Socio-metabolism approaches and their relevance for analysing agricultural transitions

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SOCIO-METABOLISM APPROACHES AND THEIR RELEVANCE FOR ANALYSING AGRICULTURAL TRANSITIONS

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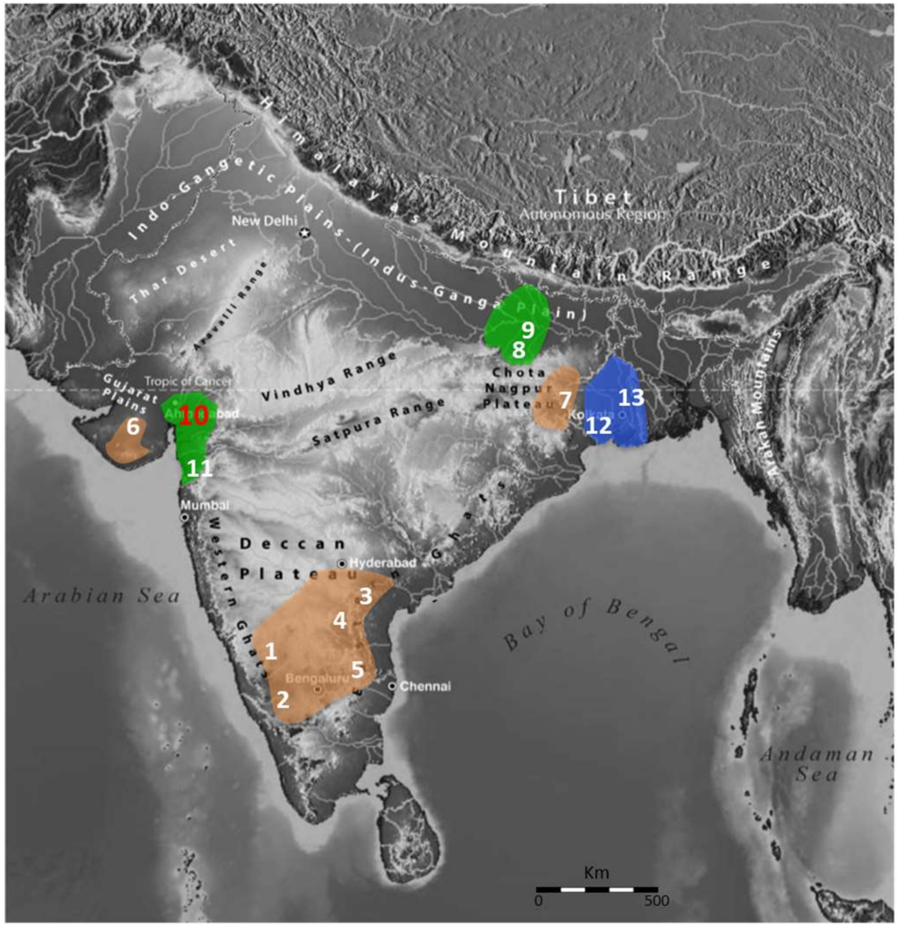
TWO SOCIO-METABOLISM CASE STUDIES

- Socio-metabolism research: a wide range of approaches with a common interest in **flows** of matter and energy
- Our approach in this presentation:

- Two case-studies in contrasted areas of India, not particularly involved in agroecological transitions but which we use as a basis for drawing lessons

1ST CASE-STUDY: NITROGEN METABOLISM AND GHG EMISSIONS IN A GUJARATI VILLAGE (2014)



PLATEAU and HIGHLANDS
Hard rock aquifer

KARNATAKA

1. **Channagiri** *(Davangere District)*
2. **Gundlupet** *(Chamarajanagar District)*

ANDHRA PRADESH

3. **Vinukonda** *(Guntur District)*
4. **Banagana Palli** *(Kurnool District)*
5. **Palamaner** *(Chittoor District)*

GUJARAT

6. **Gondal** *(Rajkot District)*

WEST BENGAL

7. **Hirbandh** *(Bankura District)*

ALLUVIAL PLAINS

BIHAR

8. **Bodhgaya** *(Gaya District)*
9. **Ekangarsarai** *(Nalanda District)*

GUJARAT

10. **Petlad** *(Anand District)*
11. **Dharampur** *(Valsad District)*

DELTA

WEST BENGAL

12. **Debra** *(Medinipur District)*
13. **Bangaon** *(North 24 Parganas District)*

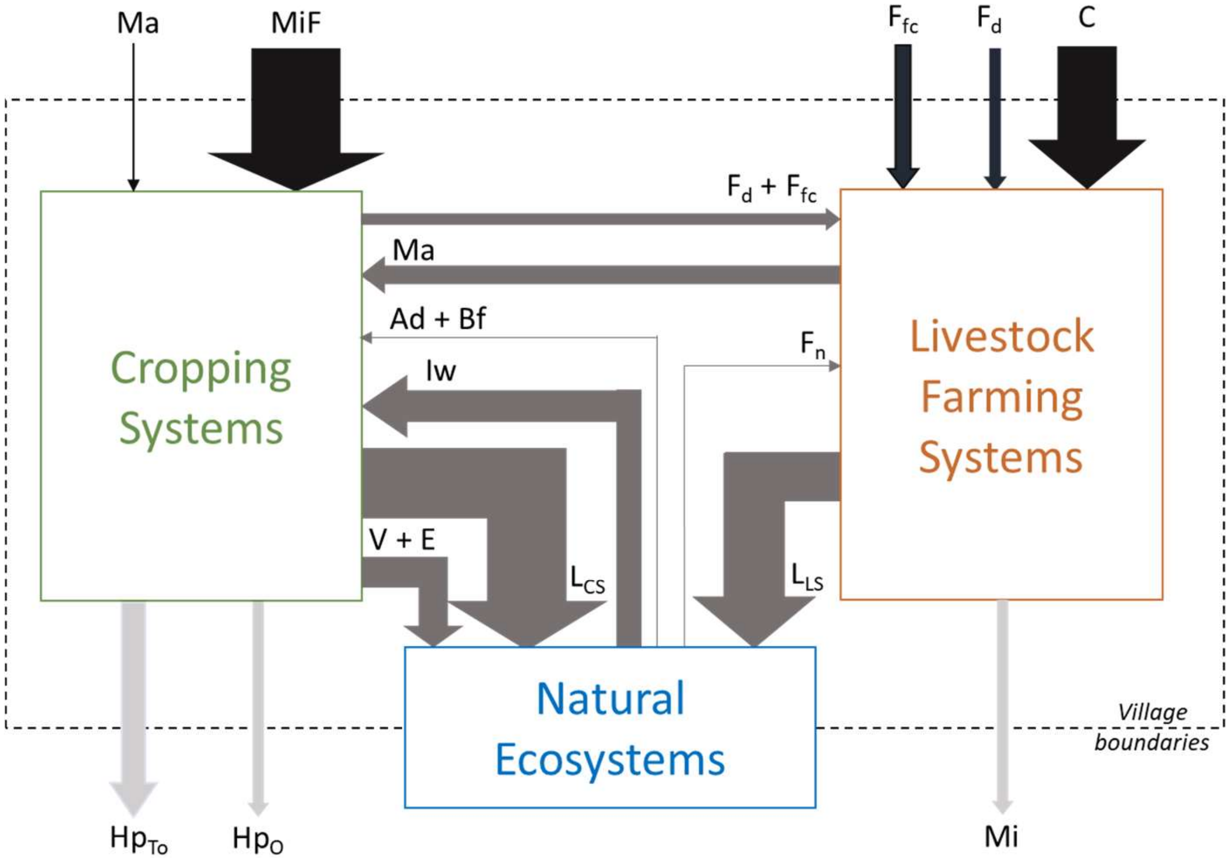
Petlad block, an alluvial plain with semi-arid climate

Densely populated by **people** (550 inhab./km^2) and **animals** (230 bovines/km^2) and intensively cultivated with **irrigation**



A highly unbalanced nitrogen metabolism

- Water pollution: 11 of the 16 samples taken are over the NO3 potability limit of 50 mg/L
- Nitrogen balance at village scale: 600 kgN/ha/yr for crops (22 times higher than the French average); total surplus (including livestock activities): 900 kg/ha/yr



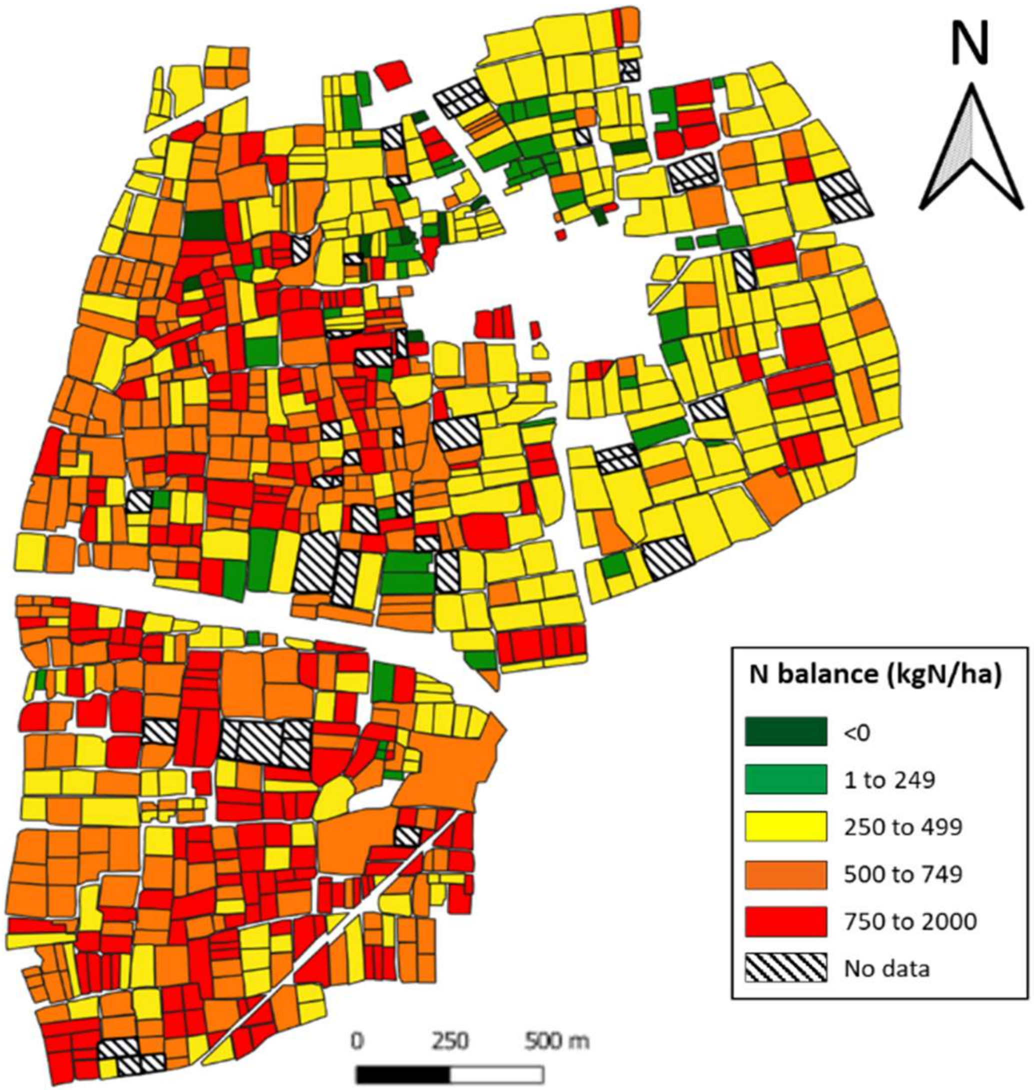
N flows entering the village
Ma: Manure *(1)*
MiF: Mineral fertilizers *(715)*
F_{fc}: Fodder crops *(75)*
F_d: Dry Fodders *(36)*
C: Concentrate Feed *(274)*

Internal N flows
V + E: NH_3 volatilization & N_2O emissions *(158)*
L_{CS} : Other N losses from cropping systems *(626)*
Iw: Irrigation water *(126)*
Ad + Bf: Atmospheric deposition & N biological fixation *(9)*
Ma: Manure *(108)*
L_{LS} : N losses from livestock systems *(284)*
F_n: Natural Fodders *(7)*
$F_d + F_{fc}$: Dry Fodders & Fodder Crops *(36)*

N flows leaving the village
Hp_{To}: Tobacco *(101)*
Hp_O: Other crops products *(38)*
Mi: Milk *(36)*

Aubron et al., 2021

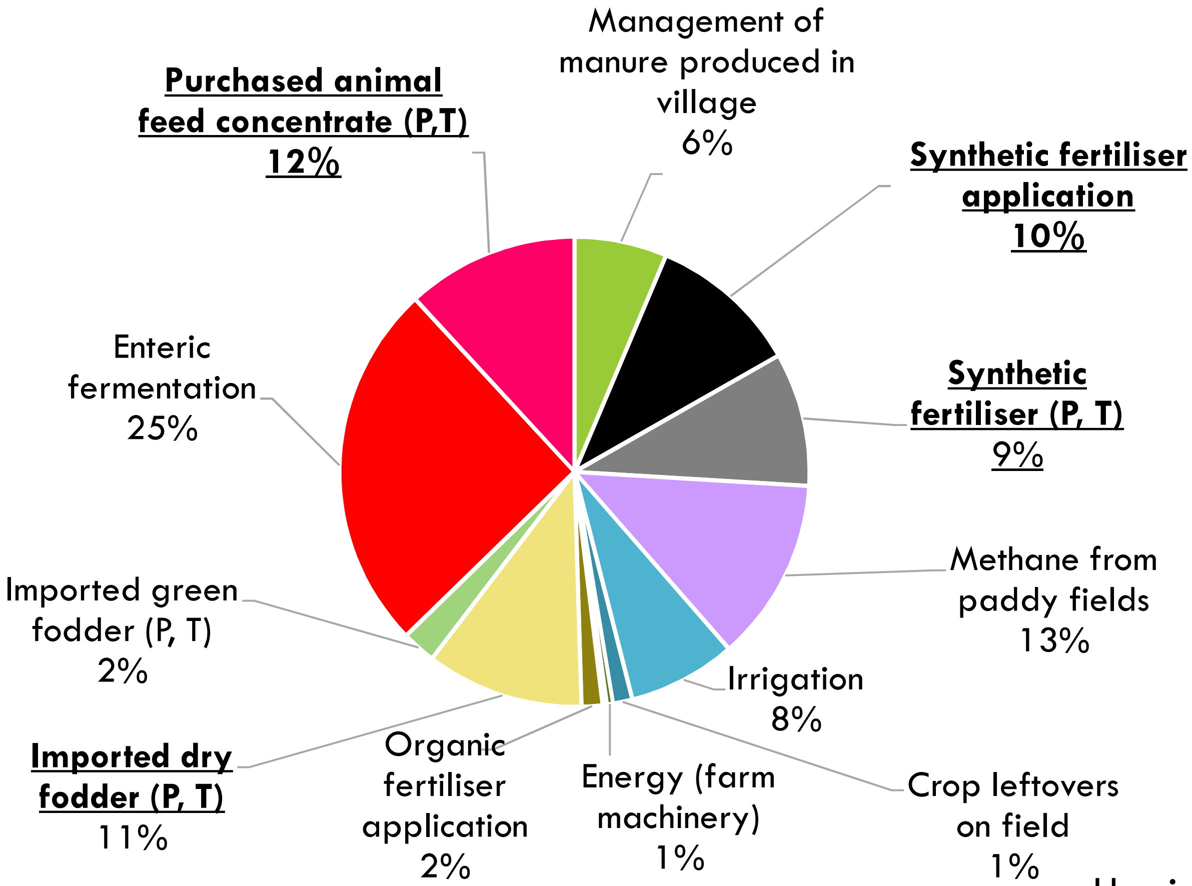
Map of the N surplus at field scale in the village (N balance for crops)



Aubron et al., 2021

High GHG emissions at village level coming from a diversity of sources

- 37 tCO2eq/ha at village level, 15 times higher than the Indian national average
- Bovine enteric fermentation is the main source of GHG emissions (25%) but synthetic fertilizers and imported feed account for 42% of the total:



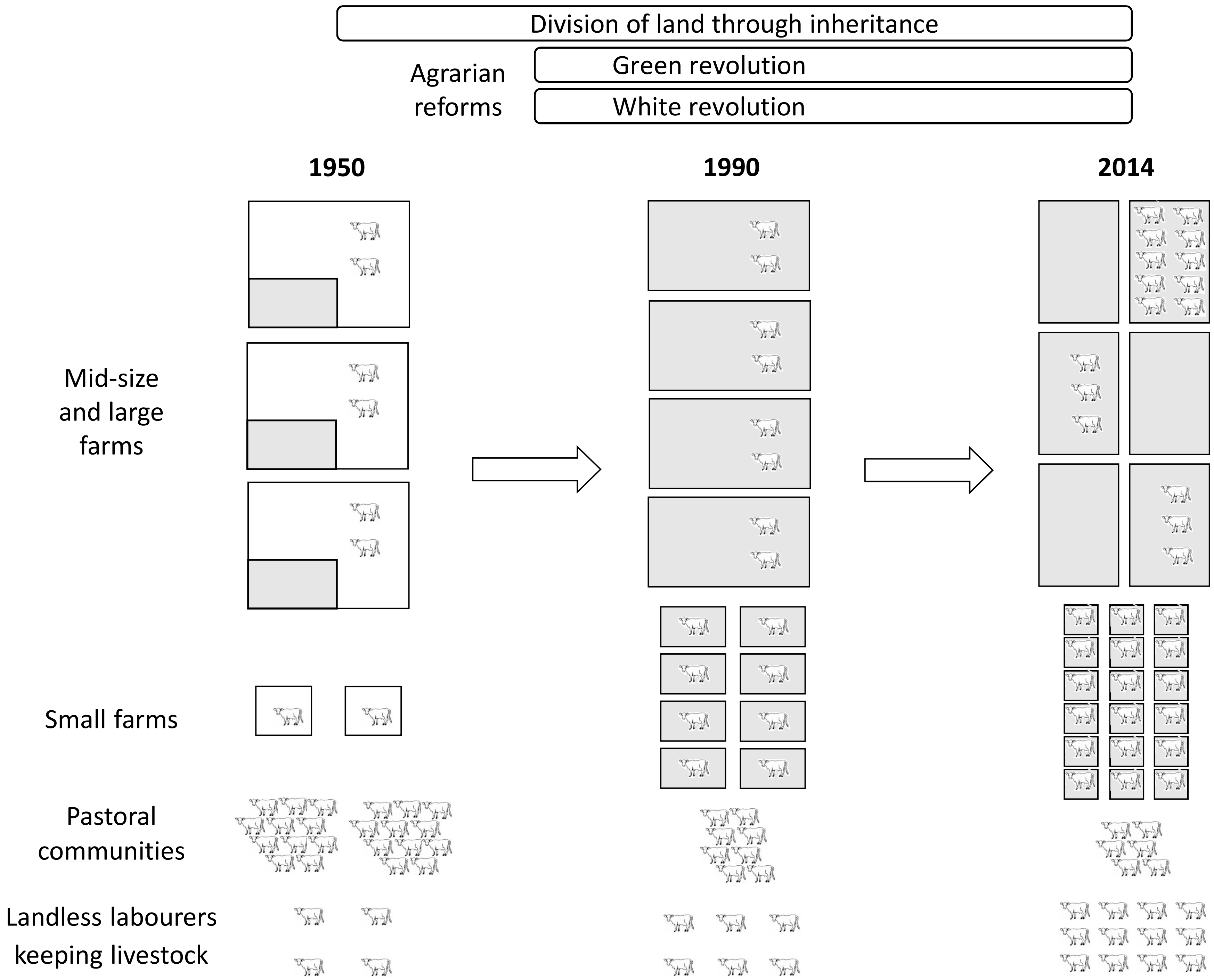
*P = production
T = transport

Hemingway et al., 2022

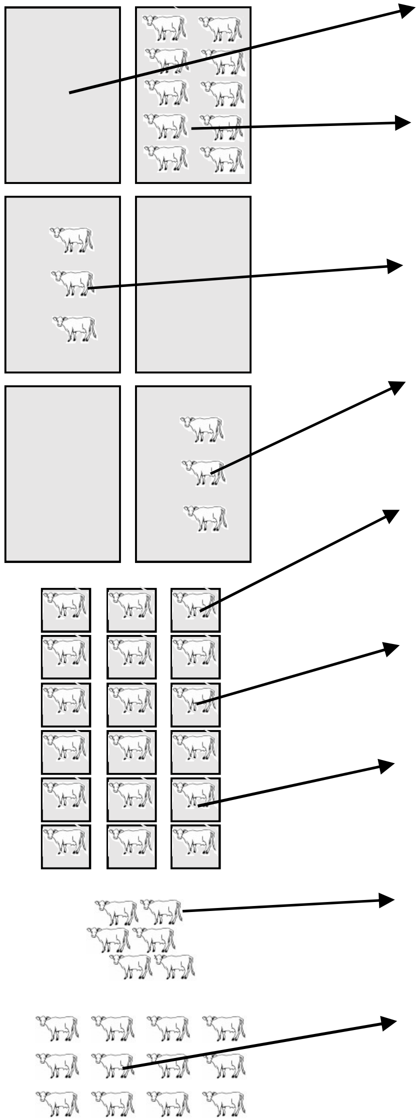
Re-integrating crops and livestock: a solution?

- Fostering the cultivation of fodder crops or crops that produce residues (≠ tobacco) to feed animals from local resources.
- Managing animal manure to limit the use of synthetic fertilizers.

Yes, but… it is not the way things are evolving!


Division of land through inheritance
Agrarian reforms
Green revolution
White revolution
1950
1990
2014
Mid-size and large farms
Small farms
Pastoral communities
Landless labourers keeping livestock

2014



	Rs Income per worker per year	N balance (kg N)	N efficiency	Contribution to N surplus at village level
PS1 – Large landowners without livestock	80-820 k	1193	0,19	++++
PS2 – Large dairy farms	205-645 k	11863	0,17	++
PS3 – Mid-size diversified farms	56-135 k	1598	0,15	++++
PS4 – Mid-size dairy farms	145-330 k	3084	0,22	++
PS5 – Small diversified farms	35-46 k	197	0,25	+
PS6 – Small dairy farms	43-49 k	481	0,16	+
PS7 – Sharecroppers with livestock	**24**-40 k	270	0,29	0^+
PS8 – Daily labourers with livestock	**22-25** k	64	0,48	0^+
PS9 – Pastoral farmers	**13**-32 k	678	0,23	0

Aubron et al., 2021

Conclusion for the 1st case-study

- Farmers are not encouraged to use synthetic nitrogen fertilizers sparingly, due to subsidies to the fertilizer industry.
- Social categories **with sufficient access to land** (>1 ha) have no interest in developing livestock farming, as they obtain high incomes from irrigated tobacco growing.
- Social categories **with limited access to land** have an interest in developing livestock farming to generate additional income through the sale of milk, but lack the resources to feed their animals.

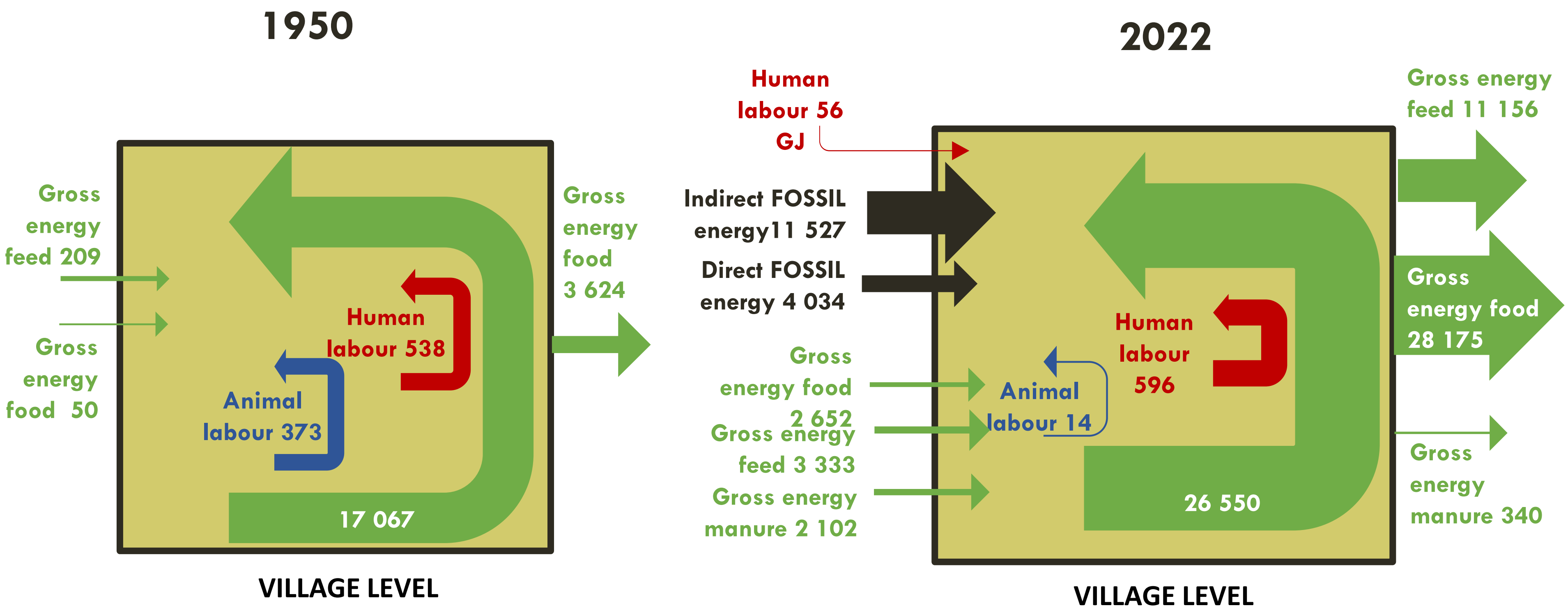
2ND CASE STUDY: GROUNDWATER AND FOSSIL ENERGY CONSUMPTION IN ANDHRA PRADESH (2021)

Rapthadu mandal, a semi-arid area on the Deccan plateau

An **rainfed groundnut** area with a late and incomplete development of irrigation (vegetables and **fruit trees**)

… also going in the wrong direction from an environmental perspective

Declining use of animal energy, rising consumption of fossil energy

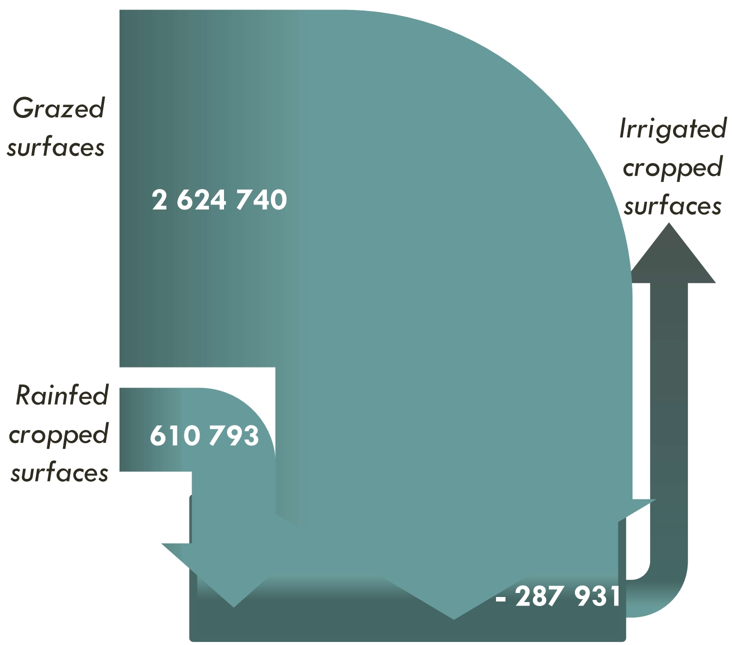


All values are expressed in GJ of energy

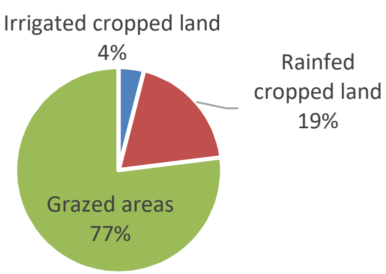
Hemingway, 2023

Territorial water balance: still positive but fragile

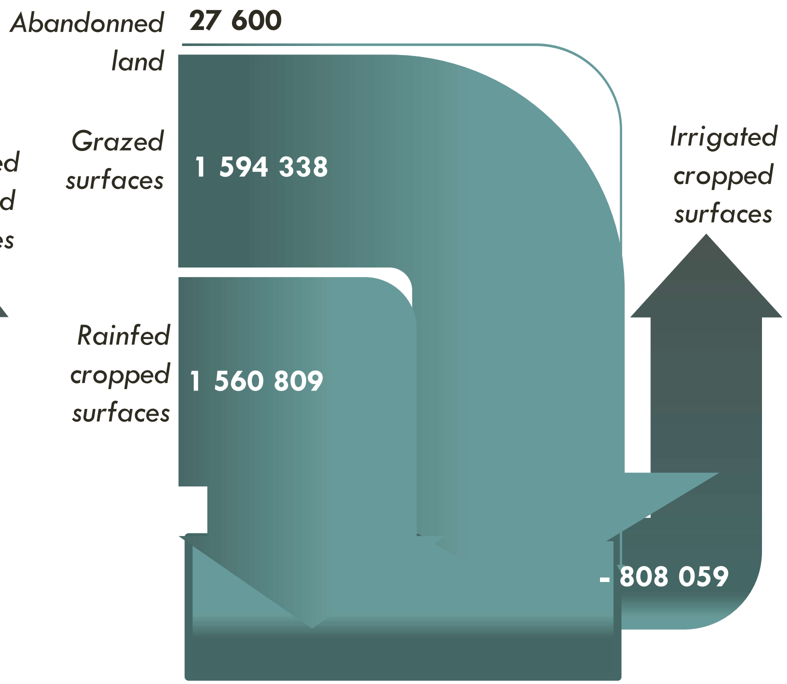
1950



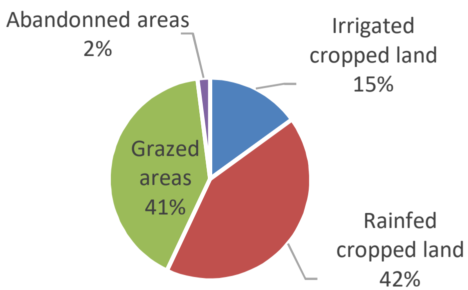
Net recharge 2 947 601 m^3



2022



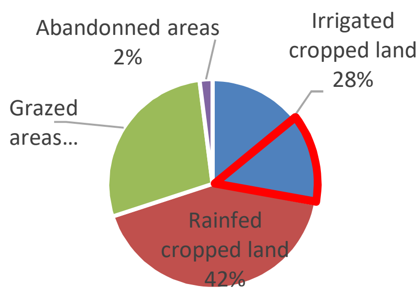
Net recharge 2 374 689 m^3



Tipping point?

+ 130 ha of fruit plantations

Net recharge = 0 m^3



Hemingway, 2023

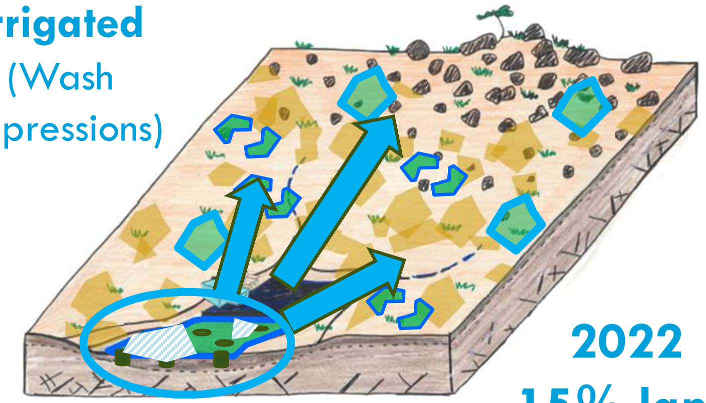
Managing water better in order to avoid reaching the tipping point

- Favouring the cultivation of irrigated crops during the monsoon/rabi seasons and avoiding cultivation during the dry season, when evapotranspiration is high
- Limiting the expansion of fruit plantations, which require water all year round

In theory possible … but that's not what is currently happening!

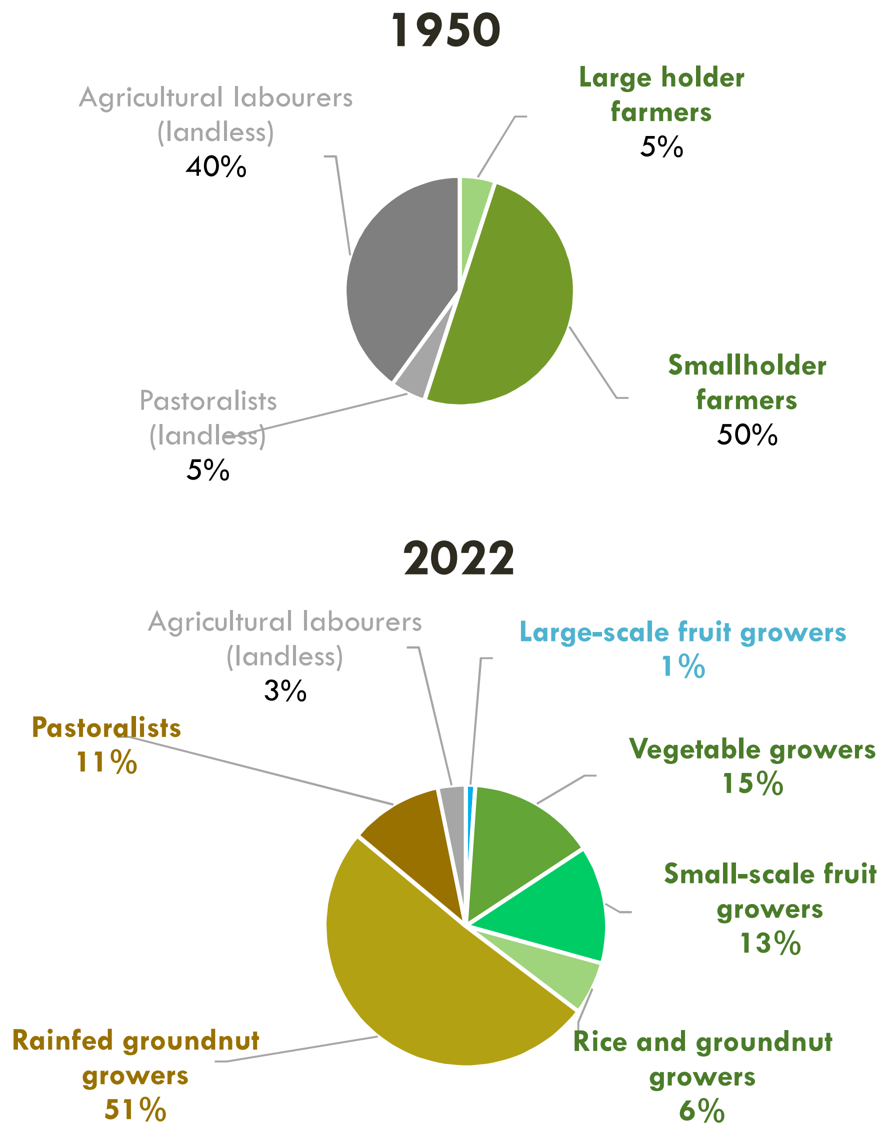
Evolution of irrigated land and social diversity (1950-2022)

1950s : 4% land irrigated (Wash depressions)



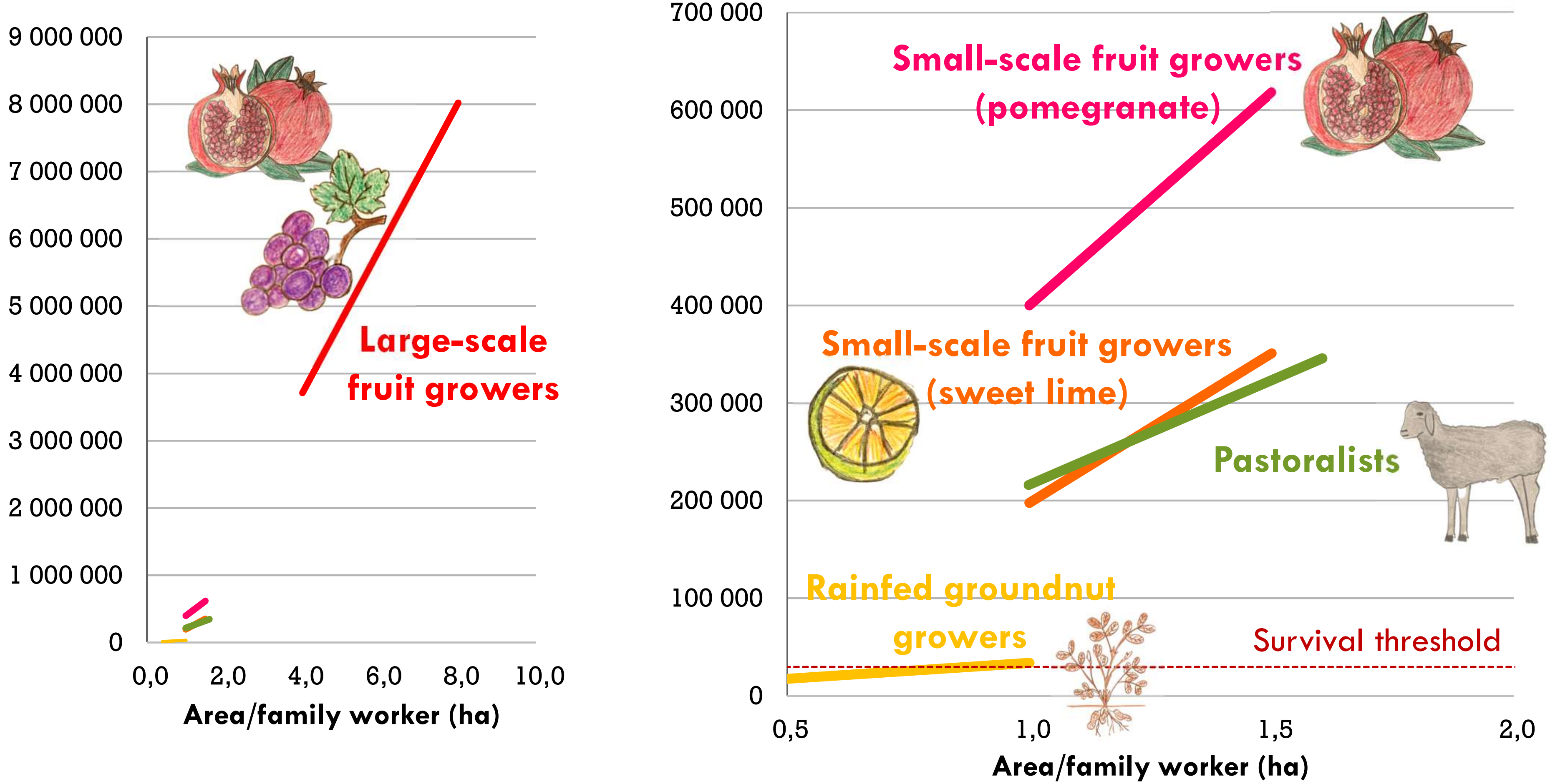
2022 15% land irrigated (Wash pediment)

% households belonging to each social category



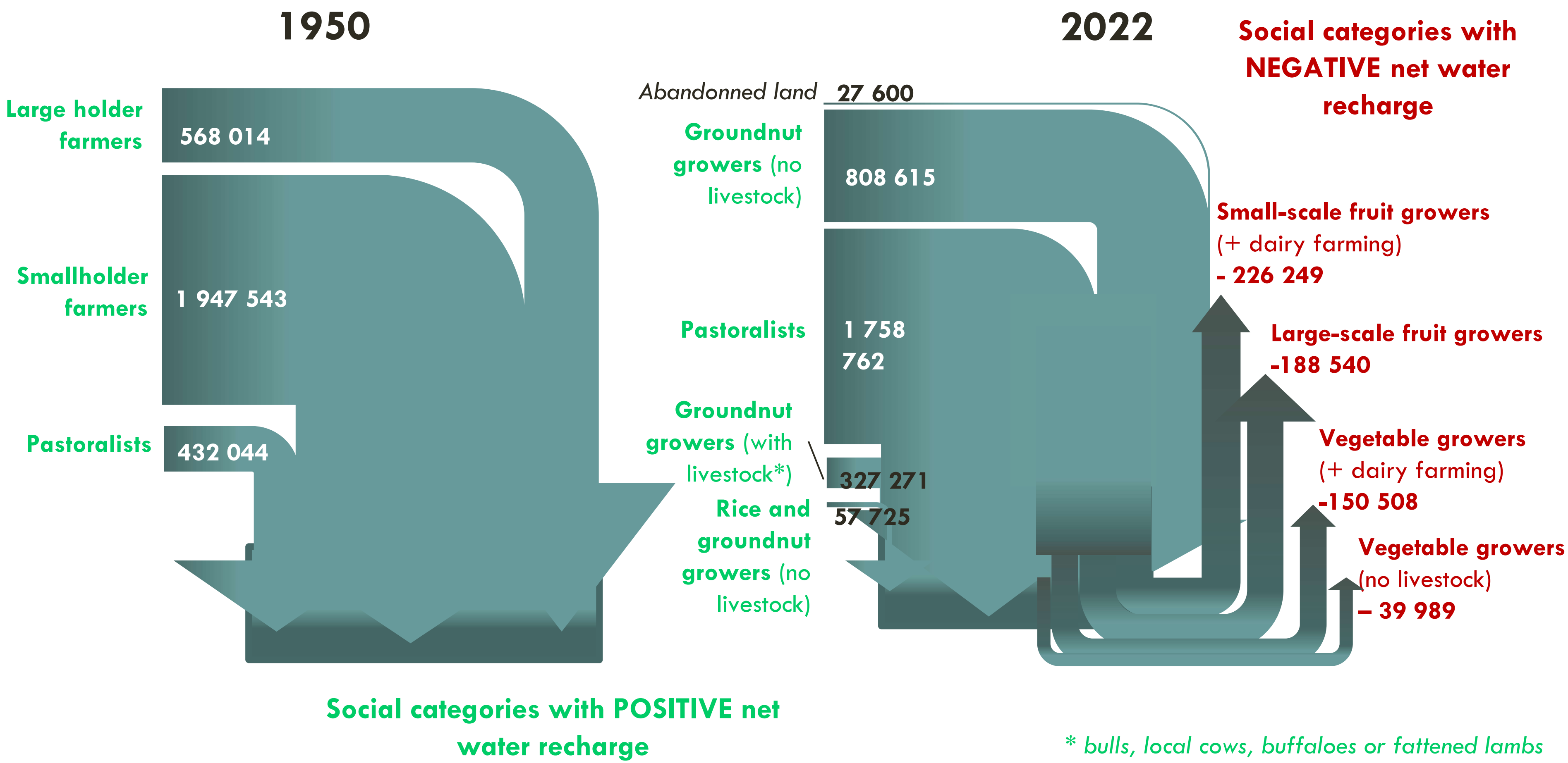
Huge income gaps, with access to irrigation (especially fruit cultivation) being the game changer

Agricultural income (Rs/family worker/yr)



Hemingway, 2023

2022: the poorer social categories recharge groundwater for the wealthier ones



Hemingway, 2023

Conclusion of the 2nd case-study

- Farmers are not encouraged to use groundwater sparingly because thanks to subsidies electricity is free and available 6-hours a day

- Social categories coming from former large holder farmers who accumulated capital with groundnut cultivation were able to **invest earlier in borewells** and irrigated crops in the 1990s. Part of them became **fruit growers** in the 2000s, earning today the highest agricultural incomes and pumping the largest quantities of groundwater in the area

- Today **groundnut growers**, for most of them former landless agricultural labourers who benefited from the agrarian reform in the 1970s, have remained in the blind spot of irrigation. They get very low incomes from rainfed cultivation and depend on the farmers having access to irrigation for employment opportunities. They make a major contribution to water recharge.

CONCLUSION OF THE TWO CASE-STUDIES

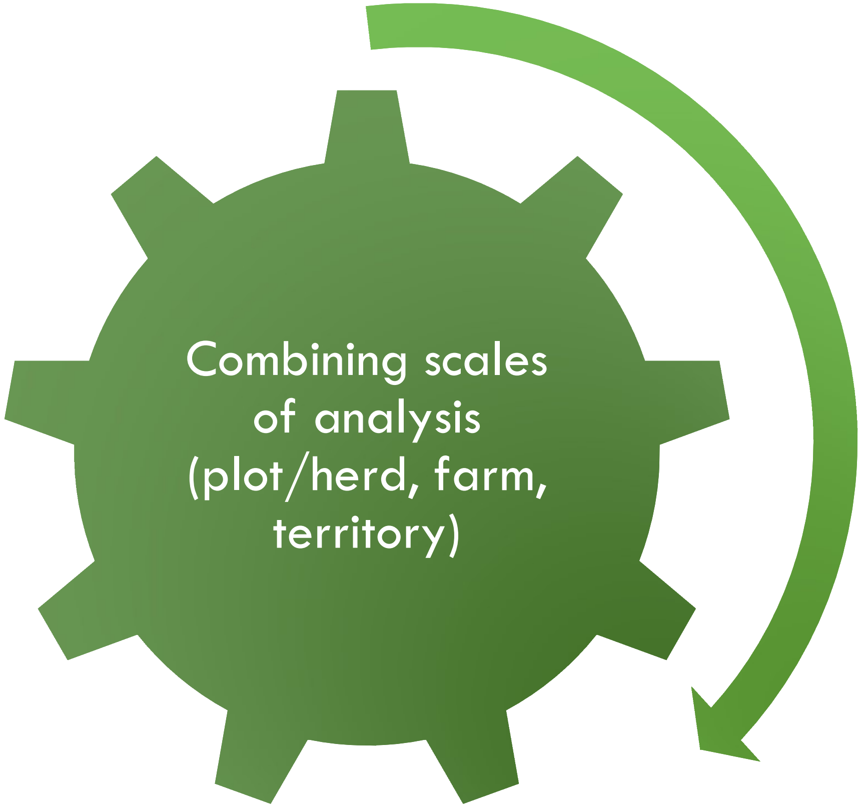
- There are good reasons to reintegrate crops and livestock in Petlad and to manage groundwater differently in Rapthadu.
- The technical terms of such evolutions are relatively well known.
- But the political, social and economic conditions are not conducive to the implementation of agroecological practices:
  - Subsidies to chemical fertilizers and electricity for pumping water, on the contrary, encourage the use of inputs
  - Social organization hinders the changes: the well-off farmers have no interest in implementing these agroecological practices, while others do not have the means to do so.

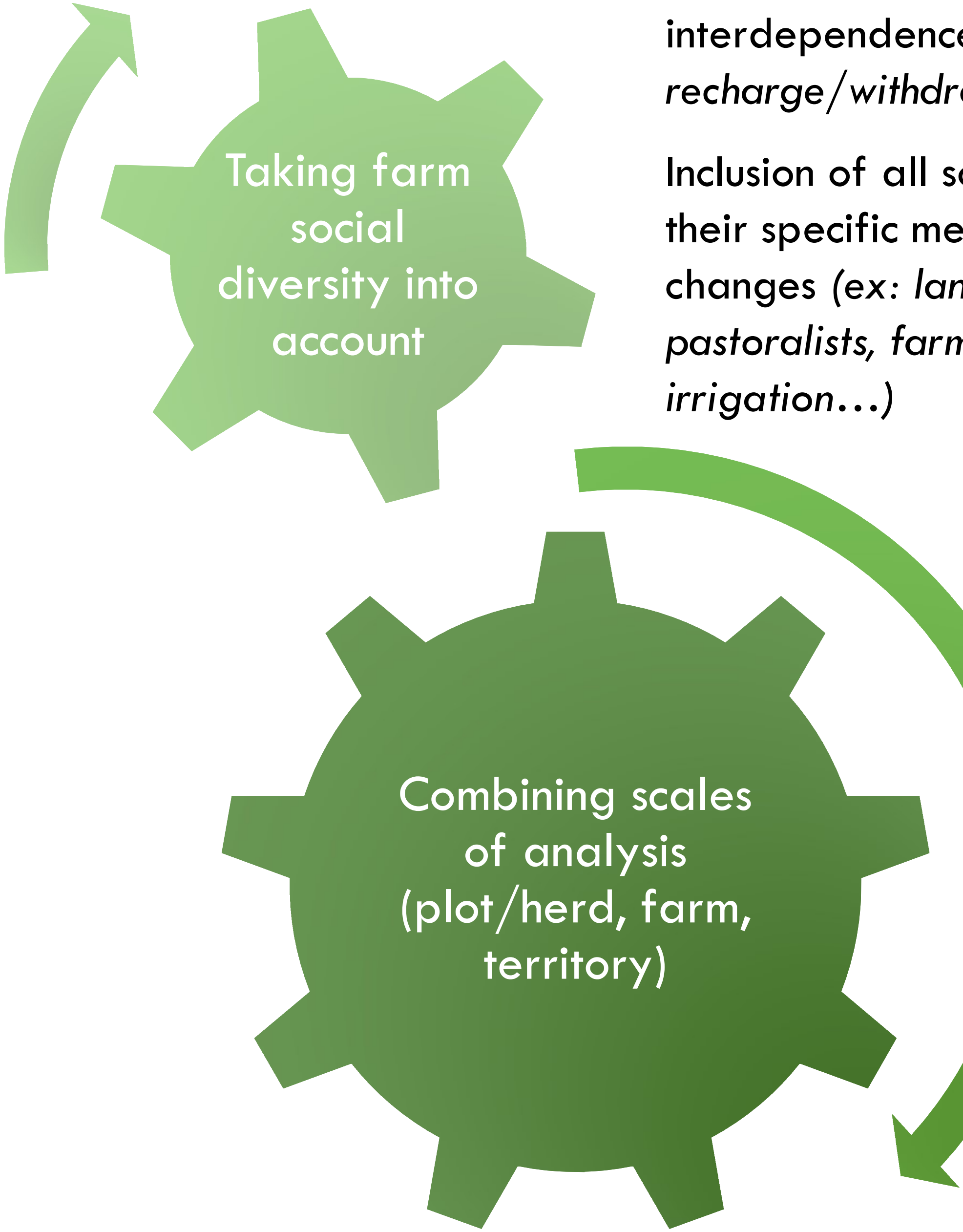
RELEVANCE OF SUCH SOCIO-METABOLISM APPROACH FOR AGROECOLGICAL TRANSITION

Territorial level *(ex: water balance between recharge and groundwater pumping on different areas)*

Farm level *(ex: crop-livestock integration)*

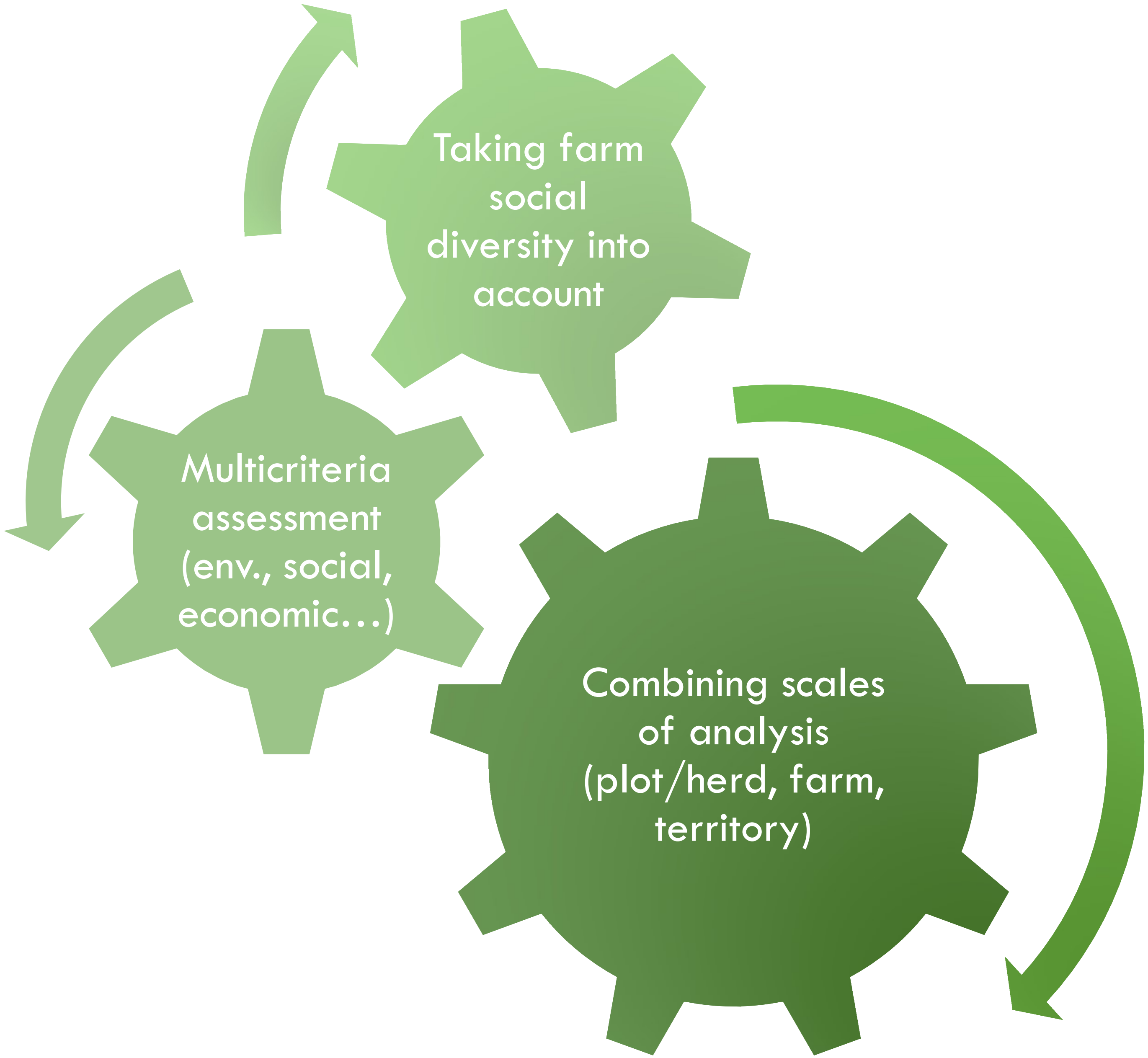
Plot/herd level *(ex: irrigation, animal feeding practices…)*





Environmental impacts differentiated amongst farm types, with possible interdependences (ex: *water recharge/withdrawal*)

Inclusion of all social categories, with their specific means and interests for changes (ex: *landless workers, pastoralists, farmers without irrigation…*)



Taking farm social diversity into account
Multicriteria assessment (env., social, economic…)
Combining scales of analysis (plot/herd, farm, territory)

Thanks for your attention!