

Implementing regenerative cotton production practices in diverse small holder farming landscapes - challenges in the Indian context

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155th birth anniversary of Mahatma Gandhi –
apostle of peace and non- violence and a champion
of cotton and hand spinning for self- reliance.

“Earth can satisfy man’s need but not his greed”-
Mahatma Gandhi



True sustainability could be achieved only when people took responsibility of their own lives and for the environment around them (pearlacademy.com/how-the-Gandhian-philosophy-aligns-with-sustainability-today/).

Global narratives, local choices and personal priorities- dilemma

Climate change, GHG emission, Harmful pesticides/agrochemicals, GMO- debate, land degradation, water productivity, biodiversity loss, soil erosion/health, C sequestration, C credit, social equity, worker health & gender issues, animal welfare etc. (**solution-Regen Agri**),

Monsoon, prices, loan, hybrid seed, area, labour, pest, yield/profit?



Residues Burnt/compost/biochar, **Herbicides**.... Use, pre or post emergence ? **Conservation tillage**.... Machines, **Rotations** – choice, water, **IPM, Cover/intercrops**..... Legumes (Tephrosia, Sesbania, Pigeon pea, Groundnut, Soybean/green gram) **Living roots** (rainfed?), **Mulches, Soil test.... Certification ..., IFS**

Regenerative cotton farming

Factors India versus other countries- bearing on adoption of Regenerative Cotton Farming (RCF) practices

Parameter	India	Australia	Brazil	USA
Cotton area (m ha)-2023-24	12.46	0.45	1.65	2.61
No of cotton farmers	6.0 million	1726	3263	8103
Farm size (ha)	1.17	368	421	513
Seed	Hybrid, Bt	Variety, Bt, HT	Variety, Bt, HT	Variety, Bt, HT
Cultivation cost /ha (US \$/ ha)	963	3733	2547	1008
Production Cost per Kg lint (US \$)	2.16	1.49	1.30	1.43

Data Source: Cotton Area (2023-24) from ICAC Cotton This Month 02 July 2024, others- ICAC Databook 2022

HT technology – main facilitator for adoption of no/reduced tillage in North and South America (Brookes & Barfoot, 2020)

Principle of RA	Regenerative cotton farming (RCF) practices recommended
Minimizing soil disturbance	Reduced tillage, bed planting, Broad bed furrow (BBF), intercropping, poly-mulching, herbicides(reduce intercultures), restricting deep ploughing in summer, sowing across slopes, reducing interculture
Keeping the soil surface covered	Crop residue/organic mulching, inter and cover cropping, multitier cropping, poly-mulching
Adding C sources and closing nutrient cycles	Addition of organic manures (FYM, Vermicompost, other composts), in-situ/ex-situ green manuring, addition of bio-char, sheep/goat penning, biofertilizers, bio stimulants
<u>Water conservation and management</u> (rain and irrigation water)	BBF, ridge/furrow planting, ridges after interculture, drip/alternate furrow irrigation, rainwater collection and recycling, mulching (organic and poly-mulch), water quality testing, conjunctive use of rain/surface and ground water, cleaning of irrigation channels, intercropping, early maturing genotypes, sowing across slopes.
Maximizing bio-diversity	Mixed/inter-cropping, trap cropping, border cropping, planting refugia with Bt cotton, microbial inoculation (seed and soil), inundative release of bio-agents (parasites and predators), integrated farming system (including agroforestry).
Reducing agro-chemicals	INM, IPM (bio-rationals botanicals/microbial consortia, mass trapping/mating disruption techniques, ETL based spray, de-topping, yellow sticky trap), HDPS with early, compact genotypes, integrated weed management, avoiding cocktails/tank mixtures, Soil test-based fertilizer recommendation.
Integrating livestock	Sheep/goat penning, IFS, rearing milch and draught cattle
Maintaining living roots	Double cropping (Cotton-wheat/paddy/chickpea/maize etc). alley cropping, cover cropping

Some research findings on RCF from India



Cotton + Black gram
CEY=1899 kg/ha ; A.G.I : 237 USD



Cotton + Groundnut
CEY=2125 kg/ha ; A.G.I : 372 USD



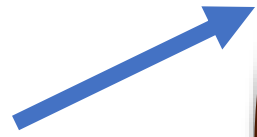
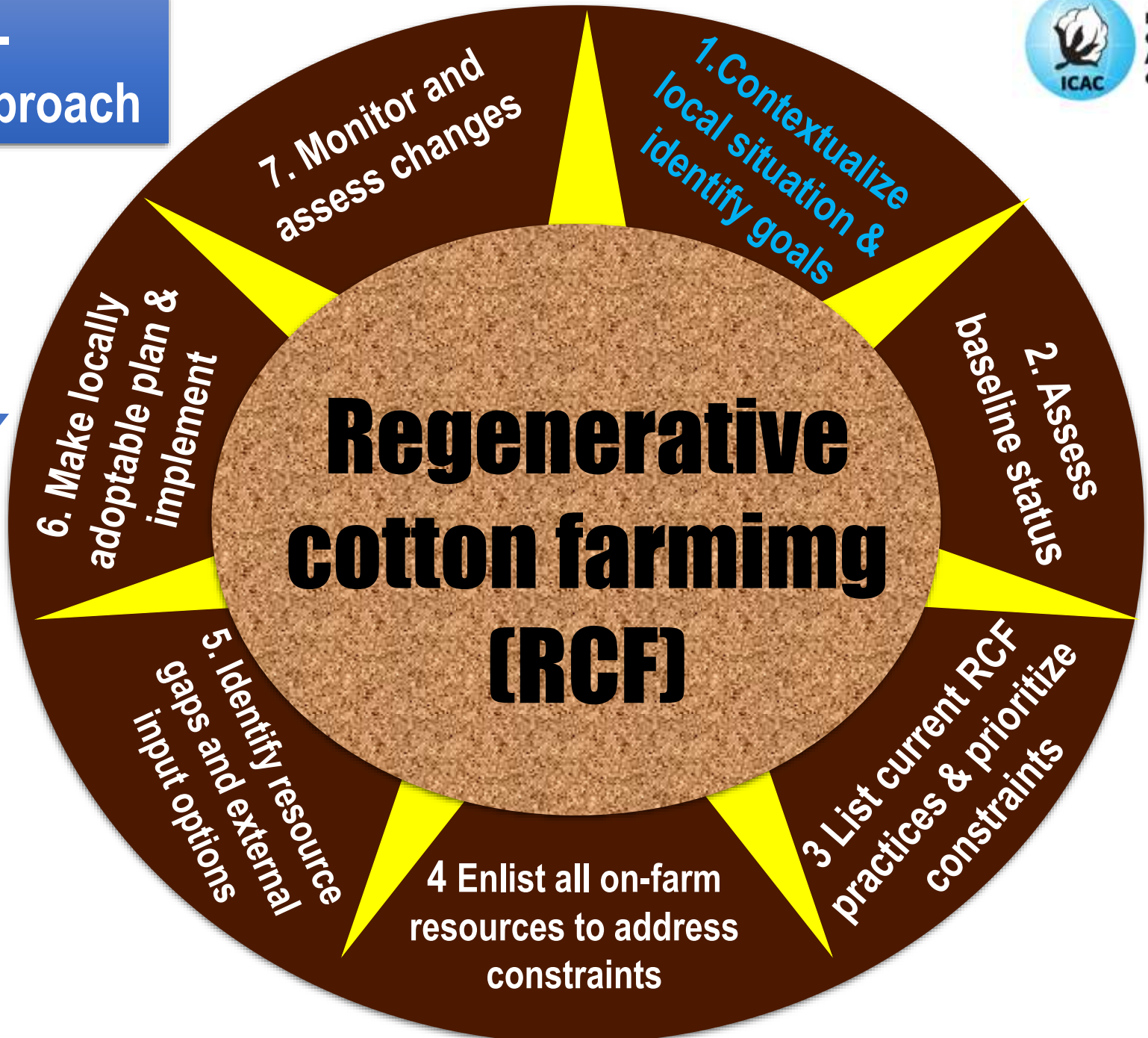
Cotton + Soybean
CEY=2412 kg/ha ; A.G.I : 542 USD

Nagpur (AESR 10.2) 17 years : 7.5 T/ha FYM + min Tillage + 90:45:45 NPK increased SOC from 4.2 g/ha to 5.4 g/kg.

Nagpur (Blaise, Environmental Advances 4 (2021) 100068) No tillage + cover crop-8 years (2013-2020)	Water stable aggregates (%)	Infiltration rate (mm/h)	Potential soil loss (t/ha)
Sorghum Cover crop (in season & turned down)	65.8	21.1	4.39
Sun hemp Cover crop	66.9	19.4	4.57
Sesame cover crop	68.4	22.6	4.09
No cover crop + Conventional Tillage	62.5	13.8	6.70



Several pilot RCF projects -
implemented using this approach



- Soil type
- Climate
- Available resource
- Labour
- Socio-cultural preferences
- Returns/profit
- Farmers' preference
- Other expected benefits

Understanding adoption behavior of RCF practices

- On-line survey-scientists, extensions officials, NGOs/CSOs, progressive farmers, research associates
- On field discussions
- Focussed group discussions
- Based on the feed- back-categorised the RCF practices having high/medium and low level of adoptability
- The reasons for partial/non-adoption - from farmers, extension personnel, researchers and policy makers.
- Classified under: **Ecological (E) /Institutional (I)/ Technological (T)**

A	C	D	E	F	G	H	I	J	K
Good Cotton growing practices -adoption rating	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6	Respondent 7	Respondent 8	Respondent 9
Conjunctive use of rain/surface and ground water	High	High	Medium	Medium	medium	high	high	low	Low
Early maturing genotypes	High	Medium	High	Low	high	high	high	medium	High
Use of Organic manure +inorganic fertilizers	High	High	Medium	Medium	high	high	medium	medium	Low
Use of bio-rationals botanicals/microbial consortia	High	High	Low	Medium	low	medium	low	high	Medium
Integrated weed management	High	High	High	Medium	high	high	medium	high	Medium
Planting refugia with St cotton	low	high	Medium	High	high	high	low	low	High
Integrating cattle/goat/poultry	High	Medium	Medium/High	Medium	high	high	low	high	Low
Ridges after second interculture,	High	High	High	High	medium	high	low	medium	Medium
Alley cropping	Low	Low	Low	Low	low	low	low	low	low
Avoiding cocktails/tank mixtures	Low	Low	Low	Low	medium	low	low	low	Low
Bio-char application	Low	Low	Low	Low	low	low	low	low	Low
Border cropping	Low	Medium	Low	Medium	high	low	low	low	Low
Broad bed furrow	Medium	Low	low	Low	low	low	low	low	Low
Cover cropping	Medium	Low	medium	Medium	low	low	low	medium	Low
ETI based spray scheduling	Low	Low	Low	High	low	medium	low	medium	Low
Green manuring (in-situ/ex-situ)	Medium	low	Low	Medium	low	low	low	low	Low
Agroforestry in IF5	Medium	Medium	Low	Medium	high	low	low	low	Low
Inundative release of bio-agents (parasites and predators)	Medium	Low	Low	Low		low	low	low	Low
Mass trapping/mating disruption techniques	Low	Low	Low	Low	low	low	low	medium	Low



High adoption: RCF practices

- Pheromone traps
- Yellow sticky traps
- Bio-rationals/ botanicals
- Mechanical de-topping
- Ridges after second interculture
- Microbial consortia
- Integrated weed management
- Integrating cattle/goat/poultry
- Soil testing for nutrient application
- Conjunctive use of rain/surface & ground water
- Early maturing genotypes
- INM- Organic manure + inorganic fertilizers



Medium adoption: RCF practices

- Inter/Mixed cropping
- High density planting
- Residue incorporation
- Drip irrigation
- Bed/ridge planting
- Bio-char application
- Alternate furrow irrigation
- Biofertilizers and Bio stimulants
- Cleaning of irrigation channels
- Double cropping (water, short duration varieties)
- Penning (sheep/goat)
- Post emergence herbicides
- Minimizing secondary tillage
- Border cropping
- Agroforestry in IFS



Low adoption: RCF practices

- Mass trapping/mating disruption
- Poly-mulching
- Rainwater collection and recycling
- Reduced primary tillage/No summer ploughing
- Alley cropping
- Avoiding cocktails/tank mixtures
- Broad bed furrow
- Cover cropping/green manuring
- ETL based spray (sucking peats)
- Release of bio-agents
- Organic Mulching
- Multitier cropping
- Zero tillage



Challenges for adoption of RCF practices-**Farmers' perspective**

- **Weeds**-minimum/zero tillage, cover cropping, intercropping or HDPS. HT cotton not available (T & I).
- **Water** - plant cover crops after cotton and maintaining living roots year- round or for spraying (E & I).
- **Farm machinery** -planting, land shaping, shredding cotton stalks (not available/ affordable) (T&I)
- RCF practices- **labour** intensive (availability and high labour wages) (T & I)
- Diverse **certification** standards & cumbersome book -keeping (I)
- Mass trapping/mating disruption - cannot be practiced by individual small farmers and needs to be **supported at community level** over a large contiguous area (T & I)

E: Ecological, T: Technological, I: Institutional

Challenges for adoption of RCF practices- **Extension officials' perspective**

- Convincing farmers and **changing their mind set**. Bringing about attitudinal change (E & I).
- Addressing **knowledge and skill gaps**- need long term investment (E, T & I).
- Reluctance to change the existing production system, **inadequate resources (finance, farm power/machinery, labour, farm fence), limited market access** (to inputs and diversified farm produce) are other reasons for non/partial adoption (E & I).
- Some RCF recommendations are **too generic** and have to be refined and dovetailed to fit into the specific production system (e.g. choice of border/inter/trap crop, most compatible variety of the inter/rotation/trap/border crop for intercropping, planting pattern where the farmers can use the farm equipment's available with them) (T & I).

E: Ecological, T: Technological, I: Institutional

Challenges for adoption of RCF practices- **Research and policy perspective**

- **Limited scientific evidence** from India - benefits and time frame under diverse landscapes (T).
- Translating research results and convincing - benefits of **RCF** -of carbon capture, carbon storage, GHG emissions and climate change. These are not necessarily the farmers' priority in the short term (T).
- No uniform set of **standards to measure, compare and quantify** the benefits of **RCF**. Needed for gaining consumer trust and sensitize the partners along the value chain (T&I)
- Outputs of RCF –(soil health, farm profits, biodiversity) visible only in **long run**. Difficulty in keeping farmers motivated during transition. Financial incentives. (T,E &I)
- **RCF** practices are local/contextual dependent and need modifications before adoption. Resources (finance, land, skilled staff) are inadequate for micro level validation and refinement (T &I).
- **Carbon credit** - important farmer incentive to adopt **RCF**. Need techniques that are credible, accurate, affordable and reproducible for measurement, reporting, and verification (MRV) of C sequestration (T&I)

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Thank you