Chapter 1

Bhoochetana: Reviving Soils for Agriculture

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The evolution: Earlier attempts & learnings

Insights from an exemplar scaling-up initiative in Karnataka

The *Bhoochetana* program in Karnataka, India, has been one of the initial exemplar attempts at scaling-out best practices in reviving soils on a large scale involving thousands of farmers in the state. The stagnant to declining growth of the agriculture sector in Karnataka between 2000 and 2008 demanded a multi-pronged strategy to revive agriculture. Given the alarming situation, in 2009 the state initiated measures to address soil health through a state-wide, flagship program called *Bhoochetana*. The program was designed to get the state's agriculture back on track by increasing crop productivity and strengthening agriculture-based livelihoods.

Deterioration in soil fertility and the widespread prevalence of nutrient deficiencies, especially of micronutrients, posed a threat to soil health, the productive performance of crops, incomes of millions of smallholder farmers and more importantly, food security of the state (Sahrawat et al. 2007, 2016). Against this backdrop, extensive soil nutrient mapping was initiated to assess the extent of soil degradation. As an entry point activity, large-scale soil sampling was initiated to build a rapport with the farmers, as a prelude to securing their buy-in as partners in the process of restoring soil health. A stratified soil sampling methodology was adopted involving the collection of a proportionate number of samples from all the three toposequences, i.e., upper, middle and lower from 25% of the representative villages in each of the 176 blocks of the state. Further, at each toposequence, samples were collected proportionately from different farm size groups, i.e., small, medium and large. Care was taken to collect an equal number of samples to represent soil colour and texture, cropping system and agronomic management systems practiced by the farmers. More than 100,000 samples collected were analyzed in the state-of-the-art Charles Renard Analytical Laboratory (CRAL) at ICRISAT, Hyderabad.

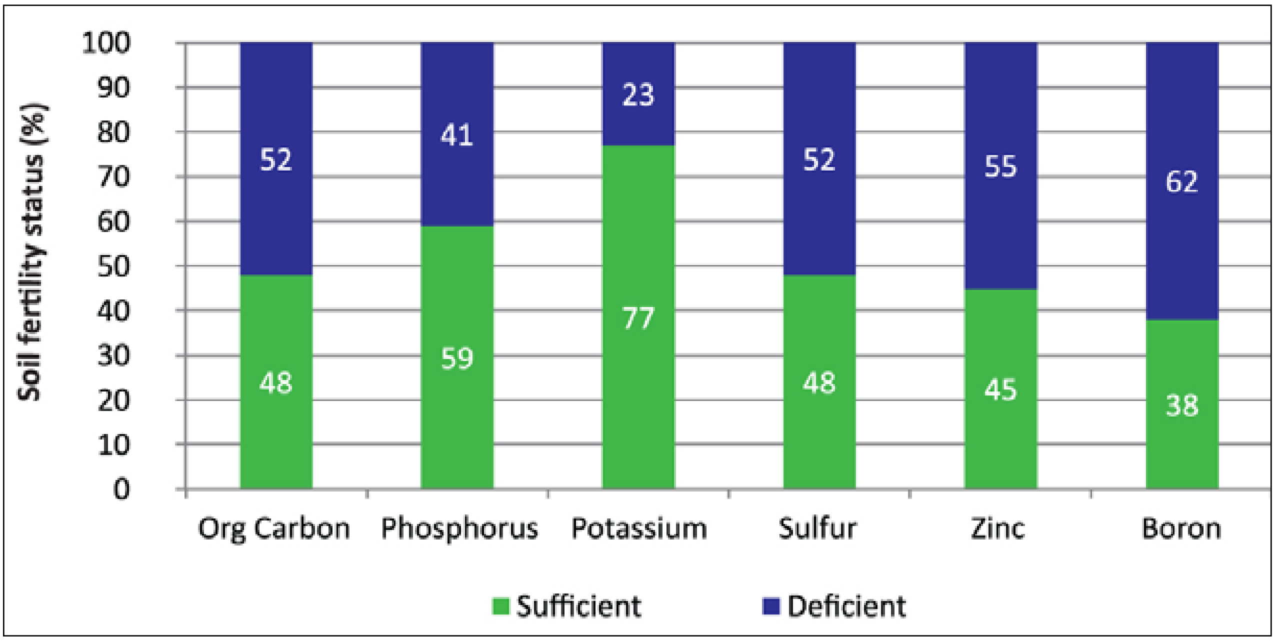

Figure 1.1 Soil fertility status of farmers' fields (2009-2013) in Karnataka, India (Chander et al. 2016).

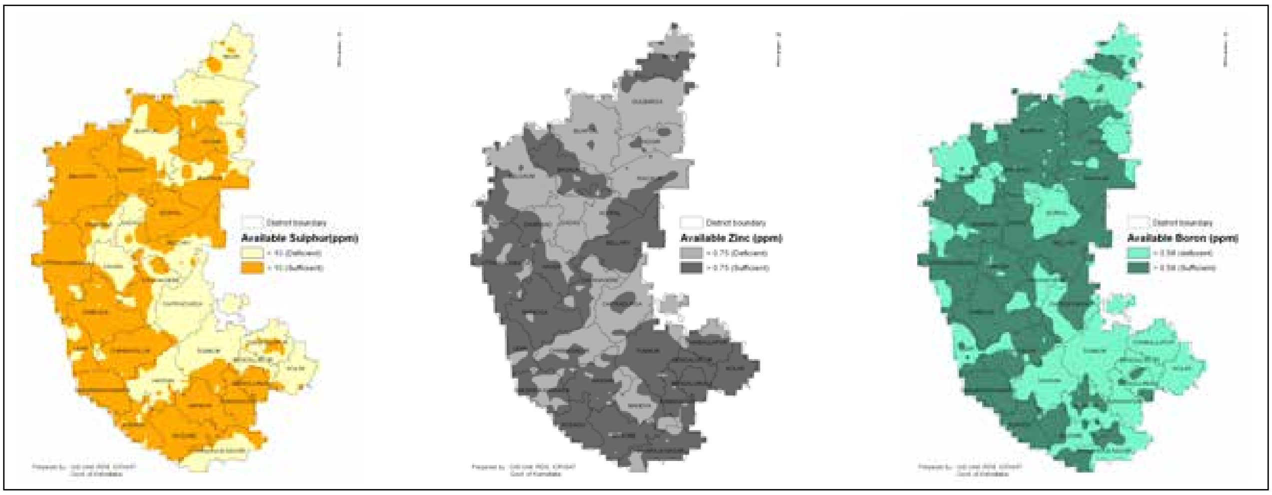

Figure 1.2. Extensive micro- and secondary nutrient deficiencies in Karnataka (Wani et al. 2016).

Results revealed that unabated stripping of nutrients over the years had resulted in severe deterioration in soil health and widespread deficiencies in multiple nutrients. (Wani et al. 2011). Some secondary and micronutrients had been depleted below their critical limits, adversely affecting nutrient and water use efficiencies of soils. While the study revealed widespread deficiencies in zinc (Zn), boron (B), sulfur (S), nitrogen (N) and phosphorus (P), it showed adequate potassium (K) in the soils (Figures 1.1 and 1.2)

This analysis formed the basis for recommending nutrient application at cluster/village/block levels, as opposed to the conventional system of recommending a blanket fertilizer application at the state level. It helped the state make an informed decision on including deficient micro/secondary nutrients in its fertilizer recommendations. At the block level, a full dose of micro/secondary nutrients was suggested if the deficiency was more than 50%, half a dose if less than 50% and no application where there was single digit deficiency. To reinforce the importance of healthy soils and create awareness among the farmers, the program conduced large-scale capacity building programs, set up wall writings, issued soil health cards, developed soil fertility maps, held farmer days, facilitated exposure visits and trained lead farmers. Best bet management practices were scaled out on about 5 million ha by strengthening institutional arrangements, capacity building and timely supply of inputs in the state. Soil test-based nutrient management significantly increased productivity. The incremental benefits varied from 25% to 47% in cereals, 28% to 37% in pulses and 22% to 48% in oilseed crops (Chander et al. 2016). The results also showed that for every rupee spent, there was a benefit of ₹ 3-15 across various regions in the state. This science-led development effort clearly demonstrated the scalability of the initiative, infusing sustainability and resilience into the state's agriculture.

Taking a leaf out of *Rythu Kosam* in Andhra Pradesh to establish sites of learning

Taking a cue from the Rythu Kosam (meaning for the farmer) primary sector project in Andhra Pradesh, state in India, a two-pronged strategy was adopted in Odisha to establish pilot sites of learning. Under Rythu Kosam (2015-2018), pilots were established on 10,000 hectares covering 265 villages across 13 districts and 36 blocks in Andhra Pradesh. The pilot sites served as on-farm field laboratories to test and evaluate technological/institutional/policy innovations and fine-tune the initiatives. In marketing parlance, the pilot areas were test markets for innovations, which were demand driven, impact oriented and having measurable indicators. While these sites served to monitor proven integrated nutrient management technologies with high guaranteed levels of success, they were a testing ground to evaluate and customize on-farm innovations and technology products. State government line departments converged their block action plans with the pilot sites to promote a holistic and systems approach.

The successfully tried and tested soil health mapping in the *Bhoochetana* program and other watershed sites was adopted as an entry point activity to rejuvenate soil resources. The analysis of about 5400 soil

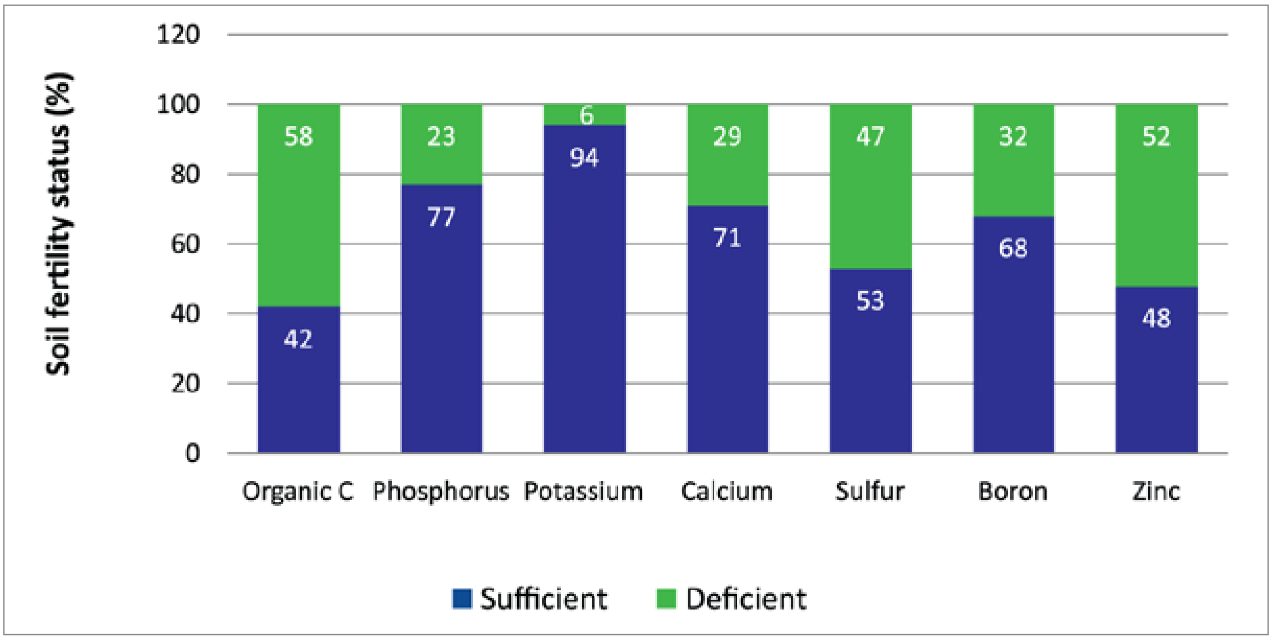

Figure 1.3. Soil fertility status of farmers' fields in pilots across Andhra Pradesh, India (Wani et al. 2018b).

samples collected from pilot sites from April to June in 2015 showed multi-nutrient deficiencies in zinc, boron, sulfur and calcium in addition to lower levels of soil organic carbon, nitrogen and phosphorus (Figure 1.3). This was followed by crop-wise recommendations for primary, secondary and micronutrients that were demonstrated in field trials at the pilot sites. Data from the field trials revealed that the analyses-based application of nutrients gave a yield advantage of 10-40% in cereals, pulses, oilseeds and vegetable crops. These encouraging findings gave a policy direction to the Government of Andhra Pradesh to scale-out soil test-based nutrient application over 1.50 million hectares.

In yet another initiative under this project, easy and quicker methods of converting crop residue into manure were demonstrated, such as the aerobic process of composting, use of crop residue shredders and bio-culture-enabled rapid decomposition of non-fodder biomass. This helped translate a proof of concept into a practical solution that aided building of soil organic carbon *in-situ.* It also served to reduce the cost on chemical fertilizers across all the sites of learning (Chander et al. 2018), while at the same time regulating soil health and improving crop yields. Demonstration of improved crop cultivars at the pilot sites showed a yield advantage of 10-50% compared to farmers' practices. These demonstrations brought home to stakeholders the importance of and benefits from making informed decisions on improving soil health and restoring the agro-ecosystem balance though judicial use of inputs, system intensification/diversification, introduction of best-bet soil-crop-water-livestock technologies, strengthening institutional arrangements and alignment of policies.

Scaling-up in Odisha

Soil health mapping, need-based nutrient management and best practices

The *Bhoochetana* project in Odisha state aims at improving crop productivity and rural livelihoods through science-based natural resource management practices. The specific objectives of the project are to:

- Assess the nutrient status of soils in all the 30 districts;
- Identify the best nutrient, soil, crop and water management options to increase productivity through demonstrations in pilot sites;
- Scale-up best practices in partnership with the Directorate of Agriculture (DoA) and other partners through convergence;

- Build the capacity of DoA staff, consortium partners and farmers to support scaling up of a science-led holistic development strategy;
- Concurrently monitor, evaluate, and document the impacts of the scaling up approach in order to enable mid-course corrections; and
- Upgrade two existing soil analytical laboratories in the state to serve as referral laboratories and run them efficiently with government support.

Soil health mapping was undertaken across 30 districts of Odisha by collecting 40,265 samples using stratified random sampling. This formed the basis of a precise and robust nutrient management strategy for the state (Figure 1.4). It also envisagesd economic and environmental benefits by avoiding the indiscriminate use of major nutrients like N, P and K fertilizers.

Taking into account the large-scale deficiencies in secondary and micronutrients, an expert consultation was organized between scientists of Odisha University of Agriculture and Technology (OUAT), ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP), Department of Agriculture (DoA), Government of Odisha and ICRISAT to devise a strategy in line with the state's nutrient recommendation policy. The consultation came out with the following recommendation:

- Application of 25% more NPK in case of low nutrient status and 25% less NPK when nutrient status is high (Table 1);
- Critical levels of deficiency for S, Zn, B, Cu, Fe and Mn are 10 mg/kg, 0.6 mg/kg, 0.5 mg/kg, 0.2 mg/kg, 4.5 mg/kg and 2 mg/kg, respectively;
- Yearly recommended dosage of boron is 1 kg/ha;
- The recommended dosage of sulfur is 30 kg/ha in cereals (i.e., 200 kg/ha through gypsum), 40 kg/ha in pulses and 45 kg/ha in oilseed crops;
- In the case of zinc, the recommended dosage is 5 kg/ha in paddy, 2.5 kg/ha in pulses and 2.0 kg/ha in oilseeds;

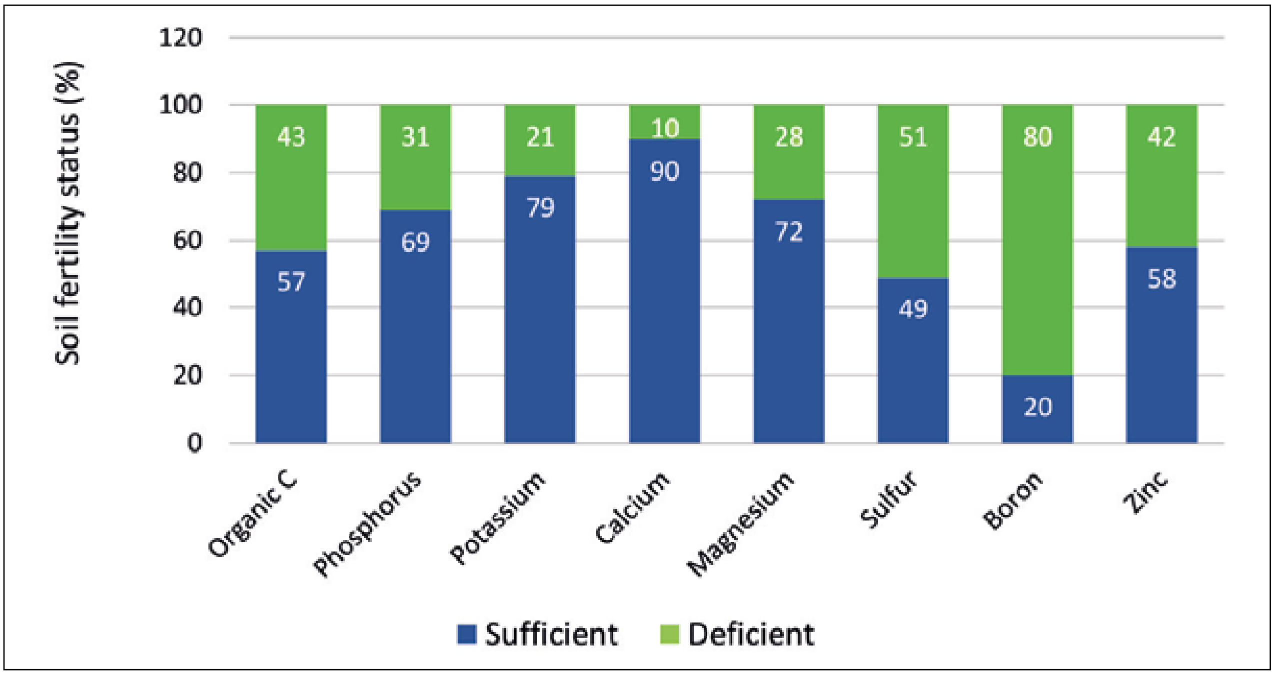

Figure 1.4. Soil fertility status of farmers' fields based on an analysis of 40,265 soil samples collected from across all the districts of Odisha, India.

- Digital soil maps to be the reference for soil fertility and recommendations;
- Large-scale promotion of aerobic composting both at individual and community levels;
- Promote the application of well decomposed poultry manure @ 2.5 t/ha in furrows as a substitute for lime in acid soil management; and
- Promote seed priming with 1% zinc sulphate heptahydrate and 1% KH_2PO_4 in acidic soils.

Table 1.1. Critical limits for low, medium and high levels for N, P and K.

Plant nutrient	Critical level (kg/ha)		
	Low	Medium	High
N	<225	225-560	>560
P	<10	10-25	>25
K	<116	116-280	>280

Keeping in view the recommendations, micro- and secondary nutrients were included in fertilizer management practices while conducting crop demonstrations at the pilot sites. Results showed significant yield advantage (20%) in paddy, maize, millets and groundnut. However, the use of improved cultivars and soil test-based nutrient management almost doubled yields in pigeonpea compared to prevailing farmers' practices. Thus, soil health mapping and demonstrations clearly demonstrated a very sound case for scaling out nutrient management, improved varieties and best practices for sustainable growth in the agriculture sector in Odisha.

Soil test laboratories turn state-of-the-art referral laboratories

Precise analysis of soil is impeded by the lack of sufficient infrastructure in laboratories across the country in general and also in Odisha (Wani et al. 2016; Chander et al. 2018). Most laboratories cannot analyze boron, sulfur, and to some extent micronutrients like zinc, copper, iron and manganese. To cater to the state's need for precision in analyzing a large number of soil, water, fertilizer and plant samples in a short time span, a need was felt to upgrade two district laboratories in Odisha, one in Bhubaneshwar and the other in Sambalpur, into state-of-the-art referral laboratories conforming to international standards. ICRISAT along with OUAT and DoA are collectively working on this. A week-long orientation training on the use and maintenance of state-of-the-art equipment was conducted at the Charles Renard Analytical Laboratory at ICRISAT, Hyderabad, for key staff from the two laboratories, OUAT scientists, and other officials from DoA headquarters involved in key decision making.

Use of ICT for dissemination and impacts

As per the National Sample Survey (NSSO 2014), around 60% of farm households don't receive any assistance from either government or private sector extension agencies. Hence, it is imperative to reform knowledge delivery systems using modern tools of information and communication technology (Wani et al. 2018a).

A tablet or computer-based extension module is being piloted with the DoA involving extension staff across all the districts. The tablets are being used to disseminate soil analysis-based advisories and best crop management practices. Results of the analyses of 40,265 soil samples were interpolated to develop interactive digital maps on macro and micronutrients and other parameters like soil carbon, pH, and electrical conductivity (EC). The soil maps have been made available to farmers, extension agents and other stakeholders through Internet-based interactive tools to guide in on-site soil health management and input use. These maps can also serve as decision support tools for policy makers while allocating crop- and season-wise inputs and in the movement of fertilizers/nutrients across the state.

Capacity building and collective working

The huge knowledge gap between 'what to do' and 'how to do it' is a major reason for the gap between potential yield and actual yield realized on research farms (Wani et al. 2018a). Previous scaling-out programs owed their success to the emphasis on capacity building of stakeholders, which were instrumental in economic growth and development (Anantha et al. 2016). Together with consortium partners, the innovative approach of demonstrating and evaluating technologies in pilot sites was a step in this direction. In this process, the focus was on knowledge sharing and formal capacity building and training of lead farmers, NGO personnel and staff in line departments. Workshops with the DoA enabled the sharing of documented benefits realized at pilot sites, and to collectively work out the roadmap for scaling-out proven technologies.

The Odisha *Bhoochetana* program envisages the involvement of many stakeholders, both in formal and informal sectors. ICRISAT entered into partnerships with more than 20 NGOs to solicit field level support and to reach out to a large number of farmers in the district. OUAT is a close partner in soil sampling, baseline studies, establishment of referral laboratories, devising fertilizer recommendations and evaluation of improved crop varieties in the pilot sites. ICAR-NRRI, Cuttack has been an important partner in building the capacities of field staff on scientific cultivation and management of improved rice cultivars. Such partnerships are instrumental in harnessing synergies.

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