Regenerative Agriculture for Soil Health, Food and Environmental Security

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nesis

December 2020, proposed to TAAS convening a BSS

TAAS instead asked organizing a BSS “Restoring Soil Health for Regenerative Agriculture” aka RA.

umped at the idea; never heard of farming concept called RA

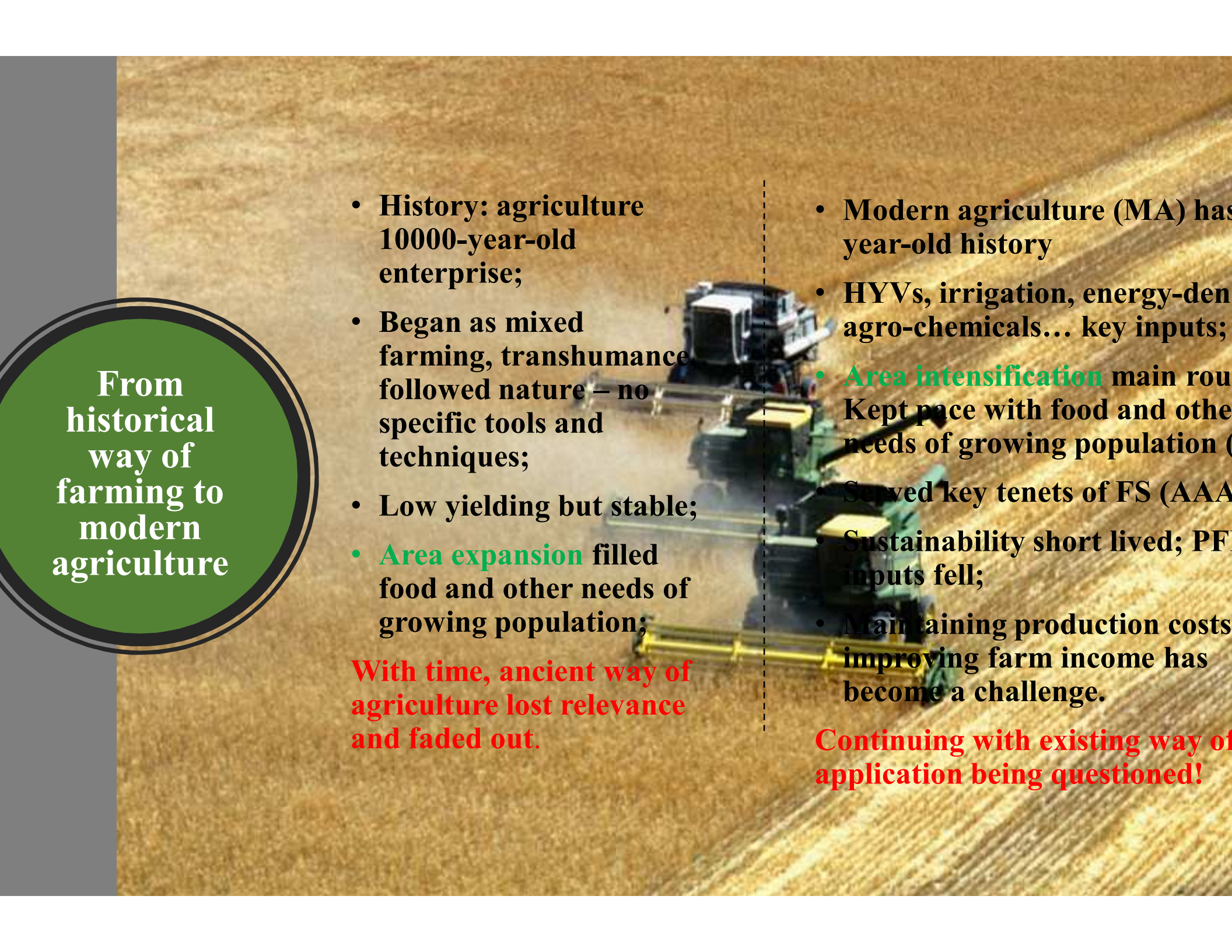
Found: Rodale Institute proposed RA system of farming in early 1980s; specific focus of RA proces s on recovering SH and sustainably enhancing its quality lost due to exclusive/faulty application of modern technologies replacing the historical way of farming;

RA is not a technology; a concept responding to enhancement of SH by utilizing the potential of soi biology to build SOC and vice versa; technology makes it possible

From historical way of farming to modern agriculture

- History: agriculture 10000-year-old enterprise;
- Began as mixed farming, transhumance, followed nature – no specific tools and techniques;
- Low yielding but stable;
- Area expansion filled food and other needs of growing population;

With time, ancient way of agriculture lost relevance and faded out.



- Modern agriculture (MA) has year-old history
- HYVs, irrigation, energy-den agro-chemicals… key inputs;
- Area intensification main rou Kept pace with food and othe needs of growing population (
- Served key tenets of FS (AAA
- Sustainability short lived; PF inputs fell;
- Maintaining production costs improving farm income has become a challenge.

Continuing with existing way of application being questioned!

exploitation of NRs and extractive agricultural practices left ulture stranded at a critical juncture?

Overstressed NRs. Observed RCA in 1928 "Indian soils depleted to the extent; no further depletion is possible". Situation no different today, rather worse (Fig)

Misuse of irrigation water, in a recent decade GW depleted by 61%; stressed water units rose,

Total reliance on HYVs; cereal-cereal rotation,

Exclusive/overuse/misuse/imbalanced use of agrochemicals,

Neglect of organic sources,

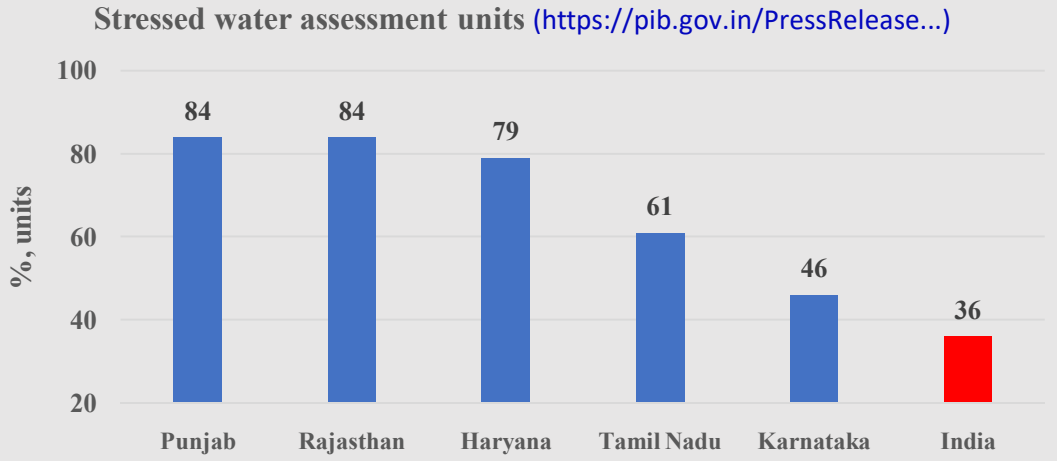
Repeat tillage,

Selective focus and inefficient use of energy,

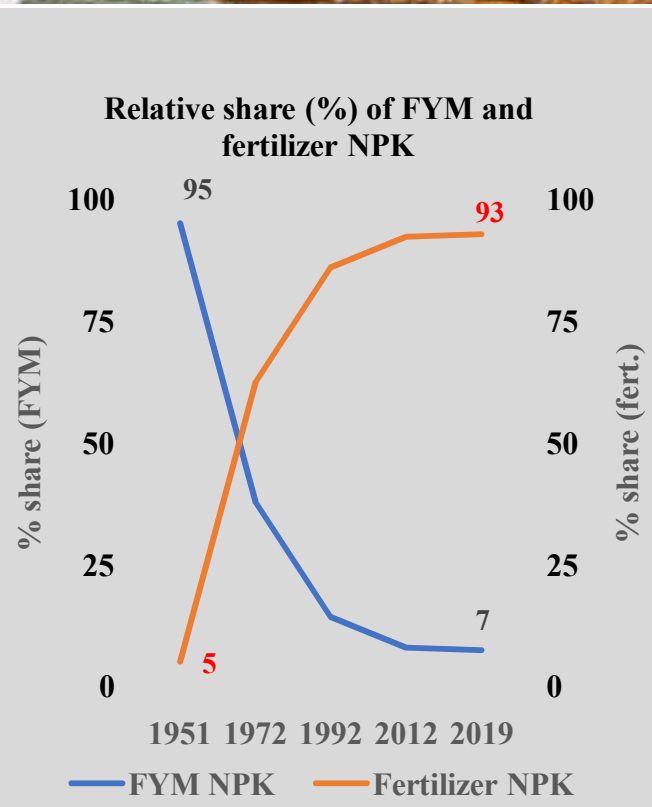
Industrial path of agriculture focusing mainly on productivity; sidestepping its consequences and environmental costs

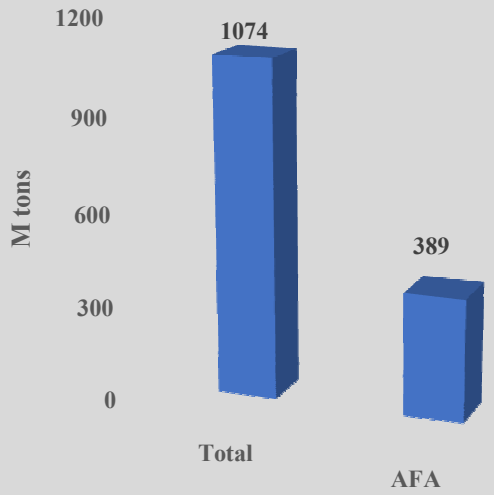
Year	1950	1960	1970	1980	1990	2000	2010	2020
	N	N	N	N	N	N	N	N
		Fe	Fe	Fe	Fe	Fe	Fe	Fe
			P	P	P	P	P	P
			Zn	Zn	Zn	Zn	Zn	Zn
			K	K	K	K	K	K
				S	S	S	S	S
				Mn	Mn	Mn	Mn	Mn
					B	B	B	B
						?	Mg	Mg
								Ca, Mo?

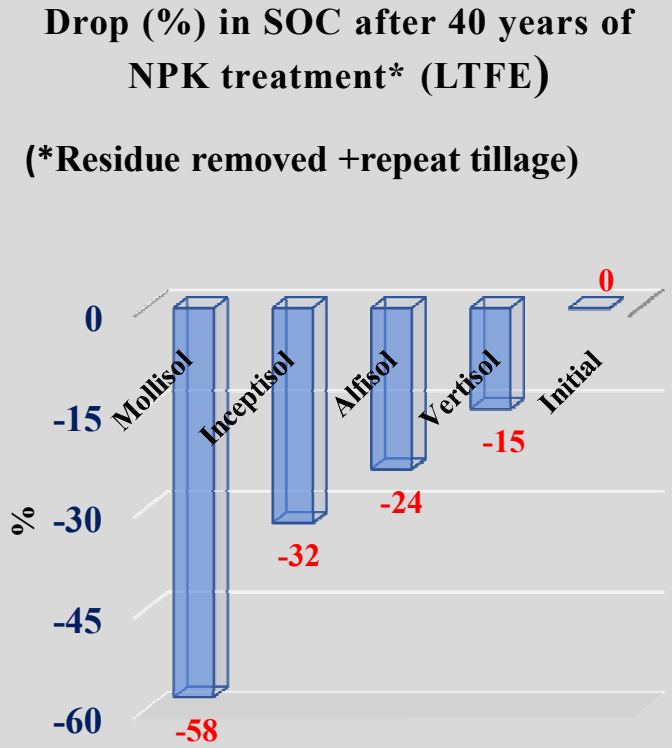
Emerging multi-nutrient deficiencies in Indian soils



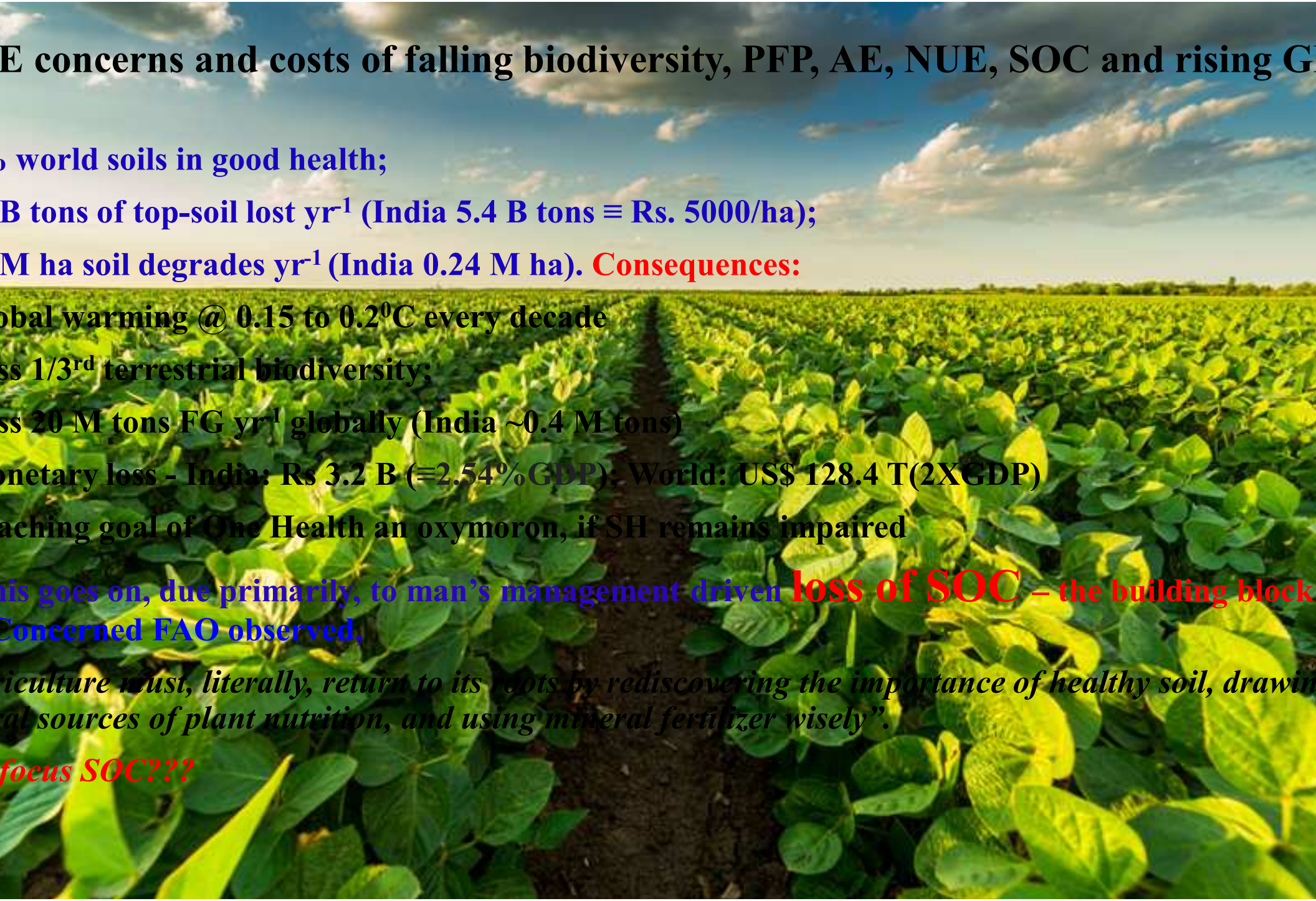
ring just on fertilizers led to falling use of organic manures and excessive focu
llage generated a cascading effect on SOC







+FYM: SOC rise ~20%; + ZT: SOC rise~30%



E concerns and costs of falling biodiversity, PFP, AE, NUE, SOC and rising G

% world soils in good health;

B tons of top-soil lost yr^{-1} (India 5.4 B tons ≡ Rs. 5000/ha);

M ha soil degrades yr^{-1} (India 0.24 M ha). Consequences:

obal warming @ 0.15 to 0.2^{0}C every decade

ss 1/3rd terrestrial biodiversity;

ss 20 M tons FG yr^{-1} globally (India ~0.4 M tons)

onetary loss - India: Rs 3.2 B (≡2.54%GDP); World: US$ 128.4 T(2XGDP)

aching goal of One Health an oxymoron, if SH remains impaired

his goes on, due primarily, to man's management driven loss of SOC – the building block

Concerned FAO observed,

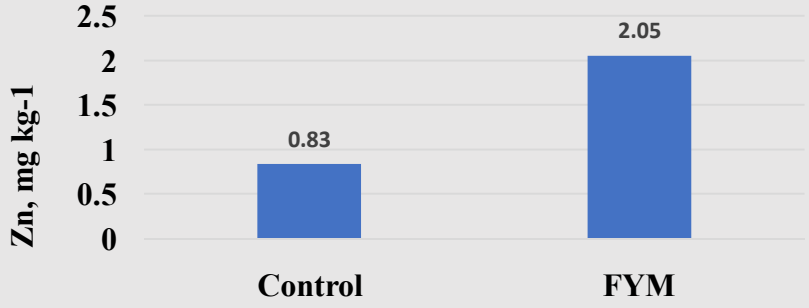
riculture must, literally, return to its roots by rediscovering the importance of healthy soil, drawin
al sources of plant nutrition, and using mineral fertilizer wisely".

focus SOC???

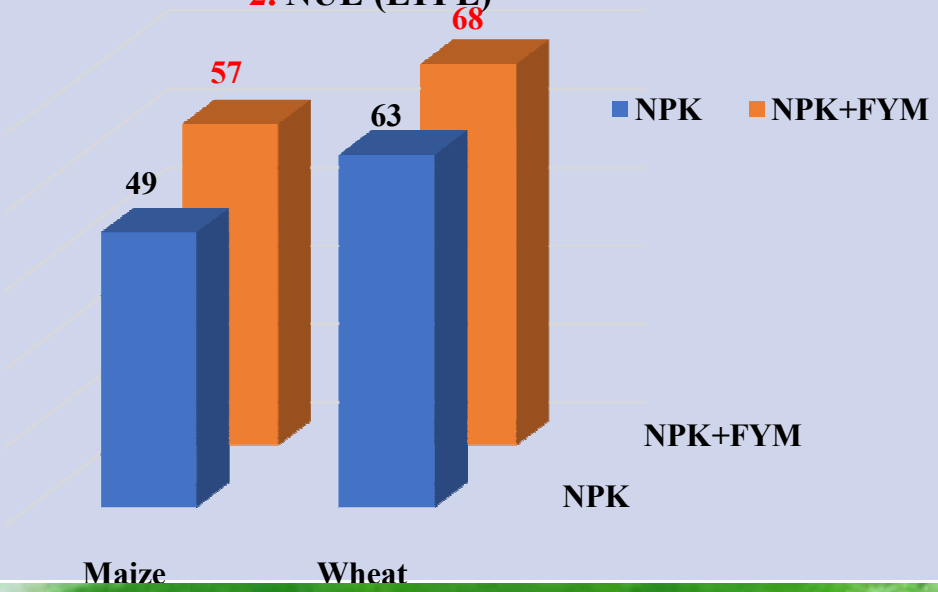
– Epicentre of SH/Food Security/CC

maintains a balance of fertility, physics and biology of soils;
ls food security; regulates CC because it is:
ehouse of nutrients;
ulator of soil structure/enhancer of WHC,
turer of soil biota; microbes decompose SOM, initiate
…cycles; elevates nutrient availability 1; affects NUE 2, FSS 3
ss FN, tillage, disuse of OM aggravate SOC loss, CC...
g to fore hitherto neglected role of soil biology to build SOC;
ALTERNATIVE SYSTEMS OF FARMING becomes 1st
strategy after GR

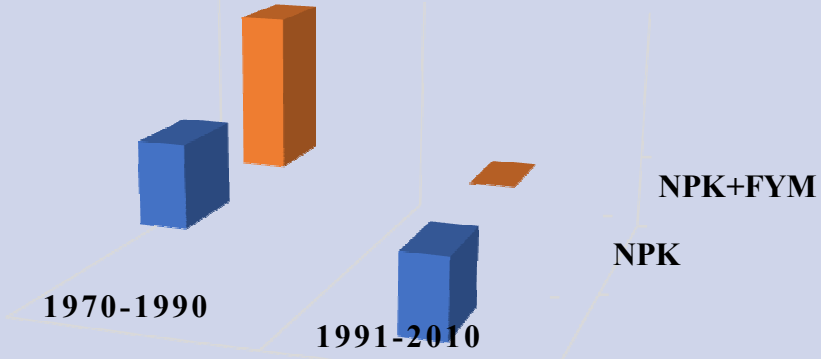
1. Available Zn after 35 Years
(Chaudhary & Narwal, 2005)



2. NUE (LTFE)



3. Food SS (CAGR %, wheat) (LTFE)



	1970-1990	1991-2010
NPK	1	-1
NPK+FYM	2	0

eed is for alternative systems of farming that inspire building SOC for SH/FSS and containing

rnative Systems of Agriculture (ASA)

LISA	LISA optimizes the management and use of internal production inputs (on-farm resources) and minimizes the use of off-farm resources (fertilizers) as is feasible and practicable to lower production costs and save the health of soil (USDA)
ZBNF	An agricultural practice that espouses natural growth of crops without adding any agro chemical. Mainly, cow dung plus urine-based decoctions smeared on seed or applied to soil replace fertilizers (Palekar).
OF	Agri. system that uses ecologically based pest control and for soil fertility management utilizes biological manures derived from animal and plant wastes, biofertilizers, organic fertilizers (unprocessed mineral sources) and nitrogen-fixing inter/cover crops.
NF	"Do nothing" but emphasizes avoidance of manufactured inputs and equipment and mimics how nature supports crop growth and development.
CA	A farming concept that promotes farming by adopting zero tillage, diversification and residue mulching. FGW re-interprets the CA principles for the faithful by employing biblical metaphors such as God doesn't plow, God's blanket, and the Garden of Eden (luxuriant plant cover) to shield soil from erosion.

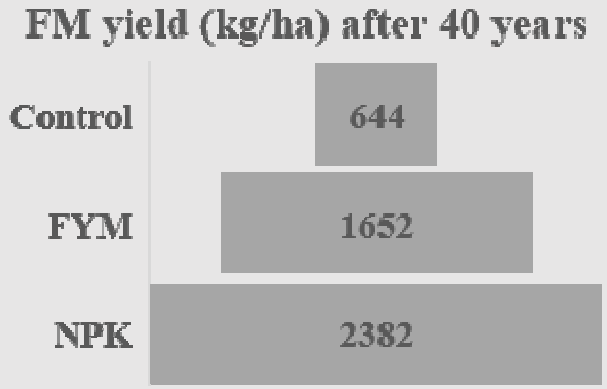
native systems of agriculture – Assessment

BNF: **Experimental** - yield of SF: NPK+FYM and YM+ jeevamrutha at par. Nutrient mobilization nd microbial diversity superior with the latter ZBNF) (Manjunath et al., 2009)

ield survey: ZBNF yields are largely inferior xcept when added with FYM; helped farmers get nore income due to reduced cost; better soil health perception) (NAARM, 2020)

OF:

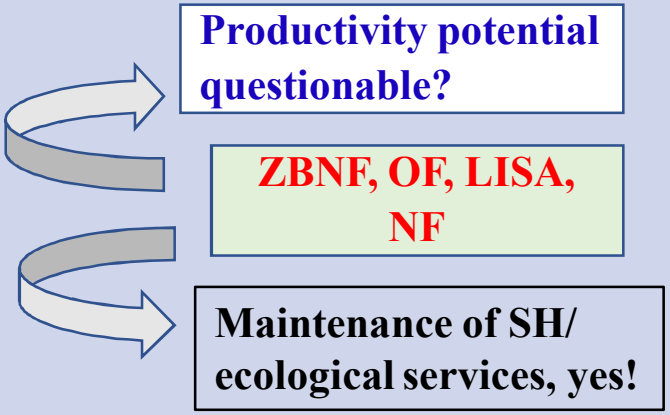
- **Relevance: specific crops & niche areas.**
- FG crop yields less by 20-35%
- Environmentally favourable (+SOC), not yield-wise.



LISA

LISA practices highly favourable for sustaining SH, but not for sustaining food self-sufficiency/ food security (F SS/S)

Conclusion



Alternative systems of agriculture – Assessment of CA

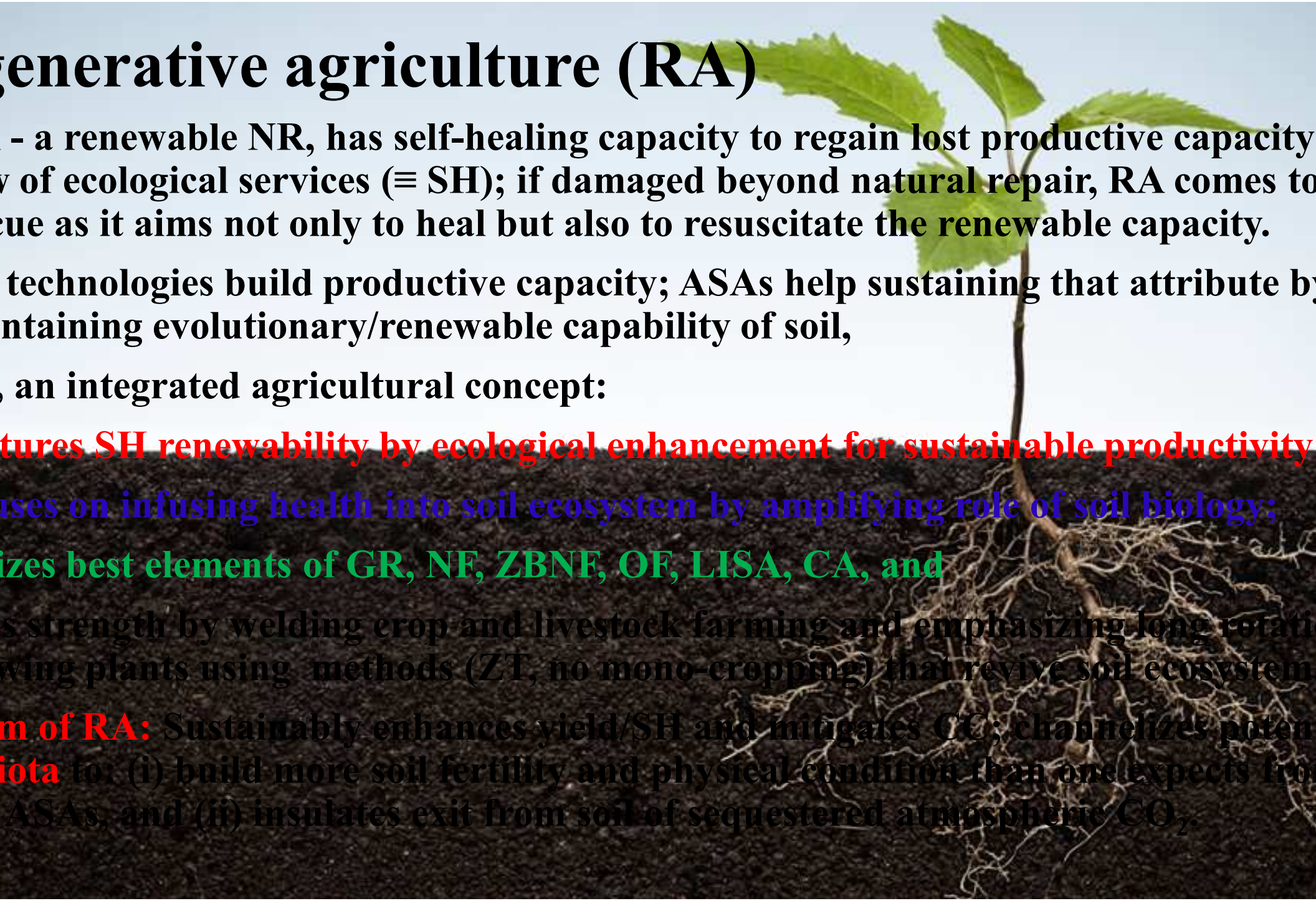
CA pro-sustainability; helpful to SH & contain CC; reduced costs.

Full compliment of CA produces yield advantage; improved drainage being critical (92% role: a meta-analysis); raised bed and furrow, SRT, CTF… improve,

Response to CA superior in rainfed areas; w/o mulching benefits diminish.

Higher response with RDF N application (meta-analysis) (Corbeels et al. 2014)

Despite proven benefits (higher returns), spread of CA limited. WHY?



generative agriculture (RA)

- a renewable NR, has self-healing capacity to regain lost productive capacity
of ecological services (≡ SH); if damaged beyond natural repair, RA comes to
cue as it aims not only to heal but also to resuscitate the renewable capacity.

technologies build productive capacity; ASAs help sustaining that attribute by
ntaining evolutionary/renewable capability of soil,

, an integrated agricultural concept:

tures SH renewability by ecological enhancement for sustainable productivity

uses on infusing health into soil ecosystem by amplifying role of soil biology;

izes best elements of GR, NF, ZBNF, OF, LISA, CA, and

s strength by welding crop and livestock farming and emphasizing long rotati
wing plants using methods (ZT, no mono-cropping) that revive soil ecosystem

m of RA: Sustainably enhances yield/SH and mitigates CC; channelizes poten
iota to: (i) build more soil fertility and physical condition than one expects fro
ASAs, and (ii) insulates exit from soil of sequestered atmospheric CO_2.

ology is the pivot. Has immense untapped potential as it inspires nutrient absorption
ittle soil; RA utilizing BEAM focuses on exploiting that power of soil biota, e.g., outsi
ide plants like Ficus, endophytes are an example of microbes, mainly mycorrhizal fu
nnect plant roots to soil nutrients that otherwise are beyond their reach; N fixing Rh

– CC mitigating potential

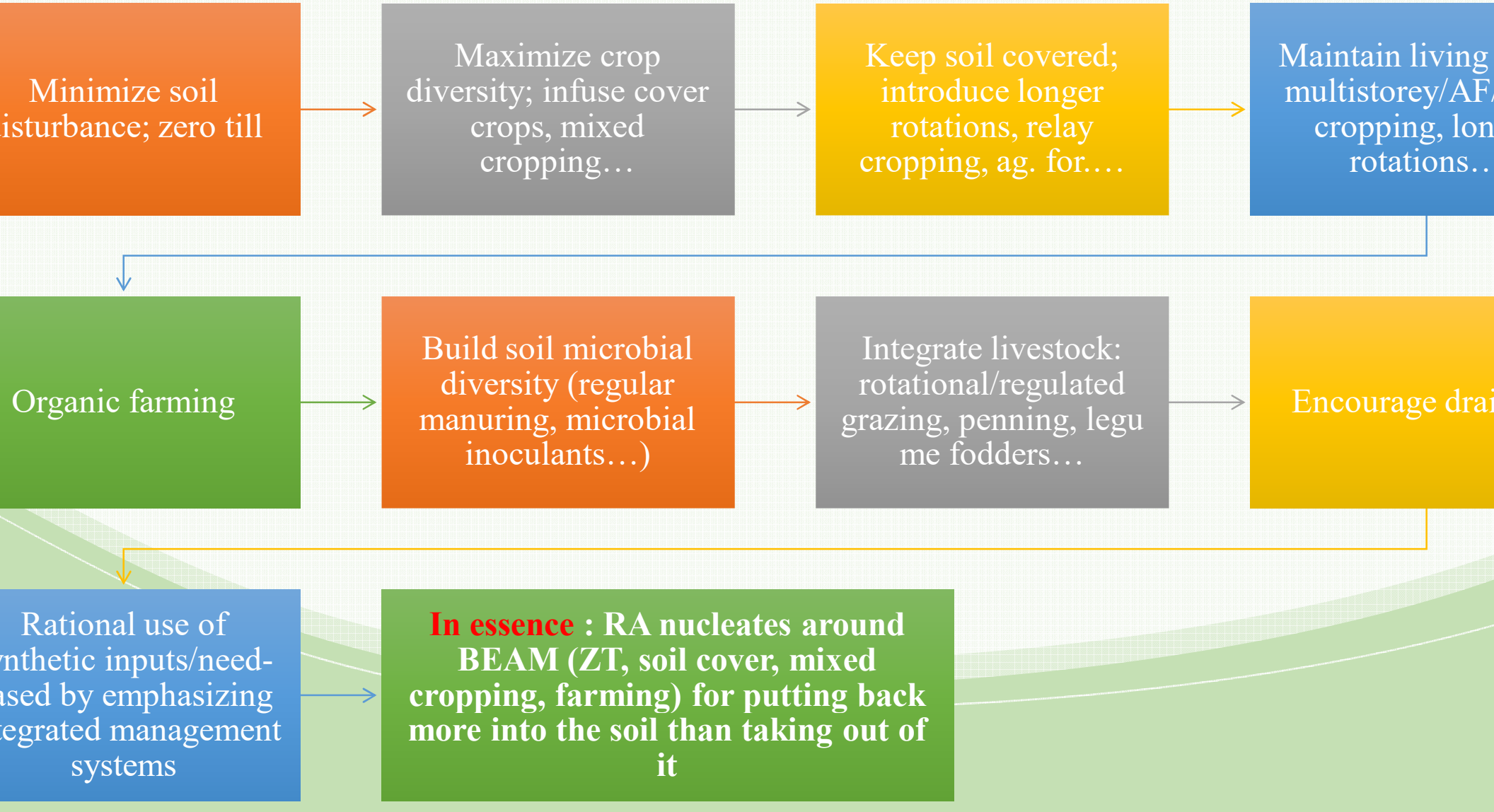
Experimental evidence on BEAM (David Johnson)

a 4.5-year agricultural field study promoted annual average capture and storage of 0.27 metric tons soil carbon/ha/year while increasing soil macro-, meso- and micro-utrient availability offering a robust, cost-effective carbon sequestration mechanism within a more productive and long-term sustainable agriculture management pproach."

- CCC potential = 10.27*3.67 means 37.7 tons of CO_2/ha or 184 G tons CO_2/year (crop lands + pasture lands); 10 times > equivalent of CO_2 increase (2.3 ppm)/year.
- Crop land: World ≡ 57 G tons (~30% area for RA); India ≡ 5.4 G tons (~50% area for RA)

lowever. insufficient experimental data to conclusively confirm Dr. Johnson's indings; multilocation large plot experiments are necessary to validate.

A Concept: General Elements



Recommendations

Adopting all 9 practices not necessary. Focus on 5: ZT, longer rotations centering on mixed cropping, use of organics, mixed farming;. Multiple practices allow to align with location and situation. Superimposing practice of self-fertilizing by endosymbionts, composting and raised-bed planting will add value.

As per selected practices, translate RA in fulfilling goal and vision of an agricultural production system for food, nutrition, CCC, and livelihood security. Need would be optimizing crop production and managing soil constraints that diminish degrading SOM.

Integrate vigorously the functioning of useful soil biology by maximizing return of larger proportion of organic resources; harnessing role of microbiota/bio-stimulants in accelerating in-situ composting of recalcitrant native materials would be necessary to enhance value of organics.

Need is there to mainstream RA practice and principles and to create a market for trade of ecosystem services; instituting a policy that supports rewarding (nay subsidizing!) farmers who adopt soil health regenerative practices - infusing resiliency into farming, would be of fundamental necessity.

Insufficient experience and experimental data call for validation of RA benefits on a sustainable basis to successfully transform MA/ASA to RA. Launch production-system based, multi- location, cross-institute, pan-disciplinary, long-term studies in action research mode. **Hence the BSS!**

BSS Objectives

To discuss potential role of OF, ZBNF, LISA, NF, CA in building RA for improving SH, FS and CCC

To assess potential economic, environmental, and social gains from the investments on AR4D on RA

To generate better understanding on prioritizing R&D efforts on modern and traditional agricultural practices contributing to RA


“Dear human! if you don't destroy me, I will give you shelter, food, water and oxygen” Helen Reidy. https://www.pinterest.ie/pin/369787819407444111/
Thank you very much