Natural Resource Management

SOIL RESOURCE INVENTORY AND MANAGEMENT

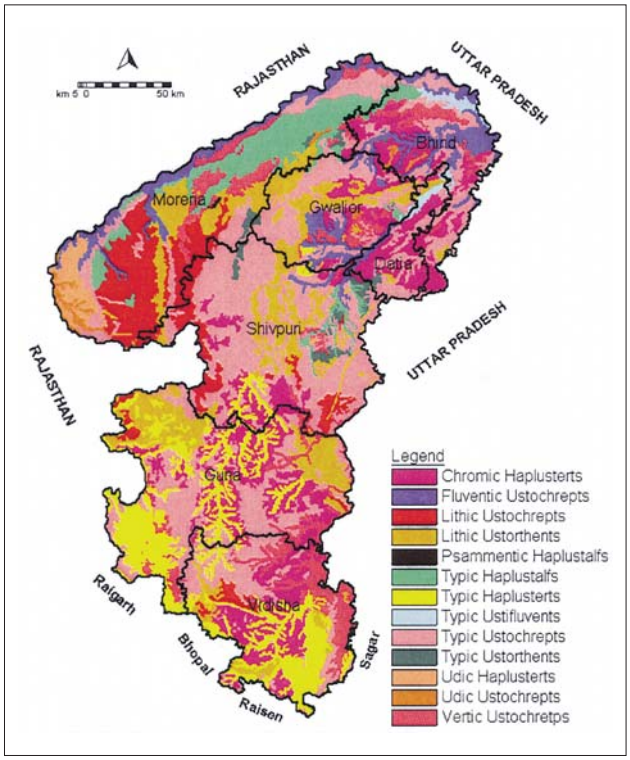
Soil resource survey

Soil resource survey and mapping on 1 : 50,000 scale of 12 districts spread over Rajasthan, Jharkhand, West Bengal, Madhya Pradesh, Bihar, Orissa, Assam and Punjab, covering 5.17 million ha, has been done for the district-level land-use planning. And 254 divisional atlases for 22 districts in Andhra Pradesh, covering 275 lakh ha, have been generated. Besides, detailed soil surveys of 13 watersheds/farms on 1 : 10,000/1 : 5,000 scale have been completed, covering 112,904 ha, for soil-resource-based land-use planning in watershed-development programme. Sindh river basin-based inventory of soils has also been carried out.

Soil correlation: Soil series identified during reconnaissance, rapid reconnaissance, detailed surveys and soil-resource mapping have been thoroughly reviewed and correlated, and finally 498 soil series comprising 121 in Bihar, 112 in Orissa, 155 in Gujarat, 45 in Medak district of Karnataka and 65 in Andhra Pradesh are retained.

- On 1 : 50,000 scale, soil resource survey done of 12 districts spread over Rajasthan, Jharkhand, West Bengal, Madhya Pradesh, Bihar, Orissa, Assam and Punjab for district-level land-use planning
- Carried out inventory of soils of Sindh river basin
- Prepared computerized digital databases and state maps of alkali and saline soils of Karnataka, Maharashtra, Tamil Nadu and Kerala on 1 : 250,000 scale
- Soil erosion maps generated for Andhra Pradesh and Orissa
- Yield of rice increased significantly under Zero-Till Direct Seeded rice compared to conventional practice

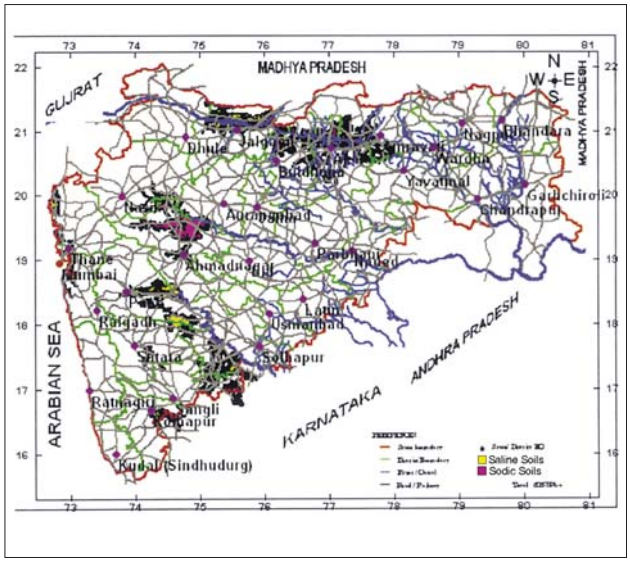
Soils of Sindh basin, Madhya Pradesh

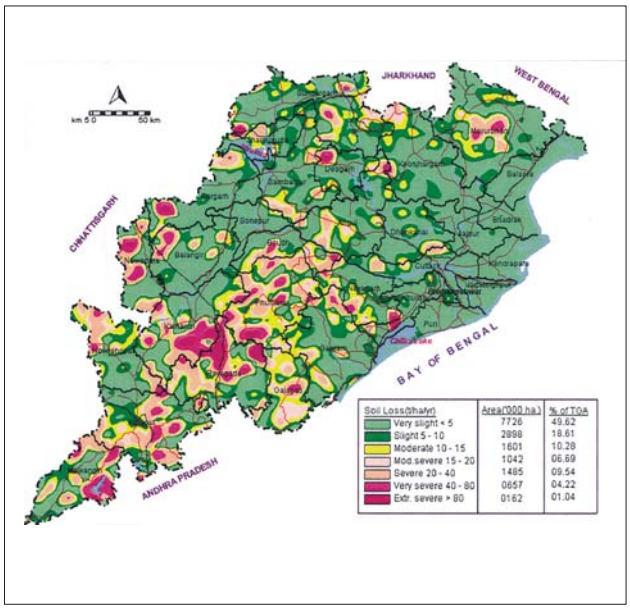


Computerized database of salt-affected soils

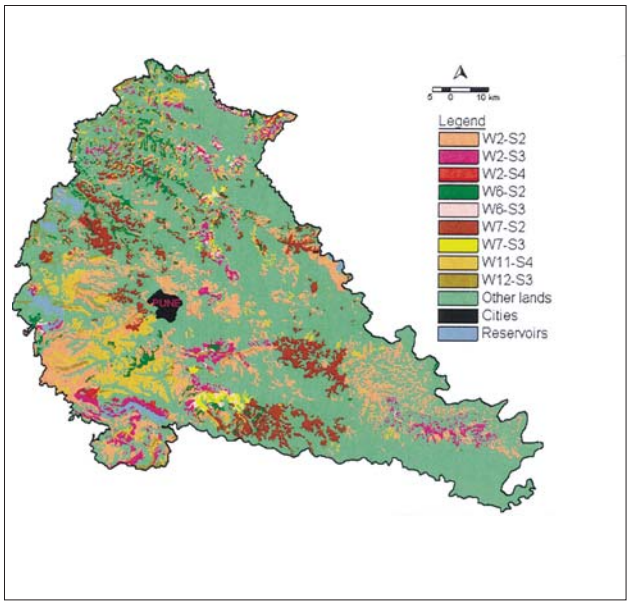
The computerized digital databases and state maps of alkali and saline soils of Karnataka, Maharashtra, Tamil Nadu and Kerala on 1 : 250,000 scale have been prepared.

Digitized map of salt-affected soils of Maharashtra

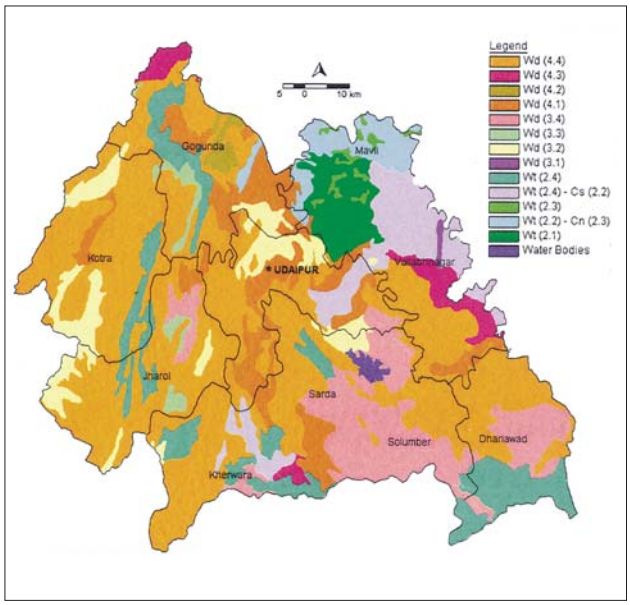




Soil erosion map of Orissa



Soil degradation map of Pune (Maharashtra)



Soil degradation map of Udaipur (Rajasthan)

Soil degradation/soil erosion

Based on the soil-resource data generated through soil-resource management project and grid observations (10 km × 10 km), soil-loss (tonnes/ha/year) maps have been generated for Andhra Pradesh and Orissa. In Andhra Pradesh, 37% and in Orissa 32% of the area suffer from soil loss of more than 15 tonnes/ha/year. Similarly, thematic map on wastelands and soil degradation of Pune (Maharashtra) and soil degradation map of Udaipur (Rajasthan) have been prepared. These maps are useful for undertaking soil-conservation measures and for prioritizing implementation programme and resource allocation.

Resource conservation technologies to boost profitability of rice-wheat system

The average yield of rice under Zero-Till Direct Seeded Rice (ZTDSR) has been 6.1–6.7 tonnes/ha in comparison to 4.2–5.5 tonnes/ha in conventional practice. The farmer saved about 50–60% irrigation water too. Zero tillage wheat sown in the rice residue gave maximum yield of 3.55 tonnes/ha. The next higher yield of 3.19 tonnes/ha was with the normal ZT wheat in rice residue under double ZT system.

Management of agricultural resources in Garhkot watershed, Dehra Dun

Cash crops, ginger, turmeric and colocasia introduced in the watershed performed excellently under rainfed conditions, and their yields were 11.5, 8.1, 12.5 tonnes/ha on an average. Under agri-horticulture and agroforestry, 3,772 fruit-plants and multipurpose trees could be planted with 70% survival. Mango, guava and citrus planted in 2002–03 have started bearing fruits. The co-efficient of improvement has showed productivity of watershed 1.3 to 1.7 times for *kharif* crops and 1.2 to 1.5 times for *rabi* crops, and this can be increased by adopting improved varieties with low-inputs under rainfed conditions.

Zero-Till Direct Seeded Rice for higher yields (6-7 tonnes/ha) compared to conventional practice

Brown manuring with *Sesbania* in rice, to save 35 kg N/ha

Soil-and-water conservation technologies

- Minimum tillage with crop residue treatment has been found beneficial for conserving natural resources, and this increased productivity under rainfed conditions in Doon valley. The treatment reduced runoff by 44 and 11%, and soil loss by 66 and 21% compared to cultivated fallow and conventional tillage. And this recorded 2,595 kg grain yield of maize/ha and 707 kg oilseed yield of *toria*/ha, which were higher by 15% and 12% over conventional tillage and were at a par with conventional tillage with crop residue treatment. The highest net returns of Rs 8,350/ha and B : C ratio of 1.48 were with minimum tillage with crop residue, followed by Rs 7,730/ha with conventional tillage.
- About 20–22% of cropping season rainfall in western Rajasthan used to be lost through surface runoff and nearly 1.5 to 2.0 tonnes of soil/ha due to water erosion. These losses could be reduced to 14 to 16% and 0.7 to 1.1 tonnes/ha with grass barriers of *Vetiveria zizanioides* (*Khas*)/*Saccharum munja* (*Munj*)/*Cenchrus ciliaris* (*Dhaman*)/*Dichanthium annulatum* (*Karad* grass). The filtering effect of these barriers promoted upstream deposition of soil and nutrients and *in-situ* moisture conservation. On an average, organic carbon, N, P and K was 3.8, 40, 5 and 12.8% higher in the upstream vicinity of grasses as compared to no barrier plots. About 15 to 24% increase in grain yield and 8 to 15% on straw yield of sorghum and soybean was observed in upstream vicinity of barriers.
- The runoff as percentage of rainfall was highest under traditional (28.3%) grazing, followed by rotational (22.6%) system and was least under cut-and-carry system (18% runoff). Trenching in combination with vegetative barriers allowed rainfall runoff of only 8.2% as compared to 41.5% under control (no measure).

Sesbania seeds at 20 kg/ha were broadcast 3 days after rice sowing. The crop when allowed to grow for 30 days and dried by spraying 2, 4-D ethyl ester could suppy up to 35 kg N/ha.

WATER MANAGEMENT

Land and water productivity enhancement

To enhance productivity of seasonally waterlogged lands in canal commands, secondary reservoir fed by canal seepage and supplemented by tubewell, fish trenches-cum-raised bed for fish-horticulture production and rice-fish culture using nylon-pen under waterlogged area, were taken up. In secondary reservoir (SR) concept, two reservoirs (control and reservoir with water exchange due to routeing of water) were constructed in the seasonal waterlogged area. Multiple uses of water by fish culture in reservoir, horticulture (two tiers: banana/guava/lemon and vegetables) on bunds, routeing water to cereal crops, and duck-rearing were evaluated. Water was supplemented from tubewell to maintain minimum water level in the reservoir for fish production. Fish yield of 201 kg (2.52 tonnes/ha) was obtained by SR multiple use and 220 kg (2.75 tonnes/ha) from SR-Control through polyculture.

To utilize waterlogged lands having water depth 0.3–1.0 m, the

- Developed a low-energy water application technology specifically for small farm-holders and for close-growing crops
- Waterlogged wastelands could be reclaimed with *Acacia* and *Casuarina* species. *Acacia* performed better than *Casuanina*
- Earned net income of Rs 132,590/ha from fish in dug-out pond with horticulture on dykes; of this 56% was contributed by fruit-crops, 17% by vegetables and remaining 27% by fish

To enhance productivity of seasonally waterlogged lands in canal commands, multiple use of water by fish culture in reservoir, horticulture on bunds and routeing water to cereal crops is being adopted (A) multiple-use system overview (B) rice+fish with centre refuge (C) fish trenches-cum-raised beds

concept of fish trenches was experimented with two types of lay-outs: (*i*) Meandering-type trenches simulating river flow in the fish trenches (Tr-R), and (*ii*) Island-type trenches simulating pond-type (Tr-P) conditions. Tr-R gave fish yields of 72.7 kg (1.66 tonnes/ha) and Tr-P of 80.9 kg (1.74 tonnes/ha). Banana was planted on the raised bed, which gave yield of 1.03 tonnes/ha.

Similarly, to enhance productivity of shallow waterlogged lands (20–50 cm) in the canal command, in an rice-fish integrated system, where fish was harvested after 120 days resulted in average fish yield of 1.13 tonnes/ha, which was slightly less as compared to

Component-wise net income from different multiple water-use systems

Water-use systems	Net income (Rs/ha)					% Increase over rice-wheat system (%)
	Rice and wheat	Fish	Fruit	Vegetables	Total	
Rice and wheat	27,965 (100)	0	0	0	27,965 (100)	0.00
Rice and wheat with fish refuge in the centre	26,392 (88.88)	3,302 (11.12)	0	0	29,694 (100)	6.18
Fish in sunken trenches, horticulture on raised beds	0	19,440 (24.01)	43,609 (53.87)	17,902 (22.11)	80,951 (100)	189.47
Fish in dug-out pond and horticulture on dykes	0	35,345 (26.66)	74,150 (55.92)	23,095 (17.42)	132,590 (100)	374.13
Fish in dug-out secondary reservoir	0	93,550 (100)	0	0	93,550 (100)	234.53

Note: Figures in the parentheses indicate percentage to their respective total

the yield of 1.42 tonnes/ha in 2004–05. Paddy yield enhanced, due to stocking of fish, by 7 to 13%. Stocking of stunted yearlings gave better fish yield as compared to fish-fry stocking. The system enhanced overall income by 11–32% as compared to sole rice-crop grown in the area.

Net income from the fish in dug-out pond with horticulture on dykes was Rs 132,590/ha. Out of this, 56% was contributed by fruit-crops, 17% by vegetables and the remaining 27% by fish. Net income gained from fish in dug-out secondary reservoir was Rs 93,550/ha/year and the amount came from fish production. Fish in sunken trenches with horticulture on raised beds gave net income of Rs 80,951/ha/year. Out of this, 54% was contributed by fruit-crops, 22% by vegetables and the remaining 24% by fish. Net income from rice-wheat system with fish refuge in the centre was Rs 29,694/ha/year. Out of this, 11% was contributed by fish and 89% by rice and wheat. These systems were compared with traditional rice-wheat system where net income was Rs 27,965/ha/year. Increase in net income was highest (374.13%) in fish in dug-out pond with horticulture on dykes. It was 6.18% in rice-wheat system with fish refuge in the centre, 189.47% for fish in sunken trenches with horticulture on raised beds, and 234.53% for fish in dug-out secondary reservoir.

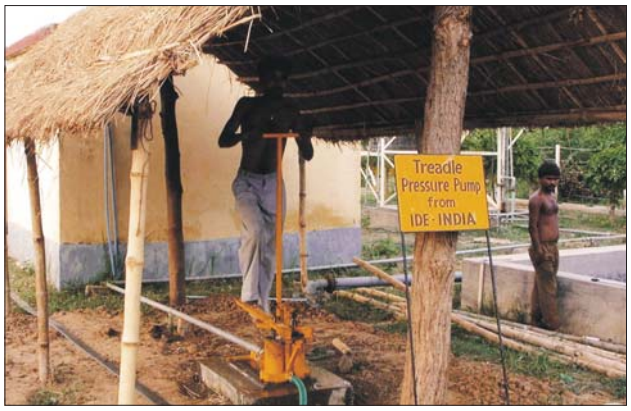
Water productivity assessment in irrigated command

A study was initiated in three outlet commands of RP Channel V distributary of Patna Main Canal under Sone Canal System and two tubewell commands in Vaishalli Districts of Bihar to determine water productivity.

Crop water productivity (Rs/m^3) considering applied water varied from 4.79 to 8.39 in the outlet commands. Considering water inflow, including rainfall, it ranged between 2.42 and 3.11. In tubewell commands, the crop water productivity for applied water ranged from 14.03 to 29.61, and it was 2.81 to 2.39 with total water inflow, including rainfall. Total water productivity (Rs/m^3) considering applied irrigation water varied from 5.28 to 10.66. Considering total water inflow, it ranged between 2.67 and 3.96 in outlet commands. In tubewell commands, the total water productivity ranged from 18.09 to 38.73 for applied water and 3.09 to 3.68 for total water inflow. Lower water productivity considering total water inflow (irrigation + rainfall) in tubewell commands may be attributed to higher proportion of rainfall in the total water used. Crop water productivity alone does not depict actual use of water in the command. Since total water productivity takes into account other water uses like trees, fodder, livestock, fish etc., and its value is higher and as such it gives the true picture of actual water use and productivity of water in an irrigated command.

Low-cost pressurized irrigation system

A low-energy water application (LEWA) technology specifically for small farm-holders and for close-growing crops has been



Treadle pressure pump operated with LEWA

Crop and total water productivities in canal outlet and tubewell commands

Item	Outlet head reach	Outlet middle reach	Outlet tail reach	Tubewell land consolidation	Tubwell land fragmentation
Area (ha)	30.61	43.68	4.65	18.74	13.21
Crop water productivity per unit of irrigation water applied (Rs/m^3)	4.79	4.95	8.39	29.61	14.03
Crop water productivity per unit of water inflow including rainfall (Rs/m^3)	2.42	2.73	3.11	2.81	2.39
Total WP per unit of irrigation water applied (Rs/m^3)	5.28	5.90	10.66	38.73	18.09
Total WP per unit of water inflow including rainfall (Rs/m^3)	2.67	3.25	3.96	3.68	3.09

SUCCESS STORY

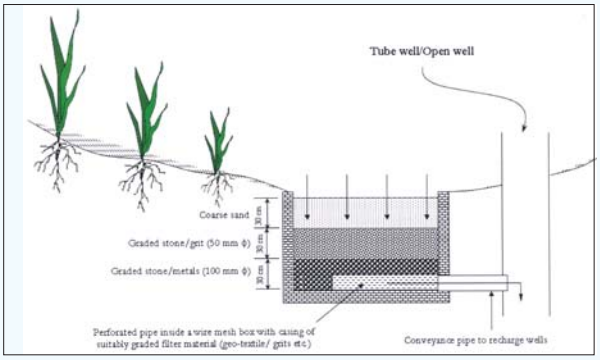
Impact of groundwater recharge in Antisar watershed, Vasad (Gujarat)

Scarcity of the water for drinking purpose as well as for the irrigation emerged as one of the major problems of the area. The conservation works for groundwater recharge included land levelling (132 ha), pond renovation (4 nos), repair of major dam (1 no.), construction of check-dams (16 nos) and well recharge filters (23 nos). Watershed development activities resulted in positive impact on the drought mitigation, crop improvement, and improvement in lives of beneficiaries. The recharge filter designed by the Central Soil and Water Conservation Research and Training Institute, Research Centre, Vasad, consists of porous filters to deliver a substantial quantum of storm-water runoff harnessed from agricultural fields and excess of drainage water from the catchment. A three-tier filter ensures sediment-free water delivery to a nearby open or tubewell through a buried pipe-line. Initially the artificial recharge filter was constructed in one of the community wells, which was dry since long. This resulted in water availability in this well in the same season. This visual impact motivated farmers to participate in this activity, particularly in drought years.

Antisar watershed (812 ha) is 100 km away from Vasad on Dakor-Pankhia road in taluka- Kapadvanj, District Kheda. About 500 families of 7 villages/ hamlets of the watershed are engaged in agriculture and animal husbandry. The watershed is the part of Gujarat agro-ecological sub-region No. VI. Monsoon lasts for about three-and-a-half months (mid-June to September) in this with an average annual rainfall of 834 mm (1983–2005).

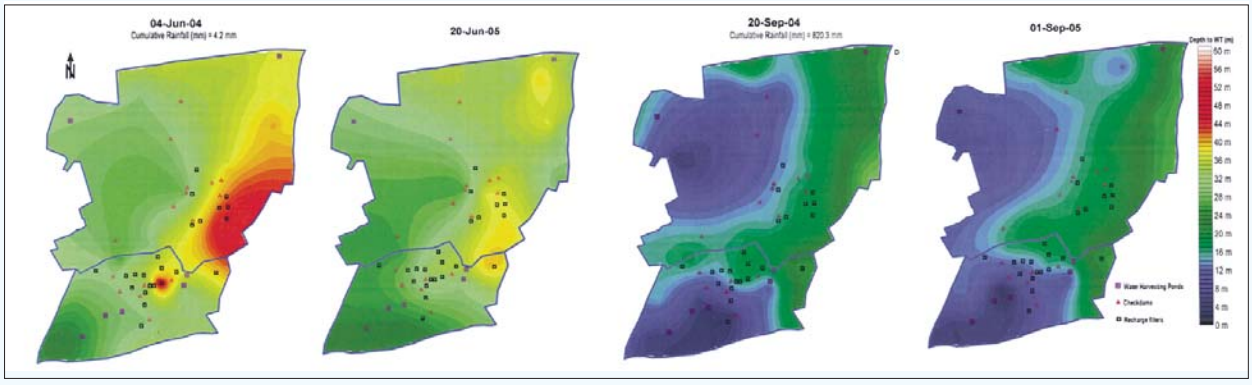
A comparison of pre- and post-monsoon (2004 and 2005) groundwater table showed quantum of recharge resulting from the water-storage structures and recharge filters. Crop sowing, which was delayed by 25 to 30 days outside the watershed, could be done in time within the watershed. Likewise, the number of repeated sowings, which varied between two and three times outside the watershed, was done only once in the watershed. The fertilizer application in the watershed was double of the quantity used outside the watershed. The green and dry fodder consumption increased by 30 to 40% outside the watershed. The various *kharif* crops saved through supplemental irrigations from these recharged wells also yielded 50% higher in some cases. In addition, the available groundwater resulted in improved crop productivity.

The enhanced groundwater recharge had attracted farmers to diversify their cropping systems. In 2002–03, drumstick (*Moringa olifera*) hybrid type was introduced as block plantation (2 ha) in the watershed. Harvest of 6,906 kg of vegetable pods/ha was realized with gross returns of Rs 57,587/ha during the first year of plantation. In second year (2003–04), 30,000 kg of vegetable pods were harvested with gross returns of Rs 107,500/ha.



Schematic representation of groundwater recharge filter

Bumper harvest of drumstick pods with enhanced groundwater recharge in the watershed



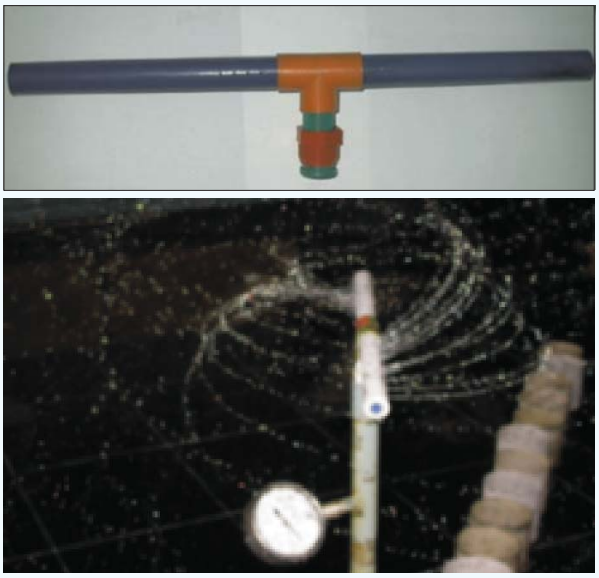
Pre-and post-monsoon watertable regimes in water-harvesting structures (ponds, checkdams etc)

Low-energy water

Wild flooding or field to field irrigation is the most common on-farm water management practised by the majority of the farmers in the prevalent rice-wheat cropping system. And the major quantity of the water thus is lost in the system in conveyance and application, besides lots of wastage of energy.

Keeping in view the increasing pressure on water and energy resources in future, it was thought of to develop a low-cost water and energy-efficient device which can be used by resource-poor farmers possessing small and fragmented land holdings. This led to the development of low-energy water application, LEWA.

LEWA unit with rotating mechanism



Flow pattern of jet from the device

LEWA system laid down on farmer's field

A 1.5-hp prime mover pump (Electric) in operation

LEWA installed on underground PVC pipe to irrigate rice

application – at a glance

Salient features of LEWA

- Suitability: Provides irrigation to most of the field and row crops such as cereals, oilseeds, pulses, vegetables, flowers
- Energy efficient: Have an added advantage in saving of energy besides water
- Recommended operating pressure: 0.4–0.6 kg/cm^2
- Throw diameter: 6–8 m
- Application rate: 2.6–3.1 cm/hr, (can be adjusted based on the crops and soil types)
- Riser height: 1 m
- Surface uniformity 60–70 % when operated at an operating pressure of 0.5 kg/cm^2 or above
- Sub-surface uniformity > 90%
- Higher discharge than infiltration rate, unlike sprinklers, just to keep soil surface wet
- Low pressure required by LEWA facilitates use of low-cost flexible flat-hose pipes, other system components, and low hp prime movers pumps leading to low-cost of system
- With flexible flat-hose pipes, a LEWA unit for 1,000 m^2 costs approximately Rs 8,100 (excluding prime mover and on shift basis)
- In most of the cases saving of water and energy by LEWA device has been to the tune of 30–50% over surface method whereas 10% saving of water and 30-50% saving in energy has been observed as compared to sprinklers without any reduction in yield.

Low-cost system components of LEWA irrigation system

Low-cost components of LEWA system for irrigating rice

Low-cost components of LEWA system for irrigating wheat

Bio-drainage for ameliorating waterlogged area

The water-table was found beyond 2.1 m in bio-drainage plots and it was within 0.5 m in the unmodified experimental plots in March 2006 in WTCER research farm. Successful establishment of trees and intercrops and their vigorous growth have revealed that bio-drainage species *Acacia* and *Casuarina* can be grown for reclamation of waterlogged wastelands. *Acacia* performed better than *Casuarina*. Average mortality of these bio-drainage plant species in such wastelands after one year was very low (< 6%). Pineapple, arrowroot and turmeric were also intercropped successfully.

Makhana—a profitable farming system component of eastern India

Makhana is being cultivated in lowland rice fields and also in natural ponds. In Purnea and Katihar districts, the cropping period of makhana is from March to September, where makhana-rice cropping system is followed, and the yield of makhana obtained is higher than ponds. In traditional ponds,

Makhana in lowland rice field

makhana seedlings germinate from left-out seeds of the previous season (January–February). This is common in Madhubani and Darbhanga districts.

Yield of makhana seeds ranged from 2.0 to 2.5 tonnes/ha in well-managed systems and 1.5 to 2.0 tonnes/ha in natural systems. Its cost of cultivation was approximately Rs 25,000 to Rs 40,000/ha. And net income from makhana cultivation was around Rs 17,500/ha.

developed. The modified nozzle of the LEWA replaces sprinklers and low-cost LDPE-flat-hose flexible pipe replaces low-cost fittings such as valves, tee, elbow, socket and riser. This has facilitated in lowering cost of the system to the existing overhead impact sprinklers. A LEWA unit covering 1,000 m^2 per shift will cost Rs 8,000 approximately whereas the cost of the sprinkler unit for the same area is calculated nearly three times higher.

The performance of LEWA was compared with existing sprinklers (two low pressure spray nozzles, one impact sprinkler and another mini Wobbler). The tested sprinkler needed to be operated between 1.5 and 2.5 kg/cm^2 when spaced at 6–12 m, and mini Wobbler required at least an operating pressure of 1 kg/cm^2. The energy saving by the LEWA is to the tune of 3–5 times from sprinkler and approximately 2 times from mini Wobbler. Treadle pressure pump devised by the IDE has also been operated with LEWA. Considering the rate of discharge of the existing pump and capacity to generate head, four LEWA devices can be operated simultaneously when it is operated directly and water is lifted from the shallow depth.

NUTRIENT MANAGEMENT

Soil carbon stocks of Indo-Gangetic Plains

The soils in the IGP are formed by calcification, leaching, lessivage, salinization and alkalinization, gleization and homogenization. The region is dominated by Entisols, Inceptisols, Alfisols, Mollisols and Aridisols. The total carbon in the region is estimated at 13.7 Pg (1 Pg = 10^{15} g); organic carbon (SOC) is 9.6 Pg and soil inorganic (SIC) is 4.1 Pg. In lower IGP, SOC stock under rice-wheat or rice-potato systems has stabilized. Intensification of cropping system towards triple cropping is likely to reduce SOC stock, which can be mitigated by adopting no tillage or reduced tillage operations and addition of organic substrates.

Granular borax (Granubor II)—a new boron source

Sodium tetraborate pentahydrate (Granubor II, 14.6% B), carrying five molecules of water of crystallization, less than borax deca hydrate, was evaluated for correcting boron deficiency in cauliflower in different regions.

The flower head yield response ranged from 2.1 tonnes/ha in acid soils of Kullu, Himachal Pradesh, to 7.5 tonnes/ha in Alfisols of Andhra Pradesh. The net profit derived from 1 to 1.25 kg B/ha application ranged from 6,181 to 22,228/ha. And net benefit per rupee spent on boron was Rs 5.60 to 35.80 with borax and was

- Developed a new sulphur fertilizer, Gromor sulphur benetonite pastille, containing 90% sulphur
- Sodium molybdate at 0.5/ha to maize in Mo-deficient soils of Andhra Pradesh increased crop yield

Granubor II effects on cauliflower. Granubor II has been found a cost-effective source of boron with returns of Rs 16 to Rs 60 per rupee invested

Rs 16.63 to Rs 59.91 with Granubor II (borax pentahydrate granular).

Gromor sulphur bentonite—a new sulphur source

Recently, a new sulphur fertilizer Gromor sulphur bentonite pastille, containing 90% sulphur, has been developed, and was tested in maize and mustard system on Inceptisol at Anand (Gujarat) and in rice-cowpea sequence on Alfisol at Bangalore (Karnataka). The new sulphur source bentonite sulphur has been found as effective as gypsum or single superphosphate (SSP) in improving grain yield of maize, rice, cowpea and mustard over NPK without S.

Gromor sulphur bentonite a new source of sulphur has proved as effective as gypsum or single superphosphate in improving the yield of mustard (Gujarat)

Mean effect of sulphur sources in correcting its deficiency in maize-mustard in Inceptisol, Anand, and rice-cowpea in Alfisol, Bangalore

S sources	Seed yield (kg/ha)			
	Maize–mustard		Rice–cowpea system	
	Direct maize	Residual mustard	Direct rice	Residual cowpea
Control (NPK only)	2,755	1,793	3,450	890
Bentonite-S	3,354	2,025	3,912	1,565
Gypsum	3,126	2,065	3,716	1,490
SSP	2,946	2,006	3,928	1,465
CD @ 5%	125	83	122	105

Molybdenum for increasing crop productivity

Molybdenum at 0.5 kg/ha as sodium molybdate to maize in Srikakulam and Vizianagram districts of Andhra Pradesh, where 49% soils are deficient in molybdenum, increased crop yield from 45 tonnes/ha to 56 tonnes/ha.

CROPPING/FARMING SYSTEM RESEARCH

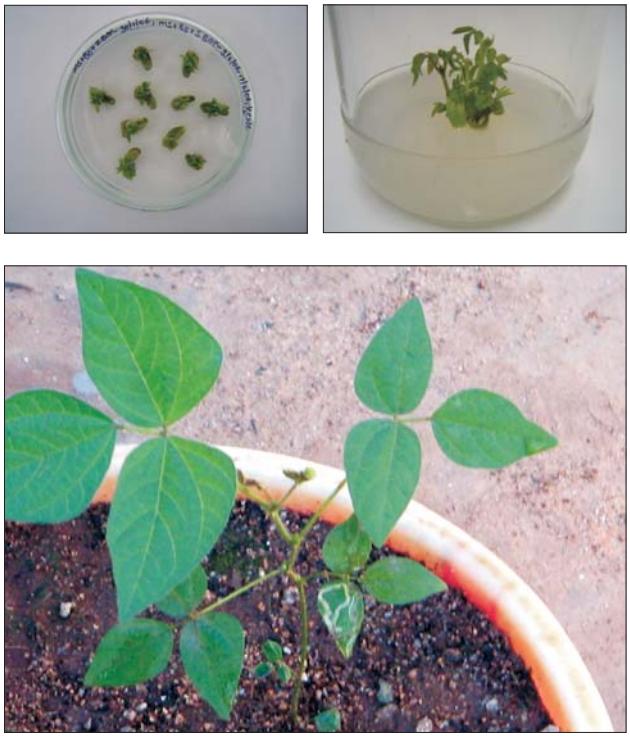
- In Bihar, wheat-elephant-yam and urdbean system provided maximum pigeonpea equivalent yield (8.16 tonnes/ha), followed by tobacco-summer maize-*dhencha* (GM) (6.96 tonnes/ha)
- Maximum yield equivalent in terms of rice was recorded in rice-tomato-bottle-gourd (48 tonnes/ha) in Bihar
- In red-gravelly soils of Dharwad, groundnut yielded higher in 20-cm wider spread teak alleys compared to 10-cm ones
- Using *subabul* leaves as fodder for feeding 70 lambs saved expenditure of Rs 20,660 on the concentrate feed
- *Amaranthus* GA 2 found as a good source of protein

CSR 36—A new rice variety for salt-affected areas

A new, high-yielding and salt-tolerant rice with long, slender grains was released by the CVRC for Haryana and Pondicherry in 2005. This variety performed well up to 11 dS/m in saline soils and up to pH 9.8 in alkali soils. This variety yielded more than 7 tonnes/ha in normal soils and above 4 tonnes/ha in the salt-affected soils.

Genetic transformation of mungbean (*Vigna radiata*) for enhancing drought tolerance

Mungbean contributes to 15% of the pulse production, and drought is the single-most important constraint affecting its productivity. Therefore, transgenic approach was tried with cultivar



In-vitro tissue culture via multiple shoots induction in mungbean using half cotylednary node with intact cotyledon as explant

ML 267 by introducing *annexin bj* gene to impart tolerance to moisture stress by relieving oxidative stress.

Half-cotyledonary node with intact cotyledon as explant derived from 3-day-old seedlings germinated on the medium containing 2 mg/litre BAP has been found most suitable and effective, and it could produce a reasonably high number of multiple shoots when cultured on the medium containing 12.5 mM BAP. The shoots so developed were elongated on medium having 5 mM BAP and 0.05 mM NAA. These shoots were rooted on a NAA medium. On transfer to glasshouse, the plants could grow well and produced normal seeds.

Pre-*rabi* pigeonpea-based cropping systems

Wheat-elephant-yam + urdbean system provided maximum pigeonpea equivalent yield (8.16 tonnes/ha), followed by tobacco-summer maize-*dhencha* (GM) (6.96 tonnes/ha) in Bihar. The net returns also followed same pattern, and the highest returns of Rs 85,805/ha were obtained in the Ist system, followed by Rs 71,737/ha by the second system. The cost: benefit ratio was highest under the Indian mustard-mungbean-urdbean cropping system (1.27), closely followed by wheat-summer maize-*dhencha* (GM) (1.25), wheat-elephant-yam + urdbean (1.24) and tobacco-summer maize-*dhencha* (GM) system (1.19).

Diversified cropping systems for irrigated ecosystem in Bihar

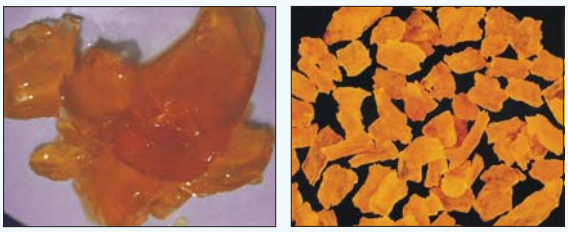
Maximum yield equivalent in terms of rice was recorded in rice-tomato-bottle-gourd (48 tonnes/ha). Minimum yield equivalent was recorded in rice-carrot-cowpea (7.62 tonnes/ha), rice-capsicum-cucumber (7.98 tonnes/ha) and rice-coriander-lady's finger (8.84 tonnes/ha). Rice-cabbage-Frenchbean (18.81 tonnes/ha) and rice-potato-onion (13.91 tonnes/ha), rice-mustard-tomato (12.88 tonnes/ha), rice-pea-green-chilli (11.43 tonnes/ha), rice-wheat-urdbean (11.25 tonnes/ha) and rice-lentil-sponge-gourd (10.34 tonnes/ha) recorded reasonable yields but they were

Diversified cropping systems for irrigated ecosystem in Bihar. Maximum net profit of Rs 83,253 has been recorded in rice-coriander-lady's finger

Edible candy and jelly from *Aloe vera*

A major problem of *Aloe vera* plant is its high perishability, even under refrigeration. A method has been developed for the preparation of 'Aloe Candy' in which active ingredient of the plant remains intact, and its shelf-life is reasonably high (> 6 months) at room temperature. The candy is made from freshly separated pulp of the leaves; by treating with sugar. Polysaccharides in *Aloe vera* leaves vary from 0.20 to 0.35%, and in the fresh juice from mature leaves ranges from 0.18 to 0.37% (w/v). Sugar is mixed as per taste requirement, but normally it should be 70–82%.

Prepared another product, 'Aloe jelly', from freshly prepared juice has polysaccharides content of 0.15-0.26% and sugar content of 9–50%.



Aloe candy and Aloe jelly from Aloe vera, a highly perishable plant, keep the active ingredient of the plant intact

CS 54—A new raya variety for saline/alkali soils

This variety yields significantly higher than other salt-tolerant and national high-yielding checks CS 52, Varuna and Kranti. Its average seed yield recorded was nearly 20, 22 and 20% more than CS 52, Varuna and Kranti.

found at a par. Maximum net profit was recorded in rice-tomato-bottle-guard (Rs 192,114), followed by rice-mustard-tomato (Rs 88,526) and rice-coriander-lady's finger (Rs 83,253).

Amaranthus—A new commercially viable option for arid Kachchh

At Kukma, application of nitrogenous fertilizer at 90 kg/ha and irrigation at 200 mm water at four growth stages to *Amaranthus* GA 2 in almost equal quantity, helped to produce 8,382 kg of dry biomass/ha and 1,206 kg of grains/ha with net economic returns of around Rs 20,000/ha, which were at a par with grain yield, biomass production and net returns obtained in the traditional *Amaranthus*-growing areas of Gujarat. The study indicates that cultivation of *Amaranthus*, which is a good source of protein, in Kachchh district is a commercially viable proposition.

Amaranthus GA2 at Kukma in Kachchh district

Agroforestry systems for different agroclimates

At Bhubaneshwar, ragi, groundnut, sesame and urdbean were grown in alleys (8-m wide) of *Acacia mangium* and *Gmelina arborea* at 625 trees/ha. The highest benefit : cost ratio was obtained from sesame (1.82) under *A. mangium,* followed by sesame (1.54) under *Gmelina arborea*. Among two trees, growth in terms of height and diameter was greater in *A. mangium* (Ht. 10.4 m, DBH 14.2 cm).

In red-gravelly soils at Dharwad, groundnut yield was higher in wider (20 m) spaced teak alleys than closer (10 m) ones. Marketable wood value of teak has been higher in 10- m spaced teak alley (Rs 228,543/ha) compared to 20-m spaced alley (Rs 125,653/ha). The net income was three times higher (Rs 11,347/ha/year) in field crops + teak + papaya system as compared to sole field crops (Rs 3,983/ha/year).

At Kattupakam, *Leucaena leucocephala* (2 m × 2 m spacing) in Napier-*bajra* hybrid fodder production system yielded 12, 34 and 12% higher dry fodder biomass, digestible protein and total digestible nutrients compared to Napier-*bajra* hybrid alone.

If *subabul* leaves were used as fodder source instead of concentrate feed, 70 lambs weighing 18–20 kg mean body weight

SUCCESS STORY

Farming systems in and around Patna

- The technology of raising early vegetable seedlings for winter and summer vegetables was adopted by large number of farmers and farm-women. This increased their income from Rs 2,700 to Rs 6,000 in 0.20 acre of land.
- Landless families adopted mushroom cultivation as an alternative livelihood support system. More than 100 women that formed Self Help Groups (SHGs) have started mushroom production in south Bihar. Women are earning a minimum of Rs 50/kg of mushrooms by spending only Rs 8.
- Rice-fish system was popularized in lowland area. By adopting this technology farmers harvested 2–3 tonnes of fish and 3 tonnes of rice in Bikram block.
- Through raising of Divyan Red breed of poultry, for rearing in backyards, on an average a farmer earned Rs 593 from a single female bird by sale of eggs. Moreover, 4 farmers raised chicks from eggs and earned an additional amount of Rs 600/family/year. Khaki Campbell breed of ducks was distributed among 41 landless farmers and unemployed youth from 8 villages. On an average, a farmer earned Rs 480 from a single bird by sale of eggs. Moreover, 5 farmers raised ducklings from eggs and generated an additional income of Rs 700/family/year.
- Twelve farmers of 5 different villages raised bunds of their fields up to 20 to 30 cm from existing 5 to 7 cm height. A total of 50 plots were under this intervention comprising 9 ha that reported following benefits : Soil moisture prolonged for longer duration; this resulted in saving of 2 irrigations; Lesser incidence of diseases as well as existence of weed were reported, and additional benefit was also reported of growing *arhar*, *okra* on bunds, this provided additional income and compensated expenditure incurred for raising bund height.

could be maintained in one hectare of subabul + Napier-*bajra* hybrid fodder production system, and could save on concentrate feed expenditure of Rs 20,660.

Water hyacinth mulch to reduce weed infestation in potato

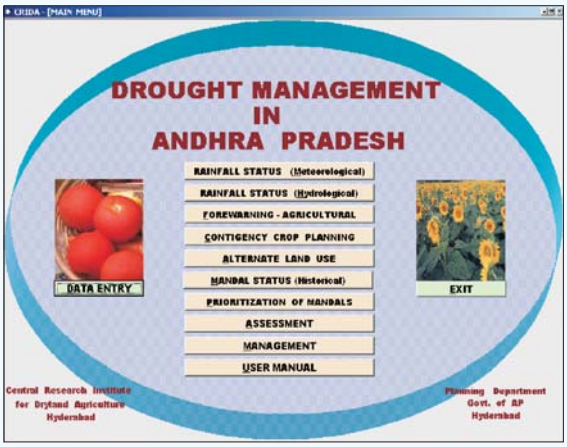
Water hyacinth mulch in potato (var. Kufri Chandramukhi) significantly decreased weed infestation (*Medicago, Chenopodium, Vicia, Chichorium* and *Physalis*), cost of earthing operation as well as cost of inorganic fertilizers by 50%. The plots which received mulch plus Metribuzin application showed minimum weed infestation and gave highest tuber yield.

IPM for managing fruit fly in cucurbits in Western Ghats

During *kharif* 2005 and 2006, the ICAR Research Complex for Goa demonstrated the technique of managing *Bactrocera cucurbitae* in hill cucurbits through on-farm trials using baits (10% banana/jaggery, 3% protein hydrolysate) laced with insecticide (0.1% Malathion 50 EC). These baits were applied in about 10 hectares in farmers' fields as fine splashes (squirts) once a week in a 7 m × 7 m grid (200 splashes/ha, 8 litres/ha, 40 ml/spot) on a 30-day-old crop (cucumber, ridge-gourd, bitter-gourd, snake-gourd) up to the end of commercial fruit production. Infestation levels were less than 10% in treated plots as compared

Drought Management Software for Andhra Pradesh Developed

Andhra Pradesh is the third most drought-prone state of India after Rajasthan and Karnataka. Rayalseema and southern parts of Telengana are considered as chronic drought-prone regions. The mandals prone to drought were assessed and prioritized using bio-physical and socio-economic parameters. Drought severity index was worked out for all mandals. A Drought Management Software (DMS) has been developed with several different modules dealing with drought assessment, mitigation and relief measures to reduce time-lag in collection, processing and transfer of data/information. Using information technology, a unique attempt has been made to bring planners and implementers on a single platform. In drought mitigation, stress has been laid on contingency crop planning and land-use diversification. Groundwater, surface water and livestock management have been given due attention as drought preparedness is much more cost-effective than relief measures. Relief measures have been focussed on developing a response plan by assigning roles and responsibilities to various departments including banks and insurance. Emphasis has been given to community-based participatory planning to improve effectiveness and transparency in various relief measures related to employment generation, public-health, food and fodder security.



Biofuel crops

- 892 CPTs (Candidate Plus Trees) of *Jatropha* and 323 CPTs of *Pongamia pinnata* (karanja) have been collected from 110 districts of India. The oil percentage in seeds ranged from 28 to 40%. All materials are in evaluation phase for growth, seed and oil yield.
- Vegetative propagation of *Jatropha* through stem-cuttings has been standardized. *Jatropha* cuttings in rooting medium containing equal proportions of sheep manure + red soil + black soil + vermicompost exhibited better overall growth. *Bacillus coagulans* (PD 7) and *B. lentus* (ALP 18) have been identified as potential strains to promote plant growth when administered through seed priming or as slurry treatment on cuttings.
- Two-year-old grafted *Pongamia* trees started fruiting whereas ungrafted seedlings are yet to flower.

to nearly 20% in plots that received no bait application. Managing fruit fly with this technique reduced insecticide load on the crops by nearly 90%.

MACHINERY AND IMPLEMENTS

Implements for reducing women's drudgery

Hand-drawn seed drill: To reduce drudgery and improve efficiency of farm-women in seeding operation, a two-row seeder with suitable attachments has been developed. The unit can be used either as a seed drill or as a weeder. The drill consists of 2

Hand-drawn seed drill. This two-row seeder developed with suitable attachments can be used as a seed drill or as a weeder

- Hand-drawn seed drill and hand-operated winnower developed to reduce drudgery of women

seed-hoppers of 22 cm × 18 cm × 26 cm, flow rate controls, conveying tubes, furrow openers with row-distance adjustment and 31-cm diameter drive-wheel and chain and sprockets. The main frame of the implement was fabricated with 25-mm pipe and 25 mm × 4 mm flat. The implement is suitable to sow dryland crops such as sorghum, *bajra*, chickpea etc. The implement has been tested in field to sow sorghum with 45-cm row spacing.

Hand-operated winnower: A simple, hand-operated winnowing machine has been developed. The machine consists of 55 cm × 75 cm × 115 cm frame on which a 12-kg capacity feed hopper with auger mechanism is fitted. A 180W 1425 rpm electric

Hand-operated winnower. For this machine, 2 women are required and they can winnow 0.25–0.3 tonne of grains per hour

motor with 15-inch fan are arranged on the frame. Two women are required to run the machine; one to operate the auger and the other to feed the material to be cleaned. Two women can winnow 0.25–0.3 tonne of grain per hour by this.