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Soil and Water Productivity

Sustainable management of natural resources is vital as agricultural development with positive growth and long term sustainability cannot thrive on a deteriorating natural resource base. Therefore, these resources need to be managed in a judicious manner ensuring optimum soil and water productivity. Accordingly, strategies for enhanced input use efficiency, reducing nutrient losses, and conserving soil and water are discussed in the following section for achieving food, nutritional, livelihood and environmental security in the country.

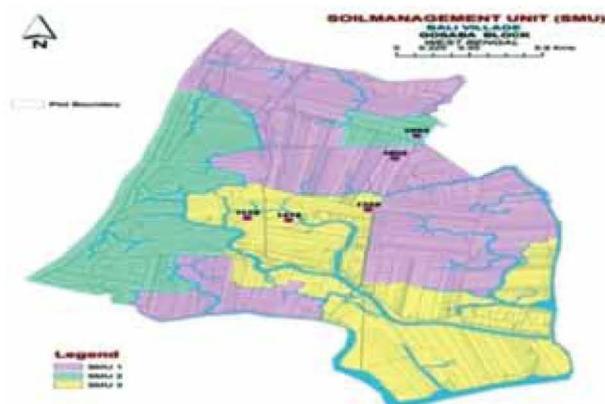
Land resource inventory (LRI) for land use planning

National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur has undertaken a country level project on “Land resource inventory on 1:10,000 scale for agricultural land use planning using geo-spatial techniques” in collaboration with NRSC, ISRO in a phased manner. In the first phase, 60 blocks, one

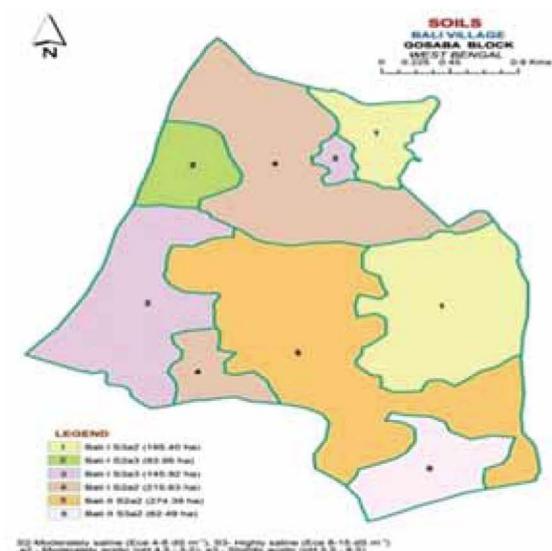
each in 60 agro-ecological sub-regions of the country, covering approximately 3.3 Mha area in four years duration, were selected.

Micro level soil resource map and land management unit maps: Bali village- Bali Island is located in Gosaba block, 24 Parganas (South) district (Sundarbans, West Bengal). Soils of Bali village were surveyed, under Tribal Sub-plan project, using IRS IV P6 data and cadastral map. Occurrence of acid sulphate layers at different depths and salinity and poor drainage were the major soil constraints. Soils were classified into soil series Bali 1 and Bali 2. Acid sulphate layer occurred between the depths of 40 and 60 cm in Bali 1, whereas it varied between the depths of 80 and 100 cm in Bali 2. Based on the nature of constraints, three land management units (LMUs) were delineated and land use plans suggested.

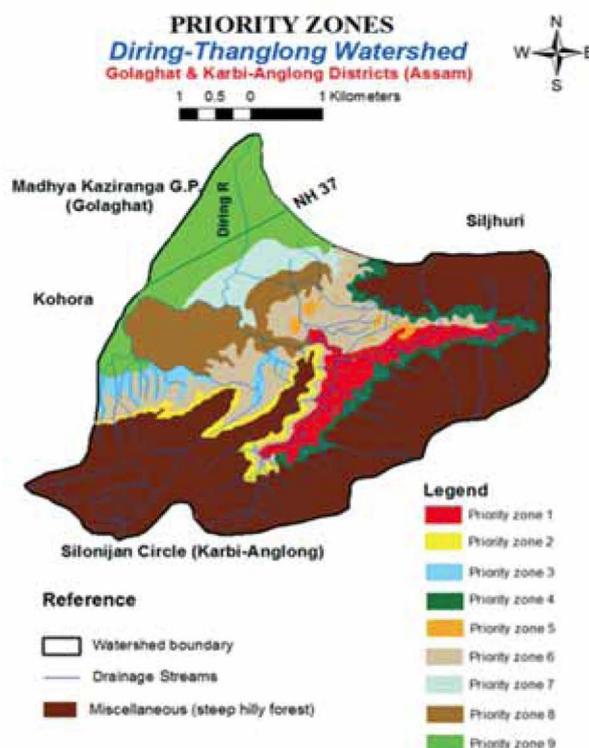
Farm pond technology was recommended for LMU3, shallow furrow and medium ridge for LMU2, and deep furrow with medium ridge in LMU1. After land shaping, vegetables and horticultural crops were recommended on the ridge, whereas paddy-cum-fish was recommended in shallow and deep furrows. Farm ponds were exclusively used for fish farming. The farm pond technology on 0.20, 0.27 and 0.39 ha under LMU1 generated employment to the tune of 285, 405 and 600 man days, respectively and enhanced the income



Land Management Units in Bali village



Soil map of Bali village



Land use planning map of Diring-Thanglong watershed



from ₹ 2,300 to ₹ 34,400; ₹ 3,100 to ₹ 47,800 and ₹ 4,500 to ₹ 68,900, respectively.

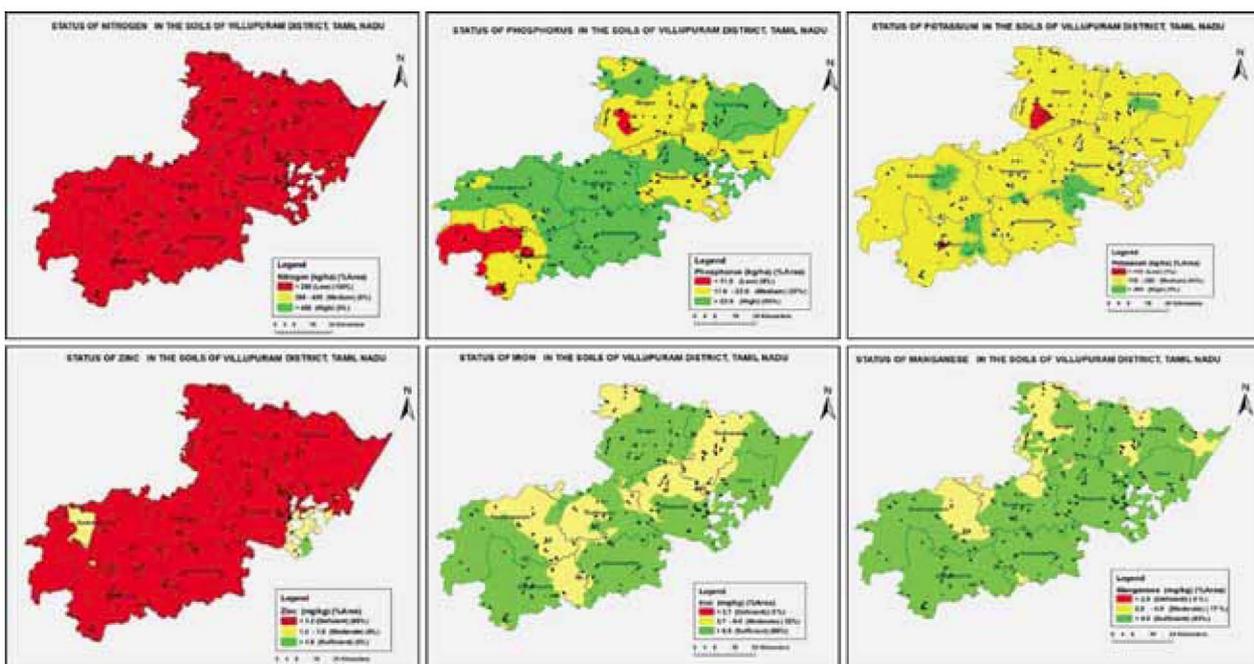
Diring-Thanglong micro-watershed-Land resource inventory of Diring-Thanglong micro-watersheds in Karbi-Anglong and Golaghat districts of Asom was carried out at 1 : 10,000 scale using IRS P6 LISS-IV imagery as base maps. The micro-watershed has been divided into nine priority classes based on ranking assigned to parameters, viz. (i) productivity for field and plantation crops, (ii) soil depth, (iii) slope and erosion susceptibility based on drainage morphometric characterization.

Soils are grouped as a member of Bhogdoi series (fine-loamy, mixed, hyperthermic family of Fluvaquent Endoaquents), which was mapped with two soil phases (Bh eA and Bh cA) in the village. Poor soil fertility and poor drainage were noticed as major soil constraints for successful agriculture. The soils are cultivated once for paddy in summer without use of fertilizers and are left fallow in the winter due to acute shortage of water for irrigation. The soils are moderately to marginally suitable for rice (Sali and Ahu), potato, cabbage, mustard and brinjal.

Based on land evaluation and interpretation of socio-economic status integrated action plans were developed in various critical zones in the micro-watershed. Scientific land use planning involving suitable land use, life-saving irrigation, fertilizer management in the soils of flood plains of the Brahmaputra River increased the cropping intensity from 100 to 200%. Additional income and employment generated from off-farm activities like fish farming and animal rearing improved livelihood of the farm families as well as five landless families residing in the village.

GPS and GIS based soil fertility maps of 173 districts of India: Under DAC sponsored project on GPS and GIS Based Soil Fertility Maps for Precise

Fertilizer Recommendations for farmers of the country, soil fertility maps of 173 districts of India were developed. These geo-referenced maps can be used for monitoring soil fertility, fertilizer recommendations and distribution of fertilizers for balanced nutrient application in various parts of the country. The segregation of districts based on the soil fertility maps may be used to distribute/channelize fertilizers and more priority may be attached towards districts with poor fertility. In North Zone, majority of the soils are medium to high in available P and available K status. Only few soils (0–1%) in 1 or 2 districts are low in P and K. In West Zone, majority of the soils are low to medium in available P except Gujarat. About 92–100% area in Gujarat is medium to high in available P. Altogether only 1–3% area in west zone is low in available K. Most of the soils in Gujarat and Maharashtra are high and Rajasthan are medium in available K. In East Zone, most of the area in Odisha (73–97%) is low in available P. Majority of the soils of Asom and West Bengal are medium to high in available P status. Majority of the soils in East Zone are medium in available K except Kurda district in Odisha where 60% of the area is low in available K. In South Zone, majority of the soils in Andhra Pradesh, Tamil Nadu and Kerala are medium to high in available P. In Karnataka, most of the soils are medium in available P. Available K content of majority soils of Tamil Nadu, Karnataka, Kerala are medium, and majority of the soils of Andhra Pradesh are high in available K. Micronutrient fertility maps showed that almost all soils of Punjab, Haryana, Uttar Pradesh, Uttarakhand and Himachal Pradesh in North Zone are high in available Zn, whereas majority of Uttar Pradesh soils are medium in available Zn. Majority of soils of this zone are high in available Fe, Cu and Mn with minor exceptions. Manganese deficiency is widespread in four



GIS based soil fertility maps of Villupuram district of Tamil Nadu



districts of Punjab (15–56%). Fe deficiency was observed over an area of 25–61% in Fatehabad and Hisar districts. In West Zone, Zn and Fe deficiency is widespread in Maharashtra. Otherwise, majority of soils are sufficient in available Zn, Fe, Cu and Mn. In East Zone, majority of soils are high in available micro nutrients. Zn deficiency was observed only in West Bengal. In South Zone, majority of soils of Andhra Pradesh, Karnataka, and Kerala are sufficient in available micronutrients. In Tamil Nadu, about 50–60% of the area is low in available Zn and 20–30% deficient in Cu. All soils of Wayanad district in Kerala are deficient in Mn.

Soil and water productivity

CSR BIO-an eco-friendly bio-growth enhancer:

A cost-effective bio-growth enhancer 'CSR BIO' was introduced to small and marginal landholders of major banana and tomato growing areas of Barabanki district of Uttar Pradesh. The overall increase in yield was 22 and 15% with increased gross profitability of about 17 and 20% for tomato (var. Himsona) and banana (var. G 90), respectively. The use of plant protection chemicals was 47 and 33% lower in tomato and banana, respectively.



Commercial cultivation of bio-primed banana and tomato

Low cost runoff sampler for micro watersheds:

A low cost runoff sampler was designed and tested in the field for monitoring runoff, soil, nutrient and carbon loss from different land use management practices. The four components, viz. (i) for collection of depth and width integrated sample; (ii) series of interceptor



Runoff sampler installed at RC, vasad

cum channel one below another for reducing volume of samples; (iii) clock mounted receiver that delivers temporal sample to different funnel, and (iv) storage bottles, works on gravity. The sampler can be installed below the weir/notch in a tank or plastic drum if there is drop of more than 60 cm in V notch. More drop is required in rectangular weir depending on its width. The new sampler collects samples at 15 min up to 24 hr interval and does not need any external source of energy.

Integration of low cost water harvesting and micro-irrigation system:

The study was aimed at exploring the feasibility of integrating the low cost water harvesting ponds with low head gravity fed drip irrigation system suitable for vegetable production in terraced fields of N-W Himalayan region. Silpaulin lined (200 gsm) poly tanks were integrated with low cost drip irrigation system operating on low head (3–5 m) under tomato (var. Himsona) crop with row-to-row and plant to plant spacing of 1 m and 0.3 m, respectively in 0.06 ha area. In addition to increase in yield (11%), the integrated system is found to be more convenient in irrigating the crops and it saves labor significantly (worth ₹ 3,000 per 1,000 m²/season) as compared to hand watering normally practiced in hilly regions. Economic analysis revealed that recovery of investment cost of the integrated system can be made in a maximum of three seasons of tomato production on account of increase in tomato yield and substantial labor saving in irrigating the crop.



Low cost water harvesting system with drip irrigation for tomato

Filters for direct well recharge using agricultural runoff:

Clogging of filter system was observed as main problem in gravity based sand filter, in all combination with gravel/agro-net that need high frequency of cleaning and therefore alternate design was thought of. A new design of up-flow filter was developed. It takes advantage of gravity for sedimentation of particle before entering the filter system. The design is suitable for flat to gentle sloping



Up-flow filter

Two component filter

Up-flow filter and component filter for recharge of well



(slope < 3%) agricultural field. Higher slope poses risk of churning of filter materials.

For filtering runoff from higher slope (> 3%) and from channel, an alternate design was envisaged, and tested in the laboratory as well as in the field. First component is up-flow filter that comprises coarse material, whereas second component is gravity based sand + gravel filter that receives partially filtered runoff from first component. The two component filter can be connected even to tube well for recharge. None of the above discussed filters are capable of removing chemical pollutants.

Canal and poor quality groundwater for production of grapes: Productivity of grapes cv. Perlette under tubewell irrigation with poor quality water can be increased considerably with the application of either sulphitation pressmud or its alternate use with canal water with minimal adverse effect on soil health. Results revealed that treatments canal water/tubewell water (CW/TW), tubewell water + 50% of gypsum requirement (TW + GR₅₀), and TW + sulphitation pressmud significantly increased the grapes yield by 28.3, 11.3 and 31.0% respectively, as compared to TW (RSC = 6.4 meq/l, EC = 2,400 μ mhos/cm) alone. Irrigation with tube well water caused detrimental effect on soil quality as it resulted in highest pH (9.35), electrical conductivity (EC, 0.6 dS/m), sodium adsorption ratio (SAR, 11.01) and low organic carbon content (OC, 2.0 g/kg) of the soil. In light textured soils, it is recommended that either application of sulphitation pressmud @ 6 kg/vine on dry weight basis every year after pruning in January or cyclic use of sodic water with good quality canal water (1 : 1) may be practised to obtain optimum fruit yield with minimum adverse effect on soil health.

Increasing water productivity by application of polymer: Soil application of super absorbent polymers increased water use efficiency. Results of a field experiment on the effects of application of different rates of polyacrylamide – potassium acrylate polymer (PAM) on maize (cv. DHM 117) in light textured red soils showed that PAM at 25 to 50 kg/ha delayed wilting of maize by 5–6 days during initial dry spell and maintained higher soil moisture retention at different crop growth stages as compared to control. Application of PAM at 25 kg/ha enhanced maize yield by 16% as compared to control.

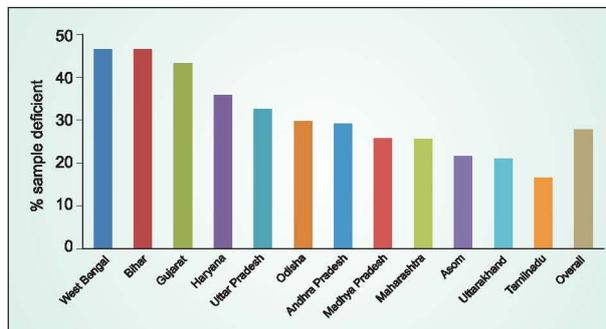
CAZRI soil moisture calculator: Regression-based pedotransfer functions (PTFs) were developed to estimate soil water retention at 1/3 bar (field capacity) and 15 bar (permanent wilting point) from available soil data in the hot arid zones of western India. The models showed satisfactory performance when validated and tested with independent datasets and were better than several established PTFs available in literature. A user interface was prepared for wider applicability and drop-down menus made available for choosing a particular PTF model and the required input parameters. This application called 'CAZRI soil moisture calculator' is hosted on the CAZRI website (www.cazri.res.in/)

CAZRI soil moisture calculator

soil-moisture-calc.php) and its use will optimize irrigation water use in the drylands.

Nutrient management

Reassessment and delineation of sulphur deficiency: State-wise data generated under AICRP on Micro Secondary and Pollutant Elements for 12 states of country revealed S deficiency (< 10 ppm S) in 46.5% soils of West Bengal followed by Bihar (46.4%), Gujarat (43.3%), Haryana (35.8%), Uttar Pradesh (32.5%) and Tamil Nadu (16.5%).



Status of sulphur deficiency in soils of different states of India

Microbial diversity for biofertilizers: Studies on diversity of rhizobia of 20 major legumes revealed high diversity for 16S rRNA, *nif* and *nod* genes. Rhizobium isolates of legumes from 'Tal' lands of Bihar and endophytic rhizobia of stem nodules were characterized. Consortia of rhizobia and plant growth promoting rhizobacteria (PGPR) for blackgram in Andhra Pradesh increased yield by 30%.

Zinc mobilizing microbial cultures *Trichoderma viridae* and *Pseudomonas striata* showed 23% and 18% increase in seed cotton yield, respectively, as compared to recommended dose of fertilizer. They also increased zinc availability in soil by about 10%. Significant improvement in soil enzymes like acid phosphatase, alkaline phosphatase and dehydrogenase activity was observed by inoculation with these cultures.

In field demonstrations of PGPR, *Bacillus licheniformis* controlled the white root rot disease of



apple and increased yield by 40% in Himachal Pradesh. Also, the biofertilizer package for cauliflower increased yield by 25–30% in Himachal Pradesh and saved 25% N and P fertilizers.

Bioinoculation of knol khol and pointed gourd in acid soil of Odisha increased yield by 8–12% and 10–15%, respectively, and increased NPKS uptake efficiency significantly. Bitter melon yield increased by 12%, along with increase in vitamin C by 8% and protein content by 11%. Similarly, in jute–rice–greengram system in Odisha, jute yield increased by 19%, rice by 8% and greengram by 12% due to biofertilization over soil test dose. In Assam, application of biofertilizers to jute decreased the consumption of chemical fertilizers by 50%.

Liquid biofertilizers when applied to maize in Alfisols of Andhra Pradesh through seed, seedling, soil or drip irrigation resulted in 50% higher grain yield over solid carrier. Further, liquid inoculants of rhizobium and PSB gave 15% extra grain yield over 100% RDF besides saving 50% RDF.

Decision support system for vegetable crops: A web-based decision support system for diagnosis and management of macro and micronutrient deficiencies in vegetable crops was developed to provide a guide for identification of mineral nutrient deficiencies and disorders in vegetable crops and their remedial measures. Besides, the system also provides information on the mineral nutrients availability in soil, their functions and deficiency symptoms in plants and ameliorative measures for correcting the deficiencies.

Environmental flow estimates of rivers for fisheries development: Environmental flow requirements for sustaining fish diversity in river Dri of Arunachal Pradesh indicated that the river maintained flow of 50 m³/sec during monsoon (May to September) and 35 m³/sec in post-monsoon (October to March). A flow of 250 m³/sec for short spells of four to five days during September and October ensured healthy flood spells for return migration of fish species and river geomorphology.

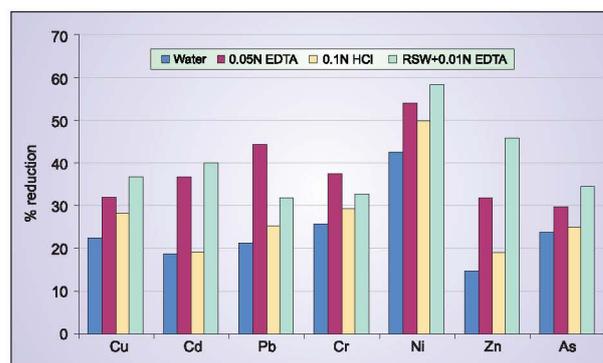
The incoming and discharge data of river Ganga at Bhimgoda barrage, Haridwar, Uttarakhand for the period 1980–2010 showed little difference in quantity of inflow and discharge during peak flood season, but the discharge significantly declined during the lean season. This difference in water flow up-stream and down-stream of the barrages is affecting water quality, plankton abundance and fisheries at Maneri, Tehri, Srinagar, Haridwar, Bijnore, Narora and Kanpur.

As per the environmental flow estimate of the river

Sone at Indrapuri barrage the river is in critically modified condition (Class F) and to maintain at least moderately modified condition (Class C) 18.9% of mean annual runoff (MAR) is projected, while the actual discharge of the river is only 5.16% of MAR. Altered flow has led to loss of fish diversity and invasion of exotics. The river presently holds 89 fish species. About 20 fish species have got wiped out, while 14 new fish species were encountered.

Removal of heavy metals from composts: A survey conducted by IISS, Bhopal in 29 Indian cities indicated that composts manufactured from mixed wastes (MWC) and partially segregated wastes (PSWC) were unsuitable for land application due to high heavy metal content (being greater than the quality control limits specified by Fertilizer Control Order, 1985). Finer (<0.5 mm) particles in MWC and PSWC contained higher concentrations of heavy metals.

A technology was developed for removal of heavy metals from municipal solid waste compost through extraction-cum-wet sieving procedure. Extractants used were EDTA (0.05N), dilute HCl (0.1N) and untreated distillery spent-wash containing 0.01N EDTA (RSW+EDTA). Removal of finer particles reduced on an average, Cu by 22%, Cd by 19%, Pb by 21%, Cr by 26%, Ni by 42%, Zn by 15% and As by 24%.



Reduction in heavy metals contents in MSW composts using extraction-wet sieving methods

Among the extractants, 0.05N EDTA was usually most efficient in removing Pb and Cr whereas, RSW+0.01N EDTA was most efficient in removing Cu, Cd, Ni, Zn and As. Wet sieving using efficient extractants (0.05N EDTA and RSW+0.01N EDTA) reduced different heavy metals on an average by about 34–58% from MWC and PSWC. This method has considerable potential in diminishing the magnitude of soil contamination potential from the regular use of MSW composts in agriculture.

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