having SHC in all three crops. Among different farm size classes, small and marginal as well as large farmers experience decline in costs in all the selected crops, while medium farmers reported decline in the case of paddy and soybean crops (Table 38).

Table 37. Impact of SHC on fertilizer use, costs and crop yields (per ha)

Crop/region	SHC	Cost C2	Gross return	Net Return	Yield (qtl)	N (kg)	P (kg)	K (kg)	Fertilizer (kg)	Fert (Rs)	Manure (qtl)	Manure (Rs.)	Cost A1	Returns over variable cost
Cotton														
South	B	66613	80500	13887	17.5	124	64	33	221	6904	9	1004	38636	41864
	A	63283	82800	19517	18	105	60	28	193	5912	12	1256	34806	47994
West	B	73327	96600	23273	21	131	62	22	215	7172	22	2553	42530	54070
	A	70807	101200	30393	22	106	55	20	181	5976	28	3273	38236	62964
Total	B	69970	88550	18580	19.25	127.5	63	27.5	218	7038	15.5	1778.5	40583	47967
	A	67045	92000	24955	20	105.5	57.5	24	187	5944	20	2264.5	36521	55479
% change		-4.2	3.9	34.3	3.9	-17.3	-8.7	-12.7	-14.2	-15.5	29.0	27.3	-10.0	16
Paddy														
North	B	54895	81675	26780	45	78	34	18	130	4373	9.5	399	31839	49836
	A	52968	81675	28707	45	68	29	17	114	3786	10.5	473	28603	53072
South	B	73886	92565	18680	51	79	42	22	143	7441	15.5	651	42854	49711
	A	70397	96195	25798	53	67	41	20.5	128.5	6290	19	855	38718	57477
Total	B	64390.5	87120	22730	48	78.5	38	20	136.5	5907	12.5	525	37346	49774
	A	61682.5	88935	27252.5	49	67.5	35	18.75	121.25	5038	14.75	664	33661	55274
% change		-4.2	2.1	19.9	2.1	-14.0	-7.9	-6.3	-11.2	-14.7	18.0	26.4	-9.9	11
Soybean														
South	B	24459	30800	6341	11	31	46	6	83	2074	4	572	17610	13190
	A	23529	30800	10271	11	26	42	6	74	1850	5	762	16000	14800
West	B	35590	42000	6410	15	30	45	6.5	81.5	3597	4	848	25625	16375
	A	33646	44800	11154	16	26.5	38	7	71.5	2976	5	1087	23552	21248
Total	B	30024.5	36400	6375.5	13	30.5	45.5	6.25	82.25	2835.5	4	710	21618	14782
	A	28587.5	37800	10712.5	13.5	26.25	40	6.5	72.75	2413	5	924.5	19776	18024
% change		-4.8	3.8	68.0	3.8	-13.9	-12.1	4.0	-11.6	-14.9	25.0	30.2	-8.5	22

Note: B=before soil health card; A=after soil health card scheme *because of the lack of availability of bio-fertilizers farmers are not able to adopt.

Fig 17: Soil Test Interpretation Categories

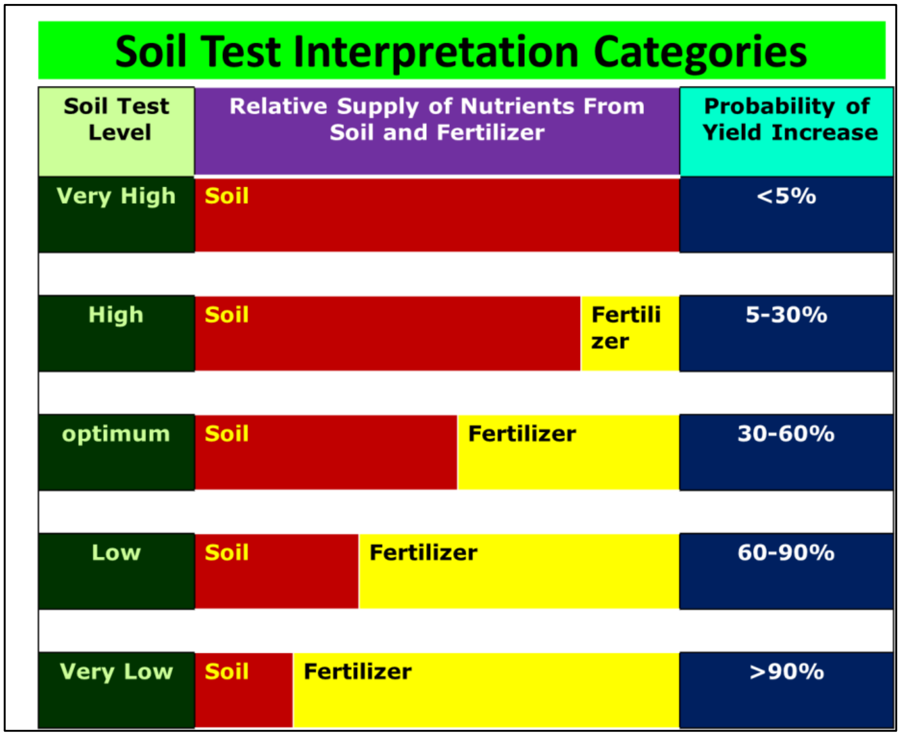


Fig.18: Azolla- a potential source of bio fertilizer

Table 38. Impact of SHC on fertilizer use, costs and crop yields by farm size category

Crop/Farm size	SHC	Cost C2	Gross return	Net Return	Yield (qtl)	N (kg)	P (kg)	K (kg)	Fertilizer (kg)	Fert. (Rs)	Manure (qtl)	Manure (Rs.)	Cost A1	Returns over variable cost
Cotton														
Large	B	53173	87400	34227	19	128.5	66	30	224.5	7144	14	1580	30840	56560
	A	49891	92000	46709	20	108.5	59	26	193.5	6170	16	2045	27590	64410
% change		-6.2	5.3	36.5	5.3	-15.6	-10.6	-13.3	-13.8	-13.6	14.3	29.4	-10.5	14
S&MF	B	63136	87400	24264	18	126.5	60	25	211.5	6934	17	1973	37882	49518
	A	61701	92000	30299	18.5	102.75	56	22	180.75	5725	24.45	2485	34367	57633
% change		-2.3	5.3	24.9	2.8	-18.8	-6.7	-12.0	-14.5	-17.4	43.8	26.0	-9.3	16
Paddy													`	
Large	B	71075	99825	28750	55	85	43.25	21	149.25	6195	11.75	485	41224	58602
	A	68995	103455	34460	57	69	38	19.5	126.5	5115	13.75	580	40017	63438
% change		-2.9	3.6	19.9	3.6	-18.8	-12.1	-7.1	-15.2	-17.4	17.0	19.6	-2.9	8
S&MF	B	57690	73508	15818	40.5	72	33	19.2	124.2	5617	13	659	33460	40047
	A	54360	73961	19601	40.75	66	31.7	18.2	115.9	4956	15.5	878	31529	42432
% change		-5.8	0.6	23.9	0.6	-8.3	-3.9	-5.2	-6.7	-11.8	19.2	33.2	-5.8	6
Soybean														
Large	B	31082	36400	5318	13	33	47	8	88	2811	4	595	22379	14021
	A	29620	36400	6780	13	28	42	8.7	78.7	2500	5	850	20142	16258
% change		-4.7	0.0	27.5	0.0	-15.2	-10.6	8.7	-10.6	-11.1	25.0	42.9	-10.0	16
S&MF	B	28984	36400	7416	13	28	44	7	79	2524	4.5	790	20868	15532
	A	27560	39200	11640	14	24.55	38	7	69.55	2050	5.65	933	19292	19908
% change		-4.9	7.7	57.0	7.7	-12.3	-13.6	0.0	-12.0	-18.8	25.6	18.1	-7.6	28

Note: B=before SHC scheme; A=after SHC scheme

Table 39: Status according to longevity of card (cotton/ha)

Before SHC scheme	Cost C2	Gross return	Net Return	Yield (q/ha)	N (kg/ha)	p(kg	k(kg)	fertilizer(kg)	Fert (Rs.)	Manure (Qtl)	Manure (Rs.)	Cost A1	Returns over variable cost
Old	70905	87400	16495	19	114	57	21	192	6381	24	2550	38530	48870
New	69793	82800	13007	18	121	54	20	195	6472	22	2447	40583	42217
% change after SHC scheme													
Old	-5.1	4.5	35	4.3	-20	-10	-15	-17	-18	31	28	11	17
New	-3.4	3.4	33	3.5	-15	-8	-11	-12	-14	27	27	9.2	14
	-4.25	3.95	34	3.9	-17.5	-9	-13	-14.5	-16	29	27.5	10.1	15.5
	-4.2	3.9	34.3	3.9	-17.3	-8.7	-12.7	-14.2	-15.5	29.0	27.3	-10.0	15.7

Table 39 show that in case of cotton crop, farmers who possessed SHC since one year have reduced fertilizer use significantly compared to farmers who possessed SHC just three months back. Yields have increased by near about 4 per cent both in old and new cluster groups while, Cost of cultivation was significantly less (3.4%) when compared to the farmers who possessed SHC since one year (5.1%).

Table 40: Status according to longevity of card (Paddy/ha)

Percentile Group based on period of holding SHC	Cost C2	Gross return	Net Return	Yield (qtl)	N (kg)	p(kg/ha)	k(kg)	fertilizer (kg)	Fert (Rs.)	Manure(q)	Manure (Rs.)	Cost A1	Returns over variable cost
Before SHC scheme													
Old	54668	68970	14302	38	79	35	22	136	4482	14	1237	35346	33624
New	55223	72600	17377	40	82	65	25	172	4570	13	1250	40195	32405
% change after SHC scheme													
Old	-5.2	2.3	22.9	2.6	-16	-9	-5.5	-12.2	-16	16.5	25	-11	12
New	-3.2	2.1	16.85	1.5	-12	-7	-7.2	-10	-13.5	20	28	-8.5	10.2

In case of Paddy (Table 40); yields have gone up among farmers who possessed SHC since for one year (2.6 %). Use of NPK is consistently less after SHC scheme. There is consistent decrease in fertilizer use which is true for all farmer categories. Net returns of the farmers who possessed the SHC since one year (22.9 %) have increased compared to the farmers who received SHC Just three months back (16.85 %).

Table 41: Status according to longevity of card (Soybean/ha)

	Cost C2	Gross return	Net Return	Yield (qtl)	N (kg)	p(kg/ha)	k(kg)	Fertilizer (kg)	Fert (Rs.)	Manure(q)	Manure (Rs.)	Cost A1	Returns over variable cost
Before SHC scheme													
Old	28496	39200	1304	14	20	37	3	60	2687	5	937	20459	18741
New	26760	33600	3840	12	22	35	4	61	2590	4	1000	19152.2	14448
% change after SHC scheme													
Old	-5.8	4.5	72	5	-16	-13.8	5	-13	-16	27	33.5	9.8	23
New	-3.7	3.2	64	2.8	-11.5	-10.5	3	-10.3	-13.6	23	28	7.2	20.8

Interestingly, use of fertilizer has reduced to near about 10-13% in soybean after SHC (Table 41). Among the farmers who possessed SHC since last one year, crop yields have increased by 5% with the reduced cost of 6%. Use of NPK is consistently less after SHC scheme in soybean was observed.

Table 42: Status according to longevity of card (Pigeon pea/ha)

Percentile Group of Month, Year SHC	Cost C2	Gross return	Net Return	Yield (qtl)	N (kg)	P (k)	k(kg)	fertilizer(kg)	Fert (Rs.)	Manure (q)	Manure (Rs.)	Cost A1	Returns over variable cost
Before SHC scheme													
Old	62437	92398	29960	19	48	41	9	98	4030	2	209	37462	54936
New	61950	91800	29850	18.5	47	40	10	97	4150	2	200	35931	55869
% change after SHC scheme													
Old	-4.5	-9.9	-21.1	6.7	-16.9	-13.9	-10	-18.9	-7	4.9	5.3	112	24
New	-4.5	-9.7	-20.4	5.4	-12.8	-10	-7	-16.7	-7.2	5	7.5	10.5	21

The use of fertilizers has reduced to 19% in case of pigeon pea, which is appreciable. It is a good sign, as the farmers generally don't apply fertilizers for pulse crops as indicated in Table 42. In line with this the yields have increased slightly among the oldest SHC users (6.7%) although from a very high base for Pigeon pea. As the crop is mostly grown under rainfed conditions and farmers priority on these crops are less. It also pointing that the design of the SHC scheme (10 ha unit) under rainfed conditions needs to be further improved.

Table 43: Status according to longevity of card (Wheat/ha)

Percentile Group of Month, Year SHC	Cost C2	Gross return	Net Return	Yield (qtl)	N (kg)	p(kg/ha)	k(kg)	fertilizer(kg)	Fert (Rs.)	Manure(q)	Manure (Rs.)	Cost A1	Returns over variable cost
Before SHC scheme													
Old	48202	70606	22404	34	106	49	5	160	4716	4	253	27957	42649
New	48525	70514	21989	35	110	48	6	164	4800	4	270	28145	42370
% change after SHC scheme													
Old	-7	4	28	4	-10	-18	-11	-7	-6	11	7	10.5	13
New	-6	3	25	3	-9	-15	-9	-4	-4	8	4	8	10

In the case of wheat, farmers who possessed SHC since last one year reduced fertilizer use and also total cost of cultivation (Table 43). At the same time their average yield has gone up by 4%. Urea use reduced by 10%, phosphorous use reduced by 18%, potassium use reduced by 11%. As a result, total cost has come down by 7%. Although, yields were increased among other farmers after SHC scheme, there was no consistency in fertilizer use.

5.10 Success stories and potential benefits of the SHC scheme

More intensive data was collected from 157 farmers across the states during the study (Table 44). This section illustrates the changes observed among these farmers. Out of 157 farmers, 149 farmers reduced nitrogen use and only 8 farmers increased after getting the SHC. Average reduction is 30 kg/acre (Reduction ranged between 0 and 210 kg per hectare). Out of 157 farmers, 119 farmers decreased phosphorous use and only 38 farmers increased their phosphorus use after SHC. On average farmers reduced phosphorus use by 11.8 kg/acre. Sixty farmers increased their potassium use after SHC, with average increase of 12 kg/acre. About 50 % of the farmers said SHC made them aware about soil health and helped them reduce the fertilizer use which ultimately leads to decrease in cost of cultivation. Out of 157, 143 farmers experienced increase in productivity after applying recommended doses as per SHC information. Overall, after getting SHC farmers have reduced N, P and K use, especially nitrogen use and increased micro-nutrients use.

Table 44: Success stories of reduction in fertilizer use

Crop cultivated	Before SHC (kg/ha)				After SHC (kg/ha)				% change after SHC				Production Before shc(kg/ha)	Increase in production (kg/ha)	Decreased in Value (Rs/ha)				Increased production value	Total gain (Rs/ha)
	N	P	K	MN	N	P	K	MN	N	P	K	MN			N	P	K	MN		
Cotton	316	119	56	0	237	43	30	0	-25	-64	-46	0	1850	300	632	1371	464	0	10500	12967
Ground nut	92	106	28	0	32	51	44	0	-65	-52	57	0	1680	466	478	992	-287	0	16310	17493
Maize	283	70	99	0	173	51	55	125	-39	-27	-44	125	2750	863	883	340	784	-1250	9493	10250
Paddy	182	81	53	3	109	59	42	18	-40	-27	-21	18	3280	1141	582	394	200	-150	15974	17000
Paddy, gram	20	14	2	10	12	6	2	10	-40	-57	0	10	3165	927	64	144	0	0	12978	13186
Ragi	109	132	66	0	75	54	35	18	-31	-59	-47	18	1940	1317	270	1402	558	-180	15804	17855
Soybean-gram	28	73	16	0	46	111	13	0	64	52	-19	0	1350	630	-143	-683	55	0	15750	14978
Sunflower	119	79	0	0	96	62	0	0	-19	-22		0	2030	1519	181	313	0	0	45570	46064
Total	174	88	49	0	106	59	41	20	-39	-33	-16	20	2268	1010	543	523	141	-198	17797	18807

Estimates from the table 44 shows that the gains from the practices of the recommended doses of fertilizers as per the SHC shows that, up to Rs.1000 can be saved from the reduction in fertilizer expenditure per hectare and also major gain comes from the increase in yields due to adoption of balanced fertilizers to the extent of Rs.17, 000 per hectare.

Fig. 19: Soil Test Crop Response Based Fertilizer Recommendation System

Figure 20: Soil Test Crop Response Based Fertilizer Recommendation System

5.11 <u>State wise and crop wise fertilizer consumption</u>

State wise consumption of fertilizers:

As per the Commission for Agricultural Costs and Prices (CACP) data show that there was wide variation in fertilizer application among different states (Table 46). For example, in the case of cotton fertilizer consumption was the highest in Maharashtra (256 kg/ha), while lowest in Madhya Pradesh (107 kg/ha). Similarly, in case of maize fertilizer consumption was the highest in Andhra Pradesh (244 kg/ha) and lowest in Chhattisgarh (only 21 kg/ha). In case of paddy highest fertilizer use was in Karnataka (313 kg/ha) and lowest in Assam (17 kg/ha). These types of anomalies can be eliminated through the adoption of SHCs and this will also reduce regional yield gaps to a significant extent.

Table 45: Analysis of Fertilizer use by crop across states (CACP data) 2013

Crop	State	Yield (qtl/ha)	Fertilizer use (kg/ha)	Gross Return (Rs/ha)
Cotton	Maharashtra	19	256	86947
	AP	17	221	70240
	Gujarat	22	216	106209
	Punjab	17	197	94563
	TN	15	180	70542
	Odisha	12	167	47586
	Karnataka	15	158	74865
	Haryana	16	139	85466
	Rajasthan	20	114	105814
	MP	17	107	79010
	Total	19	201	90385
Maize	AP	61	244	76205
	TN	49	212	65552
	Karnataka	40	206	50524
	Gujarat	17	147	33291
	Rajasthan	20	111	31409
	Bihar	23	100	31992
	MP	19	71	24940
	UP	20	70	28512
	HP	14	46	22486
	Chhattisgarh	15	21	18356
	Total	29	130	40194
Paddy	Karnataka	57	313	93307
	TN	51	235	77414
	AP	54	230	79154
	Haryana	48	209	124345
	Punjab	58	199	97222
	Kerala	47	176	97428
	Gujarat	34	173	54250
	UP	39	160	62707
	Uttarakhand	41	157	59953
	WB	42	141	60384
	Chhattisgarh	31	131	42507
	MP	34	114	61441
	Bihar	25	106	32557
	Maharashtra	31	102	53874
	Odisha	28	85	37616
	Jharkhand	19	53	25634
	HP	24	30	43420
	Assam	30	17	34753
	Total	38	138	58543
Sugar-cane	Maharashtra	1072	665	244612
	TN	951	415	237486
	Karnataka	848	383	180535
	Haryana	572	263	175556
	UP	497	202	140784
	AP	723	180	168031

	Uttarakhand	463	149	127016
	Total	814	418	199182
Wheat	Punjab	49	242	76828
	Haryana	46	205	82292
	WB	32	191	46693
	Gujarat	32	188	56414
	UP	36	179	62352
	Maharashtra	24	157	45308
	Uttarakhand	28	154	51012
	Bihar	27	144	49135
	Rajasthan	41	127	78468
	Chhattisgarh	16	123	24359
	Jharkhand	23	114	38478
	MP	32	108	54649
	HP	16	57	31029
	Total	34	161	59333

Table 46: Fertilizer use (kg/ha) in 2014-15

State/Zone	2014-15				NPK ratio		
	N	P	K	Total	N	P	K
Pondicherry	196	43	46	285	4.3	0.9	1
AP	147	61	30	237	4.9	2.0	1
Telangana	163	53	16	231	10.0	3.3	1
Karnataka	96	48	32	176	3.0	1.5	1
TN	97	36	31	164	3.2	1.2	1
Kerala	20	8	12	41	1.7	0.7	1
A&N Islands	13	10	7	29	1.9	1.5	1
South Zone	**106**	**43**	**26**	**175**	**4.1**	**1.7**	**1**
Gujarat	96	28	9	133	10.6	3.1	1
Maharashtra	69	34	23	126	3.0	1.5	1
Chhattisgarh	57	27	9	92	6.6	3.1	1
MP	49	26	3	78	15.5	8.4	1
Rajasthan	40	14	1	55	62.5	21.7	1
West Zone	**59**	**25**	**9**	**93**	**6.7**	**2.9**	**1**
Punjab	179	43	5	227	36.0	8.7	1
Haryana	172	43	6	221	28.0	7.0	1
Uttarakhand	129	24	7	160	18.7	3.5	1
UP	112	32	7	150	16.9	4.9	1
HP	36	9	10	54	3.7	0.9	1
North Zone	**131**	**36**	**7**	**174**	**19.7**	**5.3**	**1**
Bihar	133	31	15	179	9.0	2.1	1
WB	78	40	33	151	2.4	1.2	1
Odisha	36	15	7	57	5.3	2.1	1
Jharkhand	31	7	1	38	28.2	6.0	1
East Zone	**75**	**27**	**17**	**118**	**4.4**	**1.6**	**1**
Assam	68	22	35	125	1.9	0.6	1
Manipur	45	9	8	62	5.7	1.1	1
Tripura	18	14	8	41	2.2	1.7	1
Nagaland	3	2	1	6	2.8	1.6	1
Meghalaya							
Arunachal Pradesh							
Mizoram							
Sikkim							
NE zone	**45**	**15**	**22**	**83**	**2.0**	**0.7**	**1**
All-India	**85**	**31**	**13**	**128**	**6.7**	**2.4**	**1**

Source: Fertilizer Statistics

The state wise fertilizer use was given in table 46. It shows that the fertilizer use per hectare was the highest in Puducherry (285 kg/ha) followed by Andhra Pradesh (237 kg/ha), Telangana (231 kg/ha), Karnataka (176 kg/ha) and Tamil Nadu (164 kg/ha). The NPK ratio was close to the recommended practice for states like Pondicherry, Andhra Pradesh, Karnataka, Tamil Nadu, Himachal Pradesh and Maharashtra. In general, south and eastern zones NPK ratio is nearer to recommendation. But in case of northern states Jharkhand, Rajasthan, Punjab, Haryana, Uttarakhand, Uttar Pradesh is much different from the recommended doses and needs to be changed. SHC based recommendations will help in reducing these imbalances in fertilizer application which will intern help in soil health.

Chapter VI

Policy Recommendations

Soil health and fertility is the basis for sustainable profitability of the farmers. Using optimal doses of fertilizers and cropping pattern as per the scientific recommendation is the first step towards sustainable farming. Soil testing is a science based and time-tested tool for assessment of soil fertility status and soil ailments and for nutrient amendment recommendations. Soil testing, as a tool for judicious fertilizer use, works on the principle of profitability, meaning if all other factors of production are at optimum and none of them limiting, there is all probability to obtain more profitable response to applied nutrients based on soil testing than those applied on ad-hoc basis.

In India, the current consumption of NPK ratio is 6.7:2.4:1, which is highly skewed towards nitrogen as against ideal ratio of 4:2:1. India is spending nearly Rupees Seventy thousand crore on fertilizer subsidy every year. According to the estimates, subsidy amount is about Rs.5000/ha of net cropped area and about Rs.5100/farmer resulting in excessive use of fertilizers, especially NPK at the cost of micro-nutrients and manure. Hence, there is a need for balanced use of fertilizers, keeping this government of India introduced Soil Health Card Scheme across India (GoI, 2017).

On 5th December 2015 the ministry of agriculture introduced the soil health card (SHC) scheme. The SHC scheme has been approved for implementation during the remaining period of 12th plan. SHC will be provided to all farmers in the country at an interval of 2 years to enable the farmers to apply recommended doses of nutrients based on soil test values to realize improved and sustainable soil health and fertility, low costs and higher profits.

Under SHC scheme, cropped area was divided in to grids of 10 ha for rainfed and 2.5 ha for irrigated. One soil sample from each grid will be taken and test results will be distributed to all the farmers whose lands fall under the grid. Based on the grid system, of the total 14.1 crore hectare of net cropped area, 73 lakh grid samples to be collected to cover 7.3 crore ha in rain-fed areas and 2.7 crore grid samples to be collected to cover 6.8 crore ha irrigated land. That is, a total of 3.46 crore grid samples in two years (1.73 crore grid samples per year). And, an average of 25000 grid samples per district/year or 29 grid samples per village/year. With this, all 10.39 crore farmers will be covered in two years. Every year 5.2 crore farmers need to be covered.

Under cycle-1, 2.54 crore samples were collected, 2.36 crore samples tested, 9.62 crore soil health cards printed, but only 9.33 crore SHCs distributed. It indicates that 100% target archived in sample collection, 93% of the target achieved in soil testing, but only 80% of the target achieved in SHC printing. 97% of the SHCs printed were distributed among the farmers as on 24th September 2017. Now, in many states cycle-II is already started.

Objectives of the impact study

As the SHC scheme has completed more than 2 years of implementation, the ministry has initiated a nationwide impact assessment with the following objectives.

- To examine the design of the SHC scheme in terms of planning, implementation, inputs (staff, financial and other resources), activities (trainings, lab established and strengthened), outputs (SHC's printed and distributed to farmers).
- To assess the modalities of delivery of the SHC scheme regarding procurement, sample collection, testing, SHC printing and disbursal.
- To assess the level of utilization of SHC's by the farmers across farm size class, in irrigated and rain fed situations.
- To assess the impacts of SHC scheme on judicious use of fertilizers, bio fertilizers, organic fertilizers, soil health, cropping choice, cost reduction, farm profitability and sustainability.
- To provide recommendations for improvement of overall design of the programme.

Methodology

Both quantitative and qualitative approaches were adopted to achieve the objectives of the study. Qualitative information in the form of stakeholder interviews across the states under the study, expert opinion gathering at the national and state level workshops and interactions with the progressive farmers and agricultural officers were carried out. At the quantitative level, both secondary and primary data was collected at the national, state and farmer levels. Secondary data mostly pertain to financial and physical achievements of the SHC scheme over the years, infrastructure availability, coverage of SHCs across the states, etc., were collected and analysed. Besides, information at the international level was collected for some selected countries to see the best practices in the design of soil health cards.

The secondary data was analyzed for all the states, while primary data was analysed from 16 states of India representing all agro-climatic zones. A systematic sample was drawn for the impact assessment at the farmer level. Care was taken to represent the whole country and its agro climatic conditions. A structured questionnaire was canvassed among 3184 sample farmers across 199 villages in 16 states. In addition, focus group discussions were conducted in each village, to get the feedback from key-informants, farmers not covered for individual surveys and farmers who have not received soil health card. All the indicators collected from field survey were classified as inputs (financial and physical inputs under the project), activities (different activities organized under the scheme), outputs (actual outputs of the project), outcomes (whether generated outputs were utilized by the farmers) and impacts (what are the ultimate benefits to the farmers) and listed below. The analyses were carried out across zones / states and by the date of receiving SHC by the farmers' i. e, those who received more than a year back and those who received recently. This would help to understand the long term impacts and also would provide insights into whether agriculture development helps better awareness and demand for SHC.

Cost Concepts used in calculating the net returns and returns over variable costs

1. Costs are generated following certain cost concepts. These cost concepts and the items of costs included under each concept are given below:

Cost A1 (all paid out costs incurred by owner-cultivator):

i. Value of hired human labour.
ii. Value of hired bullock labour.
iii. Value of owned bullock labour.
iv. Value of hired machinery labour.
v. Hired machinery charges.
vi. Value of seed (both farm produced and purchased).
vii. Value of insecticides and pesticides.

viii. Value of manure (owned and purchased).
ix. Value of fertilizer.
x. Depreciation on implements and farm buildings.
xi. Irrigation Charges.
xii. Land revenue, cesses and other taxes.
xiii. Interest on working Capital.
xiv. Miscellaneous expenses (Artisants etc.)

Cost A2: Cost A1+rent paid for leased in land

Cost B1: Cost A1+interest on value of owned fixed capital assets(excluding land).

Cost B2: Cost B1+ rental value of owned land (net of land revenue) and rent paid

for leased-in land.

Cost C1: Cost B1+imputed value of family labour.

Cost C2: Cost B2+imputed value of family labour.

Cost C2*: Cost C2 adjusted to take into account valuation of human labour at market rate or statutory minimum wage rate whichever is higher.

Cost C3: Cost C2*+value of management input at 10 percent of total cost (C2*).

In this study only coast A1 and cost C2 were used to calculate returns over variable costs and net returns respectively be deducting costs from gross returns.

2. Imputation Methods

Some of the inputs used in the production process are provided by family sources. The criteria adopted for deriving imputed values of these inputs is given below:

Sl.No.	**Items**	**Criteria**
(1)	(2)	(3)
i.	Family Labour	On the basis of statutory wage rate or the actual market rate, whichever is higher
ii.	Owned Animal Labour	On the basis of cost of maintenance, which includes cost of green and dry fodder and concentrates, depreciation on animal and

		cattle shed, upkeep labour charges and other expenses.
iii.	Owned Machinery Charges	On the basis of cost of maintenance of farm machinery, which includes diesel, electricity, lubricants, depreciation, repairs and other maintenance expenses.
iv.	Implements	Depreciation and charges on account of minor repairs.
v.	Farm Produced Manure	Evaluated at rates prevailing in the village.
vi.	Rent of owned land	Estimated on the basis of prevailing rents in the village for identical type of land or as reported by the sample farmers subject to the ceiling of fair rents given in the land legislation of the concerned state.
vii.	Interest on onward fixed capital	Interest on present value of fixed assets charged at the rate of 10% per annum.

3. Allocation/Apportion of Joint Costs:

The expenditure incurred on, or imputed for, some of the cost items relate to the farm as a whole. Such joint costs are allocated to individual enterprises, among different categories of livestock and so on. Depreciation on farm buildings and implements, land rents, land revenue, cesses and taxes, interest on owned fixed capital are such costs, which are allocated to each category of crops in proportion to their areas. The cost on livestock is allocated to each category of animals in proportion of its numbers to the total number of animals owned by the farmer.

The apportionment of total costs incurred jointly on different crops grown in mixture crops is done in proportion to the total value of output contributed by individual crops in the crop mixtures. The apportionment of total costs of cultivation between the main product and the by product(s) is done in proportion to their contribution to the total value of output.

- **Results**

It may be noted that the analysis is based on the representative, though limited, sample size across regions. It is too short a time for the scheme (only 2 years old) to carry out a full-fledged impact assessment. The present analysis provides insights about the direction and cautions about any short comings. While the following conclusions and recommendations are based on the analysis, the weakness of the assessment needs to be kept in mind.

- ✓ Given the short duration of the scheme, awareness levels are good. At the same time participation of farmers in meetings, exposure visits are not high. Awareness campaigns need to be organized on content of SHCs, use of recommended practices, reduction in fertilizer use and costs and increase in profitability.
- ✓ There is no apparent or significant bias against socio-economically vulnerable sections. In contrast, small and marginal farmers benefit more in some cases.
- ✓ There is some reduction in fertilizer use, especially nitrogen and increase in bio-fertilizers and other micro-nutrients use. This is a good sign as N: P: K ratio was highly skewed towards nitrogen. Costs were reduced due to low fertilizer use. Crop yields have also increased for majority of the crops, although only moderately.
- ✓ A significant impact is the increase in the use of gypsum and other micro nutrients to some extent.
- ✓ There is a need for strengthening the soil health card related extension services to provide better advisories.
- ✓ Two-thirds of the sample farmers indicated that SHC is beneficial which is encouraging, given the short span of the programme.
- ✓ Main complaint from the farmers is the timeliness of providing the results. This, however, is linked to the infrastructure (soil testing labs) and human resources. However, after the introduction of the SHC scheme, the time lag is significantly reduced. Results needs to be disseminated before sowing season, so that farmers will practice recommended crop choice and fertilizers.
- ✓ It is important to address these issues to gain confidence of the farmers in adoption of the fertilizers as per the recommendation in the SHC.
- ✓ The scheme has a poor backing of infrastructure and human resources, with significant gaps. Although some southern and western states performed better, some states are even allocated resources are not being spent or utilized due to lack of capacities. This should be of high priority in the immediate future.

- ✓ Proactive regions seem to be better in this regard.
- ✓ Lack of capacities with regard to skilled personnel and STLs is affecting the quality of services, which in turn affects the credibility of the scheme, and needs immediate attention.
- ✓ Results need to be provided in time so that farmers can benefit better.

6.1 Soil sampling related (SHC design)

- There is a need to identify best practices in soil sample collection and testing by examining across countries and different state governments practices. There is also a need for coordination and cooperation.

- The existing uniform grid of 10 ha for dry lands and 2.5 ha for irrigated lands is not taking in to consideration local soil variability. Grid size should be variable based on the soil variability index. Grid size should be decided at least at block level based on soil heterogeneity, fertility maps, cropping pattern, irrigation facilities and remote sensing maps. If soil is more variable, grid size should be reduced and vice-versa. Sampling errors needs to be reduced by using variogram. There should be a separate cell to monitor and recommend grid size across the country. It will also reduce cost, money and manpower and increase relevance of recommendations to farmers. In order to gain credibility of the farmers, at least one sample from each farmer should be included where soil variability is high.

- Soil variograms needs to be developed at each block level. Based on the soil variability, grid size may be determined. Variogram gives information about spatial pattern of continuous soil attributes. The variogram may be used as a critical input to decide required soil samples to be collected based on the soil variability index. More soil samples should be collected if the block level soil variability index was high and vice versa. Variogram is a tool to investigate and quantify the spatial variability of soil properties. The geostatistical literature shows that the following soil quality indicators were found to be the most important for variogram analysis. Ministry may consider following soil quality indicators. The available data with Indian Institute of Soil Science, Satellite maps of remote sensing agency of ISRO and Land use planning data can be used to estimate block level soil variograms.

- The following soil indicators may be considered to construct block level soil variogram: (1) Soil Colour, (2) Slop, (3) Sand (%), (4) Silt (%), (5) Clay (%), (6) Nitrogen (N), (7) Phosphorus (P), (8) Potassium (K), (9)Organic Matter (OM), (10) Organic Carbon (OC), (11) pH, (12) Cation Exchange Capacity (CEC), (13) Electrical conductivity (EC), (14) C:N Ratio, (15) Cropping Pattern. The ICAR-Indian Institute of Soil Science (IISC), Bhopal, ICAR-IISWC- Indian Institute of Soil and Water Conservation, National Remote Sensing Agncy (NRSA), Hyderabad and land classification/atlas can be consulted for developing block level soil variogram.

- Evidence shows that sample collected from 20% to 30% of the farmers in a village is enough to get reasonable soil quality for advising farmers, hence there was no additional benefit in covering each grid of 10 ha in case of dry lands and 2.5 ha in case of irrigated land if the soil is fairly uniform. In some cases, only 20-30 samples/500 ha is sufficient as evident from ICRISAT experiments. This, however, needs to be explained to the farmers so that they would take the SHC recommendations seriously. One needs to be mindful of efforts and resources gone into ICRISAT experiments.

- Although, in some states, grids were pre-determined in the mobile app (like in Punjab), but in some cases the procedure followed in dividing the cultivated village land in to grids is not known to many agricultural officers and needs to be widely disseminated for accurate sampling and same should be mentioned in the guidelines. Interestingly Punjab state is adopting GIS-tablet grid identification and GPS-based soil sample collection application, which seems to be working well and likely to solve many field level sample collection problems. This model should be adopted across all the states after an in-depth understanding (study) of the model.

- High density soil maps need to be developed for increasing precision at village level.

- Agricultural officers and agricultural extension officers' need to be given appropriate training, transport and easy to use sampling tools and incentives for scientific sample collection.

- Coordination of agricultural extension officers and farmers needs to be enhanced and extension officers should make sure that most of the grid farmers, if not all should be present at the time of soil sample collection. This will build confidence on the soil health cards by the farmers.

- It was observed by study team that in some of the block agricultural offices, soil samples were kept aside for many days and soils were exposed to moisture and weather. After soil sampling, drying should be done within 15-20 days, grinding, machine sieving and bottling should be done in time for proper test results. Sample test results should reach farmers before sowing season. It may be a good idea to limit sample to the capacities. The target should be to provide more accurate results rather than coverage. This would create demand for soil testing once the credibility of the testing is established.

6.2 Soil Health Indicators (SHC design)

- The whole chain of soil health-plant health-human health should be taken in to account and there is a need for promotion of application of balanced application of soil (macro & micro) nutrients.

- Excess application of urea results in accumulation of nitrate in soil and water is becoming a huge environmental problem in India. Hence, water quality information need to be included in the SHC.

- The soil health card is more focused on chemical nutrient indicators; among physical and biological properties only soil color is included. Some more physical properties like slop of the land, etc. needs to be incorporated.

- Microbial activity, moisture retention activity are essential but missing in SHC. Although soil organic matter is indicated, many soil testing labs are not equipped with latest tools to measure it.

- At least one or two physical and micro-biological indicators (such as soil texture, water holding capacity, water quality and bacterial content) need to be incorporated. Index of soil health needs to be developed and incorporated in to SHC which indicates overall health of the soil.
,
- Although basic structure of SHC should be uniform, states should adopt/change as per their agro-climatic zones and needs. Some of the

indicators, which needs to be included in SHC were (i) cropping history, (ii) water resources (soil moisture), (iii) slope of soil, (iv) depth of soil, (v) color of soil, (vi) soil texture (bulk density) and (vii) Micro-biological activity.

6.3 Soil Testing Infrastructure

- About 1454 labs exist in India, of which only 700 are equipped with micro-nutrient testing facilities. Although, recently agricultural departments procured about 7000 mobile kits, they are not as good as that of full-fledged labs. Very few of the labs could take up micro nutrient analysis. They are neither equipped with skilled personnel or chemicals nor functional equipment. This infrastructure is grossly inadequate by any standard, given that 11 crore farmers need to be covered.
- Under the current PPP model, investments in labs to be done by private companies with an element of subsidy. A competitive bidding process based on technical and financial bids to be called for and companies which quote reasonable cost (per sample) should be selected. Government will pay on per sample basis with the condition that they employ qualified and trained chemists. This model will be successful when there is no strong Government presence in soil testing. However, the quality of such reports should be got checked at random by authentic agencies.
- About 45% of the sample farmers are inclined to go to private STLs. At the same time only 20 % of the farmers are willing to pay for the services. Hence, one must find ways to support farmers in this regard i.e., direct subsidy to the farmers or private STLs, etc. A competitive PPP model could be explored in this regard, while government should take up the monitoring of the functioning of these labs more seriously. At the same time, there should be special incentive for Farmer Produce Companies (FPCs) to establish soil testing labs. There is a need for encouraging competition among private companies in setting up and running the soil testing labs so that they maintain quality at reasonable cost. Institutional modalities could be worked out on how to equip and manage STL within the FPCs frame work.

- Some of the private soil testing labs indicated that the cost of sample collection and testing was up to Rs.1000 / sample. Some private companies are charging Rs.75 / element and accordingly for 12 elements the total cost will be Rs.900/sample. Government should be more realistic in fixing the prices for private parties. Instead it should focus on quality of the services at an acceptable (market) cost.

- Strengthening and upgrading at least one soil testing lab per district as state-of-the-art lab, this should be equipped with world class infrastructure and accredited by internationally recognized agencies either in public or by private sector. So nearly 700 state-of-the-art labs are needed to act as referral labs and also to give broad advice to farmers. The cost per unit will be about Rs.4-5 crore/unit, with a total of Rs. 2800 crores. However, if this resulted in Rs.1000/ha savings in fertilizer use even if we don't consider the yield increase resulted in a saving of Rs. 14, 500 crores in a year to the economy. This could be worthwhile investment rather than spending money and providing services that have little value to farmers year after year i.e., ending up spending more in the long run.

- State-of-the-art district level soil testing labs at direct level should be equipped with Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) which costs about Rs.40-50 lakhs. These labs should have 24 hour generator for uninterrupted power supply, computer labs with colour printing facility, Air Conditioned Laboratories. In addition the lab should have the following equipment for conducting soil testing in large scale.
  - KEL PLUS automatic nitrogen determination distiller
  - Automated Flame Photometer (for Potassium)
  - Automated Spectrophotometer (for phosphorus)
  - Atomic Absorption Spectrophotometer (for Zn, Fe, Mn, Cu)
  - Water distillation still (20 lit/hour)
  - All glass distillation unit (5 liter/hour)
  - Auto-analyzer (N&P)
  - Automated pH meter
  - Automated EC meter
  - Centrifuge

- Some soil scientists and agricultural officers are of the opinion that test results of mini-kits (mini-labs) are not accurate enough as that of full-fledged labs. Mini-kits need to be standardized and tested for errors in calibrations. A Mini-kit cost about Rs.94,800, with this per sample cost comes about Rs.170-200. Mini-kit is useful for remote villages and tribal communities and also should be used for measuring highly volatile elements like Nitrogen which needs more frequent measurement. Some block agricultural offices received 5-6 mini-kits, but they were not able to utilize them, as they are involved in multiple-activities.

- Soil testing is a specialized and highly skill oriented job. Frequent transfers of soil testing staff adversely affect the skill development within labs and test results will affect badly. There is a need to build some permanent staff in the labs who are interested and specialized in soil testing. Field observations indicate that only women officers are interested in working with soil testing labs.

- Managing the state of the art soil testing labs could be established under the purview of FPCs federation or a nodal FPCs at the district level. The governance responsibilities should be handed over to them to run them as business models. Back of the envelop indicates that establishing a state of the art lab with Rs. 6 crore as loan from NABARD in each district looks viable give that an average 25000 samples need to be collected and processed per year. At the Rs. 1500-2000 per sample (at half the market price for a detailed soil analysis), the investments will be paid back in less than 2 years. State department can have a monitoring cell created especially for this purpose. And extension services need to gear up to deal with soil health advisories. FPCs should be encouraged to set up demonstration plots.

6.4 Soil Extension

- SHC recommendations should be accompanied by block level recommendations. Find an intermediate solution (based on both village level soil maps and SHC recommendation) for reaching the farmer's level.

- There is a need for demonstration of benefits of SHC on an experimental basis in each block by adopting a comprehensive approach (systematic and scientific analysis of soil and water) and adoption of recommended doses. This would have much greater impact than the subsidized and less authentic information. General SHG scheme and model farm initiatives should go together.

- In many villages, agricultural officers are distributing SHCs in awareness campaigns through village presidents and Mandal/block democratically elected representatives. However, in some villages, village revenue assistant is distributing SHC and taking signature, without explaining the content. Whenever SHC is distributed in awareness campaigns and meetings directly greater number of farmers feel that they are convinced to use recommended practices. There is a need for following standard protocol to inform farmers about the recommendations of the SHC, when it is handed over to farmers.

- A specialized body is needed both at central as well as at state level for the management of soils. They should be given responsibility of monitoring the quality of service by various agencies. This also provides continuity in the workings of the department.

- Development of GIS based soil fertility maps at village/block level and wider publicity through wall-posters and display boards in village panchayats should be promoted. Advertisements, slogans, etc. should be developed in local languages to increase awareness. This should be taken up in a campaign mode i.e., in the lines of anti-smoking / tobacco campaign.

- Many farmers are not aware of SHC portal. SHC portal should be more farmer friendly and simplified. A professional body may be employed to design the portal in more farmer friendly and effective manner.

- A simple tool to assess the quantity of urea, DAP and MoP based on SHC needs to be displayed as wall posters in the villages.

- It should be mandatory to enter fertilizer purchases by the farmers on the soil health card by each fertilizer dealer along with signature. It will not only increase awareness, but also help in adoption as per the recommendation.

6.5 Policy related

- If the SHC programme needs to be successful, the high fertilizer subsidy for NPK should be reduced. Prices should reflect true cost to economy, then only farmers will have incentives to use fertilizers judiciously accordingly to the recommendations of the SHC. On the contrary, subsidy on micro-nutrients should be increased. However, quality of micro-nutrients supplied on subsidy basis in some states is highly doubtful.

- Government should set up state of art labs to test quality of micro-nutrients supplied. Accreditation of such labs to National/international standard institutes should be initiated. Supply of phosphorous soluble bacteria should be mandatory along with phosphate fertilizers and rock phosphate like neem-coated urea. FPCs need to be encouraged to take up SHC scheme as a business model through setting up the state of the art labs at the district level. Since FPCs are already involved in selling fertilizers, they are in a better position to stock the all the required (according to SHC recommendations) fertilizer and micro-nutrient compositions and supply to individual FPCs across the district.
- State-of-the-art district level soil testing lab should be equipped with Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) which costs about Rs.40-50 lakhs. These labs should have 24 hour generator for uninterrupted power supply, computer labs with colour printing facility, Air Conditioned Laboratories. In addition the lab should have the following equipment for conducting soil testing in large scale.
    - KEL PLUS automatic nitrogen determination distiller
    - Automated Flame Photometer (for Potassium)
    - Automated Spectrophotometer (for phosphorus)
    - Atomic Absorption Spectrophotometer (for Zn, Fe, Mn, Cu)
    - Water distillation still (20 lit/hour)
    - All glass distillation unit (5 liter/hour)
    - Auto-analyzer (N&P)
    - Automated Ph meter
    - Automated EC meter
    - Centrifuge

- There should be some incentives/awards for the farmers who grow green manure, vermi-compost and whose soil fertility increased over the years based on Soil Health Card.
- Some incentives to be given to local bodies who encourage good practices like recycling crop residues, encourage common lands for corporates, etc.
- Similarly, incentives can be given to villages when they adopt crop rotation with legumes.

- Innovative techniques like neem coated urea (for slow release of fertilizer in to soil) needs to be promoted by the government. Provide 45 kg urea bags instead of 50 kgs. This will reduce the loss/excessive use of fertilizers by about 10-20% especially by small and marginal farmers.
- Soil sample collection, testing and printing at district level is significantly positively influenced by fertilizer use, number of bank accounts, net sown area, number of soil testing labs and households having mobiles.
- Other policies like water exploitation, electricity, etc. should be in line so that crop diversity that can protect soil health in the long run.

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Annexure-1

Feedback from agricultural officers on status of soil health card and improvement needed

Questions	Feedback from 27 officers
Status of soil health card scheme	
Status of procurement of maps(patawari maps),field instruments(GPS) and deployment of staff for collection of samples from farmers' fields	Majority of officers mentioned that they don't have patawari maps, instead they used remote sensing data. They use GPS system from their mobile and faces shortage of manpower and funds.
Methodology of soil sample collection (10 ha grid for rained and 2.5 for irrigated) is adequate?	Only 9 officers said sampling methodology is adequate. Others said, for homogenous land it is okay but it is inadequate in majority cases because of variability, topography and 10 ha is too big for precise analysis.
Status of soil testing facilities including soil testing labs and mobile labs?	Quality of almost all labs are poor. Many of them are capable of measuring only NPK, not micronutrients. Most of them are outdated and faces shortage of expert man power.
Availability of colour Photostat machine, standard paper for printing, printing machines and mechanism for distribution of soil health cards to farmers?	16 officers said laboratory infrastructure is good.
Release of funds, time lags between release of funds to actual utilization	13 officers said there was time lag, with insufficient funds.
SHC portal usefulness to farmers: rating from 1 to 5	All officers said portal is useful but farmers are not aware of it and they don't have required facilities.
Over all targets versus achievements as per the annual action plan	23 officers said they achieved their annual targets but they faces man power shortage.
Soil health Management (indicators)	
Number of AEOs/TOTs trained under the scheme	Very few of total district level officers are trained.
Number of soil testing laboratories (analyzing capacity and utilization)	20 officers said at least one good lab at district level but its capacity is low so hence there is need for more labs.

Referral labs are they sufficient?	12 officers said referral labs are not sufficient and 11 officers said they are sufficient.
How many STLs equipped with soil test based crop response (STCR)?	Only 11 labs at district level are equipped for STCR.
Number of demonstration conducted and number of participants involved?	12 officers said they have given many demonstration, reaching to many farmers.
Socio-economic impact on farmers(indicators)	
Number of SHCs among small and marginal farmers and SC/ST farmers (whether main field located in their farm)?	15 officers stated that up to some level small and marginal, SC/ST farmers are getting SHC. In some cases main field is not located in their farm.
Is there was any difference in crops identified in SHCs and actual crops sown by farmers?	Yes, farmers are not taking SHC crop advice.
Is there any difference in recommended fertilizers based on SHC and actual application?	20 officers said there is significant difference, many believe that recommended doses are not practical.
Status of use of organic manure and bio-fertilizers by farmers	Majority officers said farmers are aware about it, many are using organic manure but not bio-fertilizer. Many said there is no bio-fertilizer available in market. Organic manure use is greater in case of small farmers, large farmers don't use it.
Integrated nutrient management practices followed by farmers	Majority officers said few progressive farmers are practicing it but only in case of horticulture crops (high value crops).
What is the attitude of farmers towards soil health card?	22 officers said farmers are aware and have positive attitude but many are skeptical. It will take time earn trust of farmers.
Soil productivity and economic return to farmers	Majority of officers agree that SHC helps farmers to improve soil health and ultimately increase productivity but economic benefits are uncertain because of marketing problem.

Annexure-2

Soil Health & Soil Testing: some practical issues (expert opinion)

Soil testing is a science based and time tested tool for assessment of soil fertility status and soil ailments and for nutrient and amendment recommendations. Soil testing as a tool for judicious fertilizer use works on the principle of profitability, meaning if all other factors of productivity are at optimum and none of them limiting, there is all probability to obtain more profitable response to applied nutrients based on soil testing than those applied on adhoc basis. Unfortunately, soil testing in India continues to be a government driven programme rather than farmer's driven one. The number of STL's are inadequate vis-à-vis the number of operational holdings, but equally true is that the demand for soil testing is extremely low. Farmers do not opt for soil testing as a basis for their fertilizer use decisions.

In my opinion the qualification peaks developed by ASCI hold good when you have large number of private soil testing laboratories, which are self-financed and which can gain sufficient income. Unfortunately, the soil testing and soil health care issue is a skill development activity with little income generation. It serves as a decision tool for making fertilizer recommendations.

One of the reasons for failure of soil testing in making a breakthrough year all these be grouped as follows:

1. Lack of awareness among the farmers
2. Soil sampling techniques being followed
3. Inordinate delay in the analysis of soil samples, sometimes the results are given 3-4 months after the sample is analyzed
4. Lack of proper laboratory facilities including frequent power breakdown, availability of chemicals, glassware, water facilities, upkeep of instruments and equipment's.

In this context, the ASCI has suggested training for 3 QPS namely

- Soil samplers/collectors
- Soil and water testing lab analysts
- Soil and water testing lab assistants

5. It is worth mentioning that the soil sample collection work is normally taken up during the months of May-June of every year, i.e., 1-2 months in a year and the rest of the time, the soil samplers do not have any work. Once the sample is collected, where the sample has to be sent? Who has to carry out the analysis? Where are the laboratory facilities? Who are the people to man these laboratories? What are the standard procedures being followed? Do we have standard practical manuals for use in STLs?
6. Unfortunately the soil testing is a government driven initiate in India with very little of farmer partition.

Some of the reasons for failure of STLs indicate that lack of qualifies and capable of the manpower in STC is a major constraint as most of the staff in STL are not qualified and not competent enough to do the analysis.

Another major constraints is the lack of or week linkage between Dept. of Agricultural and other research organizations like SAU's, NGO's etc.

- Critical analysis tells that Lack of qualified and capable man power in STL is the major constraint as most of the staff in STL are not qualified and not competent enough to do analysis
- Training support from research organization to STL personnel is at poor level. Consequently, the scientific fertilizer recommendations don't get transferred from SAU, research organization to extension agencies.
- Lack of knowledge of improved analytical methods, Lack of latest and sophisticated equipment, inadequate and lack of automation are the major technical and financial constraints.
- Lack of computers and adequate software in STL also results in non-optimal utilization of STL capacity.
- To focus on soil testing, there is need to open separate Directorate on soil testing at state level on the lines of Dept. of Agriculture.

- There is need to appoint continuous monitoring committee on soil testing at state, district, *mandal* level. The monitoring committee at state level may involve Dept. of Agriculture, SAU, Fertilizer firms and farmer representatives.
- Qualified and capable personnel are to be appointed.
- Capacity building is to be provided through practical methods to all the staff involved in soil testing up to gross root level which includes method of sampling, laboratory methodology and interpretation of STCR recommendations for a reasonable period.
- Cross checking of soil sample analysis is to be made at central laboratory.
- High targets are to be reduced and are to be made reasonable
- Nominal fee is to be charged instead of free cost for soil sample analysis.
- Farmer awareness and training programs on representative soil sample collection, analysis and application of fertilizers as per STCR technology are to be organized. Few selected farmers from each *mandal* may be sent other research organizations like IISS, Bhopal for latest technology.
- Motivation techniques for soil testing personnel like performance based promotions, special increments, exposure visits, deputation for related seminars and workshops are to be followed STLs.
- Publicity program on soil testing through pamphlets, newspapers, mass media, even up to village level with fertility status maps & recommendation is to be made.
- Financial powers like contingency amount to a minimal extent to the in-charge of soil testing to meet day to day constraints at laboratory level.
- Soil testing is to be made as a central subject
- Soil testing programme is to be brought administratively under Dept. of Agriculture and technically under the State Agriculture University.
- Transfer of STL staff must be from one lab to other lab, but not to other depts. No additional unrelated works are to be assigned to them like election duty, etc.

Efficiency Factor

- Collection of soil samples will be done mostly during summer season when there is no crop.
- Thousands of samples will reach laboratories for analysis during that period
- A minimum of 35-30 samples a day (all parameters inclusive) could be a possible target.
- Running the labs at 10,000 samples/year capacity would need very efficient, effective systems and processes in place for 100% capacity utilization.
- Time saving without compromising on quality and reliability is a challenge.

Practical issues and steps to improve the facilities

- Most of the laboratories in India are still adopting single extractants for individual estimation of nutrients like P, K, and S etc.
- There is no problem with those but, consume more time and resources and strain the workers very much.
- Availability of qualified passionate, dedicated manpower to work in Labs is a challenge.
- Manpower having specific qualification, aptitude and passion shall be allotted this job to obtain desirable results.
- They should be trained often to enhance operational efficient.
- Incentivize operations and motivate them to enhance work efficiency.
- Inconsistent power supply, unfavorable working environment in rural and semi-urban areas where most of the laboratories are situated.
- In order to have un-interrupted operations, alternative power sources like generator, battery back-up will be useful.
- Adopt those instruments which can work with chargeable battery as well as power sources.
- Instruments shall be more rugged, reliable and be able to perform under abnormal working conditions.
- Use of semi-automatic/manually operable equipment (that can be serviced locally, having less power dependency) is more practical option than using fully automated equipment that will have no control on operator.

- Induction of new system is important.
- There is a need to update recommendation with the current knowledge based on sound agronomic, research. Decision support system (DSS). Models shall be widely used to make appropriate fertilizer recommendations.
- Networking and frequent up gradation of soil test information in public domain will help implementing new ways and means of fertilization practices, site-specific nutrient management options at large scale.
- Delays in reporting of test scale.
- Automation in operation from sample registrations to test results data entry till generation of test reports will save time considerably for routine operations.
- Good that some states have implemented on-line or web-based reports generations.
- Linking of soil health cards and issue of soil passbooks, linking them to fertilizer subsides, green manure seeds, organic manure and also provide only the fertilizers needed for crop in his field and avoid excess use of fertilizers.

In conclusion to make soil testing a viable tool for sustainable productivity, the following may be attempted.

- Soil testing is a great tool to assess soil fertility and nutrient supplying capacity
- Timely reporting of soil test results to farmers is crucial in whole programme.
- Speed and reliability of operation is most important.
- Appropriate systems and processes should be in place to effectively implement the program to get desired results.

Instead of planning the training for soil samplers/collectors soil and water testing lab analysis and soil and water testing lab assistants, an alternative suggestion could be that, since most of the states are offering 2 years diploma in Agriculture, such training may be given to these diploma holders, as they already have a preliminary idea about the subject, its importance and during the slack season their services could be utilized for other agricultural related activities. Further, in many of the states, there are VDO's/ AEO's (below the rank of AO's) who could drafted the soil and water analysis and the AO's could be trained on advanced aspects like GPS, induction systems, soil health cards fertilizers recommendation etc., as their services could be utilized in a more efficient way.

Annexure-3

Field Observations (compiled across states)

- In some states progress is not satisfactory
- Majority AEOs and farmers not having awareness on process of collection of soil in the fields
- Majority farmers did not get SHCs even after six months after the sample collection as there was a shortage of soil testing laboratories at local/district level.
- In most of the cases, farmers were not involved in the collection of the soil samples and many times their fields were not covered. So farmers are not taking it seriously.
- Farmers expressed that they have more than two parcels of land with varied soil quality but samples were taken from one parcel only. SHC based on one parcel is not suitable for other parcel of land.
- They wanted to take soil samples from each plot
- Some farmers did not have awareness on the utility of SHC results and they lost their cards
- Even AO/AEO did not explain content and use of SHCs to the majority farmers while distributing them.
- Some farmers told that even AEOs not much aware about the results and they need sensitization about the scheme for proper dissemination of knowledge about SHC.
- Some illiterate and marginal farmers told that AEOs have not contacted them and met only big and progressive farmers
- Progressive farmers or big farmers followed the recommendations of SHC
- In all most of mandals micro nutrients in the soil are very poor. Marginal and small farmers were unable to adapt these practices due to high cost and also non-availability of nutrients. Only some big farmers are using them.
- Some farmers not followed SHC recommendations because (i) they don't understand the content, (ii) they are costly, (iii) non-availability, (iv) believe in high doses of fertilizers, (v) followed traditional application use of fertilizers
- Sensitization meetings, trainings, distribution of SHCs through elected representatives and follow up by Agriculture department on SHC are increasing utility of SHC.
- Farmers expressed that results of soil sample were given for a specific crop. So they could not understand the application of fertilizers for the rest

crops. SHCs are also not mentioning the alternative cropping pattern suitable for the local conditions.

- Farmers were not convinced on soil test because earlier agricultural department took 4-5 times soil samples from some of the farmers, but results were not communicated even after 2-3 years. They got SHC only from this scheme.
- Farmer's feel that if they follow SHC recommendations they face some problems. For example, in tribal areas as per SHC if they use more 'N', crop would be attacked by more pests and diseases. Although some farmers adopted recommended doses of fertilizers, they revert back to their traditional methods.
- Some farmers got (1-2 farmers for GP) soil test from NGO, Private fertilizers companies and KVKs etc. during 2008 to 2013. KVKs and private labs charge for the same. But they explain the content to farmers and most of the farmers practiced the recommendations promptly.
- Overall some farmers reduce fertilizers application by getting advice help advise from progressive farmers or big farmers or educated farmers
- After soil test majority farmers using are micro nutrients earlier they did not know.

Study Limitations

- GPS not captured in some villages
- In Telangana state, new AEOs were appointed in Feb'2017. So they were unable to mobilize farmers who got SHC last year.
- In some *mandals*/villages, SHC were not distributed to farmers due to shortage of soil testing labs.

Recommendations:

- This scheme is very useful for farmers. Some constraints gaps were observed in implementing the scheme.
- Awareness to be created to the farmers on SHC and its result importance, etc.
- To build capacity of AOs or AEOs for promotion of fertilizer/nutrient management practices
- More meetings, trainings are needed to the farmers and also follow up is necessary for success of the scheme
- Separate staff is required for SHC to more efficiently promote recommendations to all farmers
- Establishment of state-of-the-art labs in all district headquarters with large capacity to meet the target in the district is need of the hour. Mini-labs needs to be further upgraded for accuracy and speed.
- Micro nutrients may be provided at subsidized prices to the farmers for 2-3 years and they follow subsequently themselves
- AEOs are not able to actively participate in SHC scheme as they have multiple tasks and having pressure
- KVKs, SAUs, ICAR institutions and Private companies should participate in the programme by involving educated local youth for soil sample collection, testing and distribution.

Appendix-1

Review of Recent Studies

No	Reference	Context	Methodology	Analysis
1	**Can information help to reduce imbalanced use of fertilizers in India? Evidence from Bihar**			
	Ram Fishman, Avinash Kishore, Yoav Rothler, Patrick S. Ward, Shankar Jha, R. K. P. Singh.	3 districts from Bihar. Period of study April 2014.	Sample from 509 households (treatment) and 294 households (controlled) were collected. A simplified becker-degroot-marschak method was used to calculate WTP of farmers for zinc deficiency.	Data from sample fields show that gap between recommended fertilizer application and actual application is huge and especially larger in case of urea. Main reasons for famers ignorance of recommendations of soil health card were as follows: 1.farmers didn't understand the contents of the SHC 2. Farmers didn't find the soil analysis and fertilizer recommendations to be reliable or compelling. 3.other factors such as cost, liquidity or timely availability of specific fertilizers were constraints

2	**Soil health mapping and direct benefit: transfer of fertilizer subsidy**			
	ICRISAT research report IDC-6		Author's collects data from various government authorities and ground level farm results after implementation of bhoomichetana project.	Introduced direct benefit transfer in fertilizer subsidy to increase efficiency and strengthening fertilizer supply chain. Apply integrated nutrient management with emphasis on organic fertilizer. Authors calculated with some assumptions that total benefits with soil health mapping and soil test based fertilizer recommendations along with improved practices will be Rs.4.33 lakh, while the cost estimated at Rs 0.254 lakh crores. The benefit-cost ratio would be 17:1. In addition to economic benefits several environment benefits, employment generation and enhancing sustainability of Indian agriculture will be additional benefits.

3	**Dynamics of Soil Fertility Management Practices in Semi-Arid Regions: A Case Study of AP**			
	B Suresh Reddy- EPW	Andhra Pradesh	A total of 360 farmers were collected from 3 district of AP and were personally interviewed, using a structured schedule and ex post facto research design coupled with case studies & PRA methods. Secondary data was also collected, Fertilizer recommendations were obtained. The data gathered was analyzed using average, frequency & percentages. The Baletese & Coelli model was used to calculate average technical efficiency. After regression analysis using frontier production function, the average TE was calculated.	Study was made for in depth knowledge on SFM strategies adopted by farmers in dry land areas, examine the significance of SFM practices and contribute to the overall policy discourse on SFM in semi-arid areas. Farmer's practices are based on their long experience & rich knowledge of locally specific conditions. Combination of chemical fertilizers and FYM was a predominate practice, followed by mixed cropping and legume cultivation. This shows that farmer understands the role of FYM and other organic manure. Analysis also showed a positive sign or the emerging organic markets. The availability of FYM is limited and advertisements cause the farmers to use more of chemical fertilizers. Recommendations given by the scientists do not hold true in the conditions under which the farmers work. Several recommendations were given based on the analysis.

4	**Impact of Saline Soil Reclamation on Enhancing Farm Productivity and Farmers Income in Karnataka – An Economic Analysis**			
	Raju R. *Thimmappa K.* *A.L. Pathan* *Siddayya -* *NAAS*	Karnataka	Study was conducted in Ugar Budruk village in Karnataka. There 70% of cultivable land was affected by salinity and waterlogging. SSD was installed between 2009-10 and 2011-12 in 925 ha covering 644 farmers. Study was based on both primary as well as secondary data which was collected from 120 sample farmers by area random sampling. The costs and returns were estimated by using inputs and outputs and multiplying it by the current year prices as well as by using the cost concepts. These were them used to compare the pre and post SSD effects.	Soil salinity- major cause of land degradation. Surface drainage technology for saline land reclamation is technically viable, economically feasible and socially acceptable. Land use was intensified, cropping patterns changed in favor of more remunerative crops and crop yields increased. Cropping intensity increased showing positive effect. There was a significant reduction in the max and min salinity. There was a wide gap in the salinity of drainage water after installation. Mean yield of all crops grown significantly increased. Yield increase by 186%. Cost of Cultivation increased due to better performance of crops due to demands for more inputs. Increase in net income was largely related to the increase in crop yield due to intervention of SSD. Significant increase in net income from off seasonal crops was also observed. Benefit-cost ratio increased more than one. Value of land increased. Thus we can say that to overcome the problem of waterlogging and soil salinity installation of SSD technology is very much required.

5	**Soil test-based nutrient balancing improved crop productivity and rural livelihoods: case study from rain fed semi-arid tropics in Andhra-Pradesh**			
	Girish chander, suhas wani, kanwar sahrawat, sreenath dixit, B venkateswarlu, C rajesh, P Narsimha rao and G.Parthsarathi. Archives of agronomy and soil science	Andra Pradesh	3 to 9 villages in 8 rain fed districts selected for study. Soil samples were collected from 826 farmer's fields in the targeted clusters following the farmer participatory stratified sampling technique. After recommending ideal fertilizer dose, on farm observation for 2008-2011 period were used for ANOVA technique to test whether balanced nutrient changed farms yields significantly.	Fields of 8 districts of Andhra Pradesh showed widespread multi-nutrient deficiencies including secondary and micro-nutrients. In on-farm trials Important rainy and post rainy season crops during 2008-11, significantly higher yield were recorded under the balanced nutrition treatment as compared to traditional farmers practice (more NPK, none micro-nutrients). Balanced nutrition while increasing crop yields maintained plant nutrient composition. Harvest in Nalgonda district showed higher contents of soil organic C and available nutrients like P, S, B and Zn in plots with balanced nutrition, which apparently are responsible for residual benefits in the succeeding seasons. In absence of balanced nutrition, farmers are apparently losing 8% to 102% of current yield levels in season 1 and 15% to 24% in each of the succeeding 3 to 4 seasons.

National Policies on Soil Management			
Plan	**Years**	**Policies**	**Progress**
1st FYP	1951- 1956	Soil conservation associations	1953- Central soil conservation board set up
		Establishment of a Soil Conservation Branch at the Forest Research Institute, Dehra Dun	Sum of about Rs. 1.6 crores was spent
		Soil and land utilization survey	Contour bunding and terracing of about 700,000 acres of agricultural lands
		Soil Conservation In Community Development Projects	Desert Afforestation and Research Station was set up at Jodhpur
		Soil Conservation In River Valley Project Areas	Eight regional research-cum-demonstration centres were established
		Central Land Utilisation and Soil Conservation Organisation at the Centre	
		Land Utilisation and Soil Conservation Board in every State.	
2nd FYP	1956-1961	Training centres have been established by the Government of India at the research stations	Rs. 18 crores spent
		Pilot project demonstration centres to be established in different parts of the country for giving demonstrations of soil conservation practices to farmers	An area of 2 million acres covered under contour bunding and terracing
		Erosion control programmes should therefore be accompanied by appropriate programmes of education and resettlement	An integrated all-India Soil Conservation and Land Use Survey was initiated
		Agency of the national extension service	70 officers and 900 assistants have been trained

		Village panchayat should become responsible for soil conservation measures and for ensuring minimum standards of land management by individual cultivators. They should also receive such technical and financial assistance as may be needed	40 demonstration projects, each covering about 1000 acres were undertaken on a catchment basis
		Central fertiliser pool	The Desert Afforestation and Research Station at Jodhpur was re-organised as a Central Arid Zone Research Institute in collaboration with UNESCO
3rd FYP	1961-1966	Intensive Agriculture Development program (IADP) was the first major experiment of Indian government in the field of agriculture and it was also known as a "package programme" as it was based upon the package approach	An area of 1.9 million hectares was reclaimed
		River valley projects	The work was initiated in 13 river valley projects
		Reclamation of alkaline and usar lands	
		The Central Arid Zone Research Institute For desert reclamation	
		Empowering State Governments to frame soil conservation schemes for the basin of a river or a stream or for groups of villages has been recommended	
		The Fertiliser Distribution Enquiry Committee	
		A Central Fertiliser Marketing Corporation	
		Set up a Central Institute of Pedology and Soil Mechanics.	
4th FYP	1969-1974	Adopt an "area saturation" approach so as to treat all types of land on a complete water-shed basis	The chemical fertilizers in terms of nitrogenous and phosphatic, was recorded 10.58 lakh and 4.1 lakh tones respectively ending 1973-74

		A resources inventory unit established at the centre during 1966-67	At the end of 1968-69, there were 65 soil-testing laboratories all over the country with a total annual capacity of handling 1.08 million samples
		scheme of soil conservation in the catchments of river valley projects	
5th FYP	1974-1979	Sharp increase in the prices of food, fertilizers and oil seriously upset the assumption on which draft had been framed	The total coverage under soil and water conservation was 21.7 million hectare in 1977-78
		Soil and water conservation programmes have also been taken up with institutional credit support and the targets of physical performance are likely to be achieved	Area so far covered by soil conservation measures is only 23.40 million hectares
		centrally-sponsored scheme of soil conservation in the catchments of river valley project (RVP) was started	
		Soil and water conservation programmes are being taken up on water-shed approach	
6th FYP	1980-1985	Flood- Prone Rivers (FPR) was started	Under soil and water conservation measures, the achievement is about 6 million hectare
		Small water-sheds with an area of 1000— 2000 hectares, treatment of which is practicable and manageable, will have to be increasingly taken up	The area treated under soil water conservation measures aggregates to about 29.4 million hectares
		Integrated water-shed management in the Catchments of 8 Flood prone Rivers of the Indo-Gangetic Basin will also be taken up	8.4 million tonnes of fertilisers which is reported to have been achieved by the end of 1984-85

			It consists of 5.6 million tonnes of N, 1.9 million tonnes of P, And 0.9 million tonnes of K
7th FYP	1985-1990	The Centrally Sponsored Scheme of soil conservation in the catchments of river valley projects and Integrated Water Management in the catchments of 8 flood prone rivers in the Indo-Gangetic basin will be continued and intensified	The consumption of fertilizers will be increased from 8.4 million tonnes in 1984-85 to 13.5-14.0 million tonnes in 1989-90.
		National Watershed Development Programme for Rain fed Agriculture	The consumption of fertilisers (N+.P+K) rose to a level of II.3 million tonnes in the final year of the Seventh Plan.
		Programmes have been taken up to encourage the use of bio-fertilisers	Forty Blue Green Algae Sub-centres were established for production of algae culture through field multiplication programme under the National Project on Bio- fertiliser development.
		Five central sector schemes, including National Project on Development and Use of Bio-Fertiliser and National Project on Quality Control were implemented	Soil and water conservation activity in 27 catchments taken up in 17 States covered 2.4 million hectares by the end of the Seventh Plan with a reported expenditure of Rs. 307crores
		Schemes for Balanced and Integrated use of Fertiliser and a National Project on Development of Fertiliser Use in Rain fed Areas were introduced	
		Schemes on soil conservation in the catchments of inter-State river valley projects, and the flood prone rivers, reclamation of alkaline (usar) soil, control of shifting cultivation and development of ravine areas were taken up	
8th FYP	1992-1997	Efficient use of chemical fertilizers, recycling of organic wastes and use of bio-fertilizers have an important place in the sustainable	An amount of Rs 40.826 crore was released to the States -of north-east region and 0.67 lakh ha. Area

		agricultural development process	was treated through treatment packages.
		A Centrally-sponsored Scheme of reclamation of alkali soil was continued from seventh plan	Reach the level of 14.3 million tonnes in 1996-97
		The scheme of Watershed Development Project in Shifting Cultivation Areas (WDPSCA) was launched in seven north-eastern State	Phosphatic and potassic fertilisers were decontrolled in August 1992. Only urea (nitrogenous fertiliser) continued to be under the price control system and involves a heavy subsidy for keeping the farm gate prices low
		To make soil treatment cost-effective, the guidelines emphasised on the vegetative conservation measures with active involvement of the beneficiaries and the non-governmental organizations (NGO's).	The All India Soil and Land Use Survey have so far covered 1155.74 lakh ha. Under priority delineation survey and 85.65 lakh ha. Under detailed soil survey
		"Application of Remote Sensing Technology for Soil Survey and Land Use Planning" scheme	Up to the end of the Eighth Plan, only 17.96 m ha had been covered/treated
		Seventh Plan Centrally Sponsored Schemes of Soil Conservation in the catchments of River Valley Projects (RVP) and Integrated Watershed Management in the catchments of Flood Prone Rivers (FPR) were continued	
9th FYP	1997-2002	Community and village institutions will be encouraged to participate in protecting natural resources from degradation.	1.5 lakh ha. have been treated with an expenditure of Rs 82 crore under water shed management
		Programmes for regeneration of land and water resources will be strengthened	An area of 0.60 m.ha. Out of 3.5 m.ha. Of alkali land has been reclaimed till the end of 2002-03

		Macro Management Mode bringing together under one umbrella 27 centrally sponsored schemes - Reclamation & Development of Alkali & Acid Soil (R&DAAS)	
		Centrally-sponsored Scheme of reclamation of alkali soil - extension of the scheme to all other States of India was approved where alkali soil problems exist as per scientific parameter.	
10th FYP	2002-2007	Unsustainable practices like excessive use of water together with imbalanced use of fertilisers were seen	Around 22 million hectares of degraded land were reportedly treated under these various schemes at a cost of Rs. 8810 crores
		A condition that a certain percentage of allotted land (say 40 or 50 per cent) must be utilised for tree cover can be stipulated so as to increase the crown area for improving the environmental and ecological conditions	
		Soil survey and land degradation mapping of the entire country would be conducted from the Tenth Plan onwards on a mission mode approach	
		Adoption of Integrated Nutrient Management (INM)/Integrated Plant Nutrient Supply (IPNS)	
11th FYP	2007-2012	The Centre introduced a new scheme, the 'National Project on Management of Soil Health & Fertility' (NPMSH&F)	Fertiliser consumption rose over 30 per cent during the Eleventh Plan, the main reason is that world prices of all fertilisers and feedstock have doubled since 2006
		Soil health cards & strengthening of soil testing labs & expanding their testing capacity	By 2010–11 there were 1,049 soil tests labs in the country with a soil analysis capacity of 106 lakh soil samples per annum
		Minimum investment of Rs 36,000 cr on Natural Resources Management (NRM)	
		Nutrient-based subsidy (NBS) system was adopted	
12th FYP	2012-2017	National Mission for Sustainable Agriculture (NMSA). Conceived originally as part of the National Action Plan on Climate Change (NAPCC)	

		The National Project on Management of Soil Health and Fertility and the Rain fed Areas Development Programme (RADP)
		Conservation agriculture (CA), integrated nutrient management, carbon sequestration, erosion control, saline and alkaline soils management, legislation for soil protection, development of remote sensing and GPS-based Decision Support System (DSS) and amelioration of polluted soil are required to rejuvenate deteriorated soils

Appendix -2:

Regression analysis: Determinants of performance indicators of SHC scheme (district level)

Table 48. Variables include in the district level regression analysis

Variables	Source
1. Number of bank accounts	RBI databank
2. Rural households having computer/laptop with internet	Census 2011
3. Rural households having mobile	Census 2011
4. Samples entered(collected)	Soil health card portal
5. Number of farmers covered	Soil health card portal
6. Samples tested	Soil health card portal
7. Soil health card printed	Soil health card portal
8. Net area sown(ha)	Data provided by CRIDA
9. Net irrigated area(ha)	Data provided by CRIDA
10. N,P,K consumption in both *rabi* and *Kharif*	Fertilizers statistics,2010-11
11. Number of cultivators	Census 2011
12. Total rural bank branches(both PSU and commercial)	RBI bank branch statistics ,2010
13. Road density	Road statistics taken from *Pradhan mantri gram sadak yojana* and divided it by geographical area.
14. Literacy	Census 2011
15. Number of SC and ST population	Socio-economic caste census
16. Number of soil testing labs and magnesium, boron, zinc testing capacity.	Soil health card portal
17. Yield	District wise data collected from Ramesh Chand's working paper 'instability and regional variation in Indian agriculture' published by NCAP.

Basic regression model:

1) Y(samples entered(collected))= f (number of bank accounts, households having computer with internet, households having mobile, Net irrigated area, net sown area, total fertilizer consumption, rural bank branches, road density, literate population, number of SC and ST population, number of labs)

Table 49. Determinants of Samples collected (district level)

Dependent variable: samples collected	B	Significance level
(Constant)	-1963	.587
Fertilizer use Total(Tonnes)	.233	.000
No. of bank Accounts	.032	.000
Net Sown Area (ha)	.050	.000
Net Irrigated Area (ha)	-.096	.000
Households having computer/laptop with internet	-3.481	.000
Household's having mobile	.071	.006
No. of labs	1098.157	.021
Total rural bank branches(both PSU and commercial)	78.164	.041

2) Y(samples tested)= f (number of bank accounts, households having computer with internet, households having mobile, Net irrigated area, net sown area, total fertilizer consumption, rural bank branches, road density, literate population, number of SC and ST population, number of labs)

Table 50. Determinants of Samples tested (district level)

Dependent variable: samples tested	B	Sig.
(Constant)	-2577	.438
Fertilizer use Total(Tonnes)	.241	.000
No. of bank Accounts	.040	.000
Net Sown Area (ha)	.039	.000
Net Irrigated Area (ha)	-.102	.000
Households having computer/laptop with internet	-3.286	.000
Total rural bank branches(both PSU and commercial)	88.392	.013
Household's having mobile	.052	.030

3) Y(Soil health card printed)= f (number of bank accounts, households having computer with internet, households having mobile, Net irrigated area, net sown area, total fertilizer consumption, rural bank branches, road density, literate population, number of SC and ST population, number of labs)

Table 51. Determinants of SHCs printed (district level)

Y=SHCs printed	B	Sig.
(Constant)	16000	.133
No. of bank Accounts	.126	.000
Net Sown Area (ha)	.101	.000
Total rural bank branches(both PSU and commercial)	474.2	.000
Net Irrigated Area (ha)	-.217	.000
Fertilizer use Total(Tonnes)	.288	.021

Appendix-3

1. **Farmer's Questionnaire**

Farmer questionnaire

Soil Health Card Scheme 2017

National Institute of Agricultural Extension Management (MANAGE), Hyderabad

Section-1: Household Details

1. State
2. District
3. Block
4. Village
5. Name of the farmer: Mobile No.
6. Social group: FC/OBC/SC/ST
7. Age:
8. Sex:
9. Family Size: M- ; F- ; C-
10. Number of Family Members working on Farm: M- ; F-
11. Education (no. of years of head of family):
12. landholding
    a. irrigated area.........number of plots
    b. Rainfed area......number of plots.............
13. Annual net income after deducting costs(Rs.)—
    a. Agriculture:
    b. Livestock:
    c. Labour:
    d. Others:

Section –II About soil health card

14. Are you aware about soil health card? Y/N
15. Are you aware of soil health card portal? Y/N
16. How many soil samples are taken from your village?
17. Are the results discussed among farmers in the village? Y/N
18. Is soil health card portal give useful information?
19. Details of soil health card scheme operation in your village

Section-III: Initial Activities under SHC scheme

Purpose	Participation (Y/N)	Number	Distance from village	Number of days	Nature of Inputs	Benefits if any
Mobilisation (farmers)						
Meetings conducted						
Exposure Visits						
Trainings Conducted						

Section-IV Cropping Pattern (for all)

Crop name	Season K/R/ annual	Area (acre)	Yield (per acre)	Fertilizer use Urea(bags)	DAP (bags)	MoP(bags)	Gypsum (Kgs)	Micro Nutrients (Kgs)	Bio-fertilizers (Kgs)	Liming material (Kgs)	Others	Total Cost
Before SHC scheme												
Crop 1												
Crop 2												
Crop 3												
Last year 2016-17												
Crop 1												
Crop 2												
Crop 3												

Section –V: Soil Health Card holders

20. Are you having soil health card Y/N
21. If yes
22. In which month and year soil testing was done …
23. In which year and month you got SHC …
24. From where you got soil health card?
25. Are you able to understand the information on soil health card? Y/N
26. Are you using fertilizers and micro-nutrients as per the SHC? Y/N
27. Have you got any financial assistance from government? Y/N
28. If you are not following recommendation, why…….
29. How many of your plots covered for soil testing?
    One / none /some/all
30. Are the recommendations suitable for all your plots?
    Y/N
31. How many soil samples are taken from your farm?
32. Do you think the samples represent all the soil types in your farm? Y/N
33. If no, how many samples are required?
34. Are the results provided in time? Y/N
35. Whether agricultural extension worker explained the content of SHC? Y/N
36. Who informed about SHC content?
    a. KVK
    b. Agricultural Extension Officer/Agricultural Officer
    c. Scientist of SAU/ICAR
    d. NGOs
37. Are the recommendations practical? Y / N
38. Are the recommended inputs easily available in the market?
39. Do you face any difficulties in adopting the practices? Y/N

Section –IV: Perception of SHC scheme

40. What is the main benefit (s) from SHC?
41. Do you suggest any improvement in the SHC system? Y/N
42. If yes provide details
43. Would you like to take your soils to private testing labs? Y/N
44. Are you willing to pay for the soil health card?
45. Observations from the Investigators.
46. Name of the Investigator:

Table 52: State-wise fund released and Unspent balance under Soil Health Card Scheme

(As on 30.01.2017)

(Rs. In lakh)

State	2014-15			2015-16				2016-17				Total		
	Released	UC Received	UC Pending	Allocation	Released	UC Received	UC pending	Allocation	Released	UC Received	UC pending	Released	UC Received	UC Pending
Andhra Pra.	124	124	0	706	458	458	0	1394	697	0	697	1279	582	697
Arunachal Pr.	12	12	0	30	17	17	0	50	0	0	0	29	29	0
Assam	51	0	51	253	142	3	139	619	0	0	0	193	3	190
Bihar	253	150	103	674	488	240	248	1289	0	0	0	742	390	351
Chhattisgarh	66	66	0	383	281	195	86	685	343	0	343	690	261	429
Goa	12	0	12	17	12	0	12	19	0	0	0	24	0	24
Gujarat	81	81	0	836	603	420	184	1057	529	0	529	1213	501	712
Haryana	34	17	18	401	288	210	78	440	0	0	0	322	227	96
Himachal Pr.	24	24	0	71	47	47	0	59	29	0	29	101	71	29
J & K	32	0	32	141	77	49	28	326	0	0	0	109	49	60
Jharkhand	51	36	15	73	54	31	23	128	64	0	64	169	66	103
Karnataka	127	101	26	894	650	650	0	2060	1030	649	381	1807	1400	407
Kerala	113	0	113	83	61	0	61	132	0	0	0	174	0	174
Madhya Pr.	143	99	44	1228	888	465	423	2747	1374	329	1044	2404	894	1511
Maharashtra	216	216	0	1285	932	932	0	2430	1215	1215	0	2363	2363	0
Manipur	13	13	0	31	18	12	6	63	0	0	0	30	25	6
Meghalaya	14	0	14	36	21	0	21	43	0	0	0	34	0	34
Mizoram	12	0	12	24	14	14	0	36	0	0	0	26	14	12
Nagaland	13	13	0	40	22	22	0	74	0	0	0	36	36	0
Odisha	80	80	0	371	270	121	148	609	304	304	0	655	506	148
Punjab	26	0	26	424	305	0	305	958	0	0	0	331	0	331
Rajasthan	143	143	0	1213	876	90	786	2217	1108	0	1108	2128	233	1894
Sikkim	12	12	0	20	12	8	4	25	0	0	0	24	20	4
Tamil Nadu	132	132	0	652	470	470	0	1290	645	0	645	1246	601	645
Telangana	93	93	0	544	353	353	0	937	468	0	468	915	446	468
Tripura	18	18	0	40	23	23	0	79	0	0	0	41	41	0
Uttar Pr.	354	354	0	2387	1716	282	1434	4884	2442	0	2442	4513	637	3876
Uttarakhand	23	23	0	119	65	44	22	236	0	0	0	89	67	22
West Bengal	117	117	0	667	480	480	0	1460	0	0	0	597	597	0
Total	2390	1926	464	13642	9644	5636	4008	26346	10249	2497	7751	22282	10059	12223

Soil Health Card

Department of Agriculture & Cooperation
Ministry of Agriculture & Farmers Welfare
Government of India

Directorate of Agriculture
Government of Goa

SOIL HEALTH CARD

Soil Health Card No. : ____________________

Name of Farmer : ____________________

Validity : From__________ To__________

SOIL HEALTH CARD	
Farmer's Details	
Name	
Address	
Village	
Sub-District	
District	
PIN	
Aadhaar Number	
Mobile Number	
Soil Sample Details	
Soil Sample Number	
Sample Collected on	
Survey No.	
Khasra No. / Dag No.	
Farm Size	
Geo Position (GPS)	Latitude: Longitude:
Irrigated / Rainfed	

Name of Laboratory				
SOIL TEST RESULTS				
S. No.	Parameter	Test Value	Unit	Rating
1	pH			
2	EC			
3	Organic Carbon (OC)			
4	Available Nitrogen (N)			
5	Available Phosphorus (P)			
6	Available Potassium (K)			
7	Available Sulphur (S)			
8	Available Zinc (Zn)			
9	Available Boron (B)			
10	Available Iron (Fe)			
11	Available Manganese (Mn)			
12	Available Copper (Cu)			

Secondary & Micro Nutrients Recommendations		
Sl. No.	Parameter	Recommendations for Soil Applications
1	Sulphur (S)	
2	Zinc (Zn)	
3	Boron (B)	
4	Iron (Fe)	
5	Manganese (Mn)	
6	Copper (Cu)	
General Recommendations		
1	Organic Manure	
2	Biofertiliser	
3	Lime / Gypsum	

International Year of Soils 2015

Healthy Soils for a Healthy Life

Fertilizer Recommendations for Reference Yield (with Organic Manure)						
Sl. No.	Crop & Variety	Reference Yield	Fertilizer Combination-1 for N P K		Fertilizer Combination-2 for N P K	
1	Paddy (Dhaan)					
2						
3						
4						
5						
6						

****