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State wise approaches to crop nutrient balances in India

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Agriculture Development in India after Independence

- **FIRST PHASE (1947-67: 20 yrs):** Major concern was the creation of the necessary infrastructure.
- **SECOND PHASE (1967-97: 30 yrs):** The country witnessed Green Revolution in wheat, rice and other crops characterized by a beneficial fusion of professional skill, political will and farmers enthusiasm.
- **THIRD PHASE (1997 onwards):** Has been witnessing a stagnation in production and productivity and a fatigue in green revolution. The other major problem have been declining soil fertility and increasing nutrient mining situations posing threat to soil health.

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NP driven Indian agriculture led to increasing deficiencies of K and other nutrients in most crops

Declining Trend of Nutrient Use Efficiency

Period	Increase in Nutrient Consumption (m t)	Increase in Food Production (m t)	Nutrient Response Ratio (kg grain/kg applied nutrient)
1960-1970	1.47	26.40	17.9
1971-1980	2.44	31.09	12.7
1981-1990	5.28	46.80	8.9
1991-2000	3.18	19.53	6.3

The major factor contributing to declining crop response is continuous nutrient mining due to imbalanced nutrient use, leading to depletion of some of the major, secondary, and micro nutrients like P, K, S, Zn, Mn, Fe and B from the soil.

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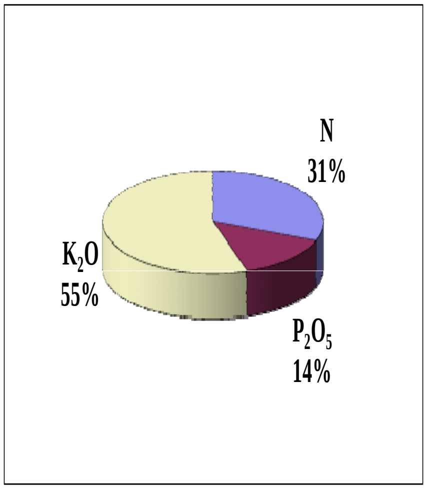
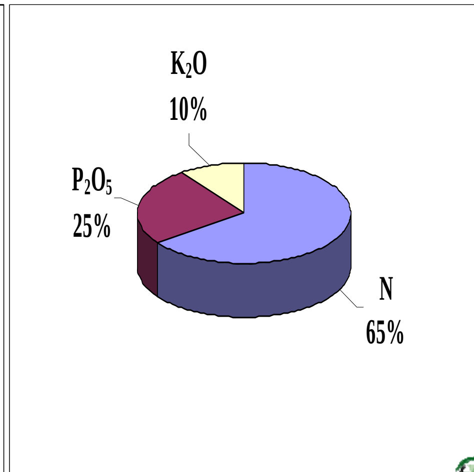
Contrasting pattern of nutrient removal (left) and fertilizer consumption in Indian agriculture (right)



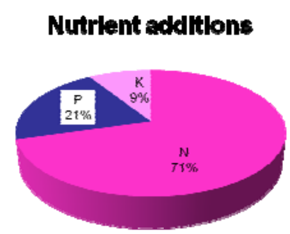


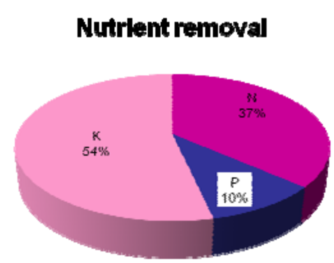
Comparison of nutrient additions and removals in RWCS

Sources	N	P	K
Fertilizer	2374.5	384.4	87.6
Irrigation water	276.6	11.3	344.8
FYM	258.9	68.4	205.1
Crop residue	55.0	11.6	206.8
Total	2965.0	475.7	844.3

NPK additions (000 t)

- 80% N applied through fertilizers and 9% through irrigation water
- 81% P applied through fertilizers and FYM contributed 14.4%
- Major contributions for K additions is through irrigation water (41%), crop residues (24%) and FYM (25%). Meager additions through K fertilizers (10%)





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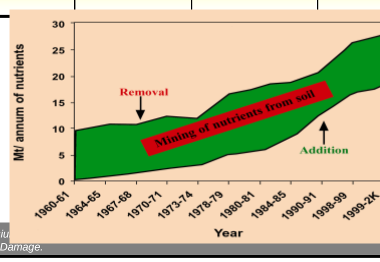
Nutrient Balance Sheet and Additional Potential of K Consumption at current NPK Use in India

Nutrient Balance Sheet – Indian Agriculture

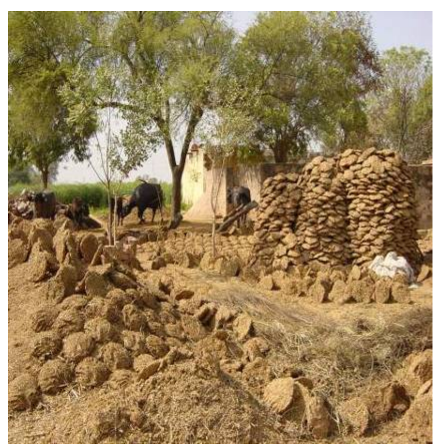
Nutrient	Gross balance sheet (000 t)			Net balance sheet (000 t)		
	Addition	Removal	Balance	Addition	Removal	Balance
N	10923	9613	1310	5461	7690	-2229
P_2O_5	4188	3702	486	1466	2961	-1496
K_2O	1454	11657	-10202	1018	6994	-5976
NPK Total	16565	24971	-8406	7945	17645	-9701

Future production targets depends on how fast the depletion of soils is reduced and the nutrient balance shifts from red towards green



Some projections on availability of plant nutrients from organic sources for agriculture in India during 2000-2025

Resources	2000	2010	2025
Nutrient (theoretical potential)'			
Human extreta (Mt N+P2O5+K2O)	2.00	2.24	2.60
Livestock dung (Mt N+P2O5+K2O)	6.64	7.00	7.54
Crop residues (Mt N+P2O5+K2O)	6.21	7.10	10.27
Nutrients (considered tappable)			
Human extreta (Mt N+P2O5+K2O)	1.60	1.80	2.10
Livestock dung (Mt N+P2O5+K2O)	2.00	2.10	2.26
Crop residues (Mt N+P2O5+K2O)	2.05	2.34	3.39
Total	5.05	6.24	7.75



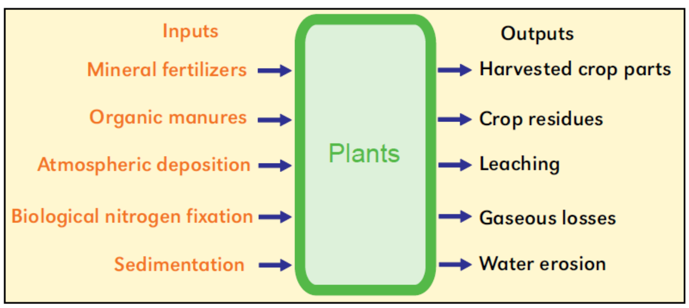
Only 20 to 30 % nutrient needs can be met from organic sources and that only if all sources are fully exploited.

Improvement in soil fertility, crop yields and nutrient balances under green manuring

Sequence	*Yield*		*Change over initial*			*Apparent nutrient balance*		
	Rice	Wheat	Organic carbon (%)	Olsen- P (kg ha^{-1})	Available K (kg ha^{-1})	N	P	K
Rice- wheat	5.73	5.65	+1.1	+15.5	-7.8	+141	+28	-63
Rice-wheat-greengram (GM)	6.80	5.71	+19.1	+32.2	+2.1	+210	+76	-04
Rice-wheat-sesbania (GM)	6.58	5.69	+14.6	+36.8	+2.5	+166	+70	-10

Source: Singh et al. (2002)

Basics of nutrient balance approaches



- More of a book keeping exercise on nutrient additions and removals
- Generates useful and practical information on whether the nutrient status of a soil is being maintained, built up, or depleted.

Nutrient Balance calculations - Advantages

- Bridge the nutrient gap and help to maintain soil health and ensure the food and nutritional security of present and future generations

- Understand the annual loss of nutrients from the soil and devise nutrient management strategies for rational use of soil resource in sustainable manner

Properly balanced crop nutrition results in higher, more efficient yields, while also safeguarding the environment.

Nutrient estimations from different sources

Source	Issues	Solutions
Fertilizers	Season-wise and district wise statistics on fertilizer use for different states are available	Thanks to FAI
FYM	-Cattle dung, available as FYM only after meeting the fuel needs -Chemical composition varies based on quality of cattle feed, animal health, preparation techniques and the state of decomposition	-Consider district-wise cattle population (Cenus 2001) -estimate total dung production at @10kg/cattle/day -Assume 40% recycling as FYM in each district -Estimate nutrient input by using average nutrient content
Crop residues	-Primarily used as cattle feed, thatching material, or as fuel, difficult to estimate the extent of residue recycling -Nutrient content of crop residues varies with crop type and nutrient management practices followed	Assume a min of 10% recycling irrespective of crop grown -Manual harvesting, 10-25% recycling -Machine harvesting, leaving entire residues in the field
Irrigation water	-Spatial variations in quality of irrigation water (two bore wells in adjacent fields differs significantly)	- Multiplying minimum water requirement of different crops with their acreage
BNF	-Difficult to measure at agro-climatic zone or district level, depends on type of soil, microorganisms, climate, crops grown and management practices	Need to develop a rationale for calculating the contributions

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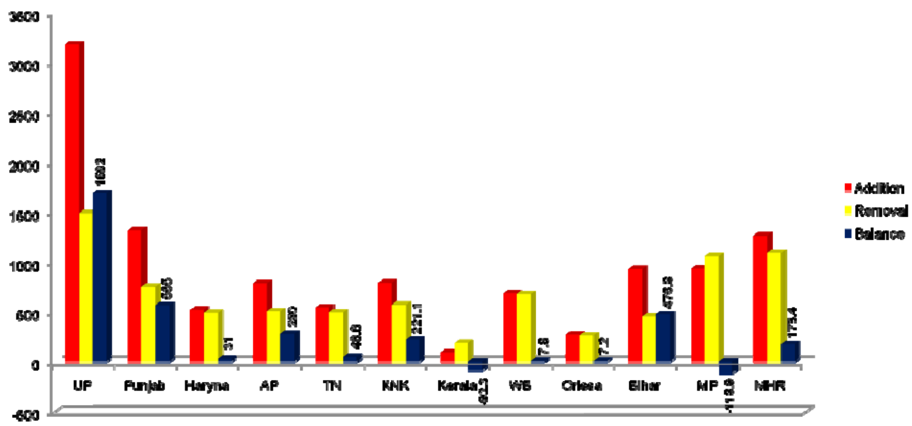
Limitations in present balance calculations

- Nutrient losses through various means other than crop removal are rarely taken into account.
  - Nutrient loss through soil erosion is second only to nutrient removal by crops and annually about 8 mt of nutrients are lost through water erosion (Prasad and Biswas, 2000)
  - Estimates of removals through leaching and gaseous losses are not available
- Most of the states are considering nutrient additions through fertilizers alone while calculating balances
- Information on nutrient additions from sources other than fertilizers is limited both in terms of application rates and contribution to annual nutrient input

N balance (000 t) in some agriculturally important states of India



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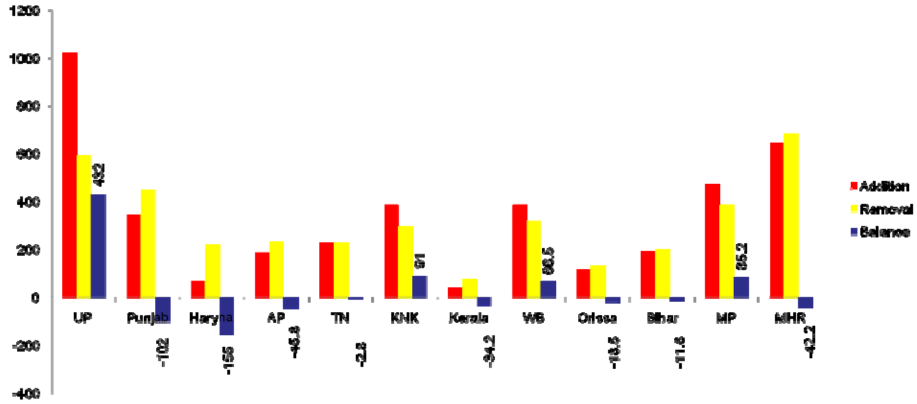
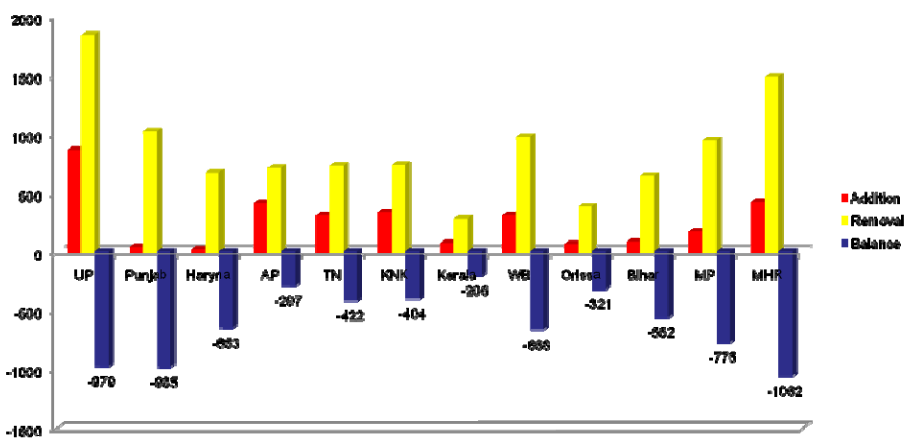
P balance (000 t) in some agriculturally important states of India



K balance (000 t) in some agriculturally important states of India



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Nutrient Balance scenarios of RWCS in Indo-Gangetic Plain region

Balance (000 t)	N	P	K
Fertilizers alone	776	-49	-2226
Fertilizers + FYM	1035	19	-2021
Fert + FYM + water	1312	30	-1676
Fert + FYM + water + Residues	1367	42	-1469
Net Balance	-116	-267	-1723

Even the well managed cropping systems raised on currently recommended rates of nutrient application end up showing negative balances

Consequences of Negative Balances

- ✓ **Decline of soil nutrient reserves and deterioration of soil health**
- ✓ **Occurrence of more widespread and more acute nutrient deficiencies**
- ✓ **Lower efficiency of nutrients applied**
- ✓ **Stagnation in growth rates of production and productivity of staple food grains – threat to food security**

Conclusions

- There is a need to compute nutrient balances for secondary and micronutrients. It is important to consider at least the most important nutrients
- Preparation of inventory of organic sources and recyclable wastes under different farming situations is required
- There is a need to document the availability of resources and their competitive uses through surveys representing different soil, crop, climate and socio-economic conditions
- Technologies for in-situ recycling of crop residues need to be popularized
- There is a need to incorporate the information generated from nutrient balance sheets while giving the fertilizer recommendations and developing decision support tools based on balance sheets and mining scenarios is the need of the hour

THANK YOU

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