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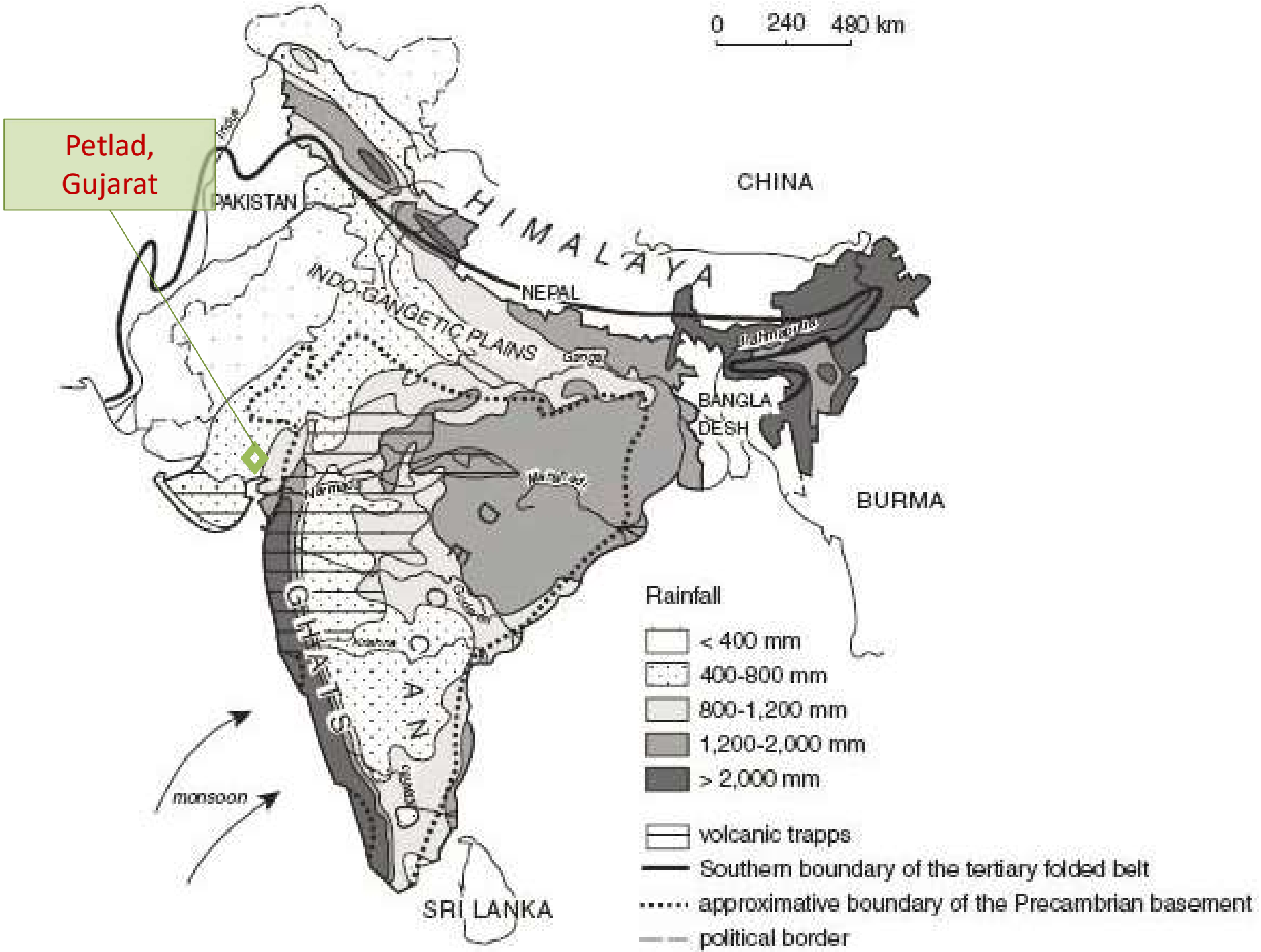
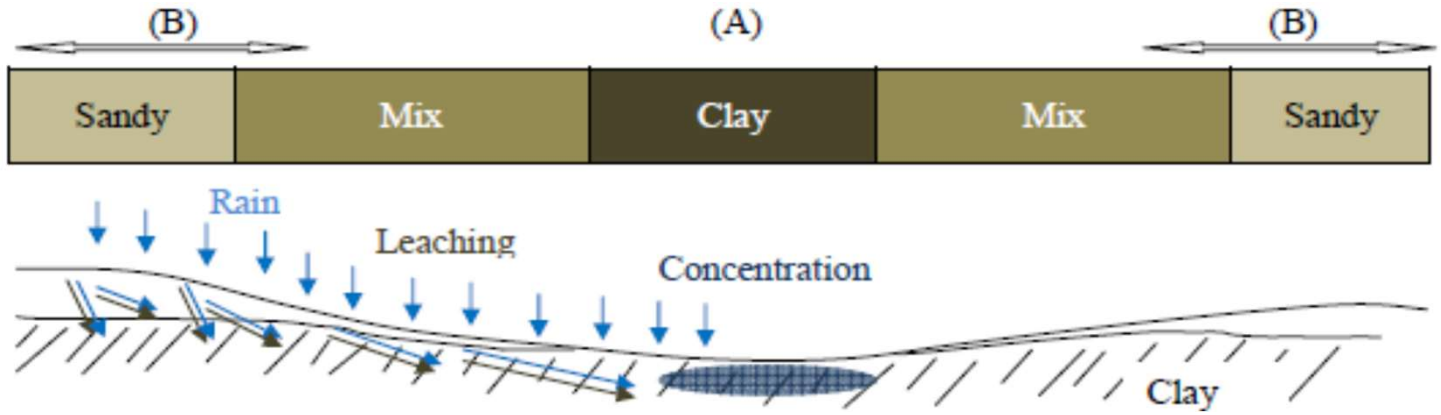
INPUTS INTENSIVE IRRIGATED AGRICULTURE AND CROP-LIVESTOCK DISINTEGRATION

Problematic nitrogen balances in a Gujarati village

C. Aubron, M. Vigne, O. Philippon, C. Lucas, P. Lesens, S. Upton,
P. Salgado and L. Ruiz


Petlad, Gujarat
0 240 480 km
CHINA
PAKISTAN
HIMALAYA
INDO-GANGETIC PLAINS
NEPAL
BANGLA DESH
BURMA
SRI LANKA
monsoon
Rainfall
< 400 mm
400-800 mm
800-1,200 mm
1,200-2,000 mm
> 2,000 mm
volcanic trapps
Southern boundary of the tertiary folded belt
approximative boundary of the Precambrian basement
political border

An alluvial plain, densely populated by people and animals and intensively cultivated with irrigation



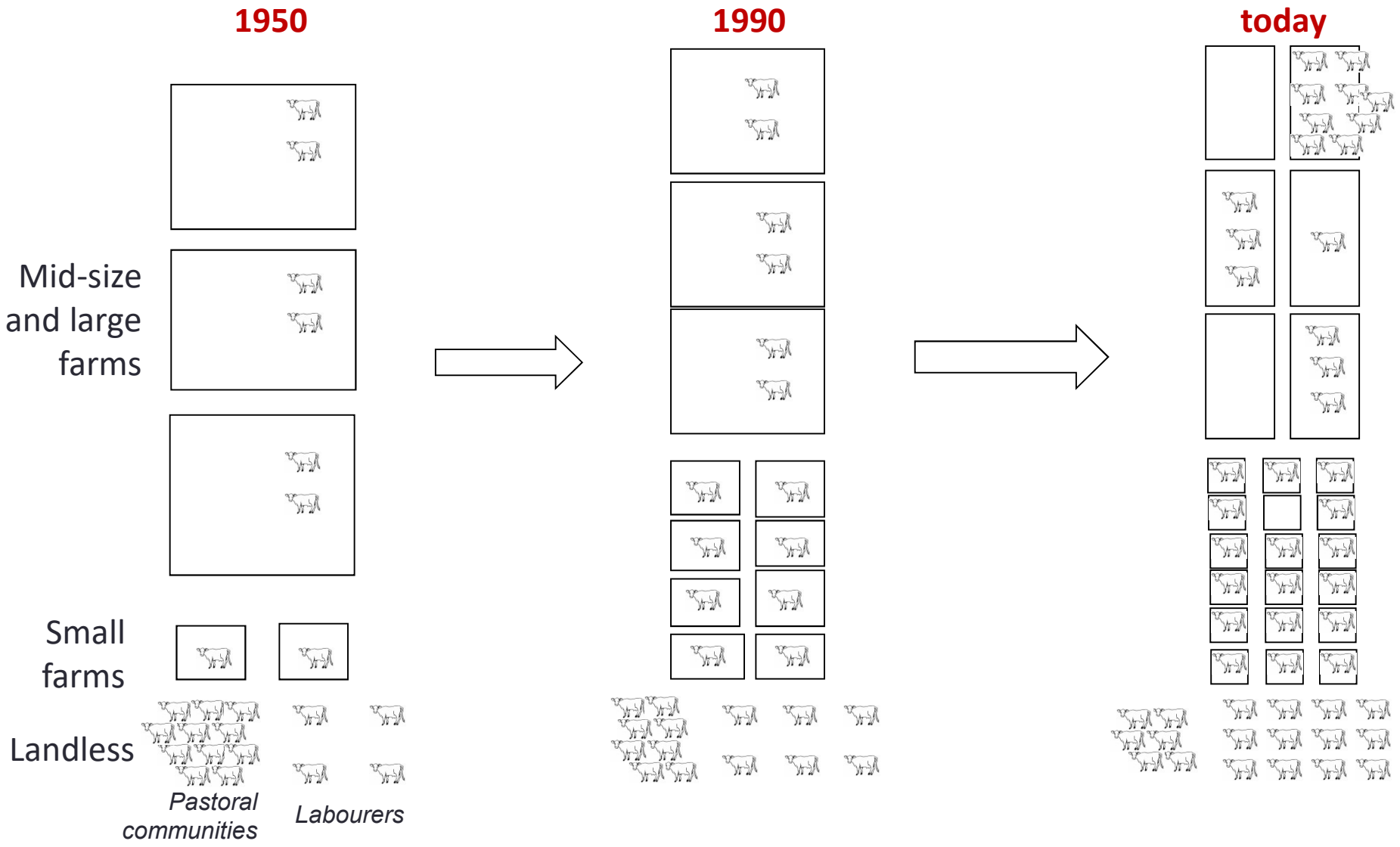
Strong social contrasts inherited from the past

Division of land through inheritance

Agrarian reform

Green revolution *Tobacco*

White revolution



Today diversity of farms

Landowners with land in sharecropping 1
0,25-9,5ha, 0-1 cow

Large dairy farms 2
2-6ha, 100-200 cows

Mid-size diversified farms 3
0,4-2ha, 3-12 cows

Mid-size dairy farms 4
1-2ha, 12-40 cows

Small diversified farms 5
0,1-0,4ha, 1-2 buffalos

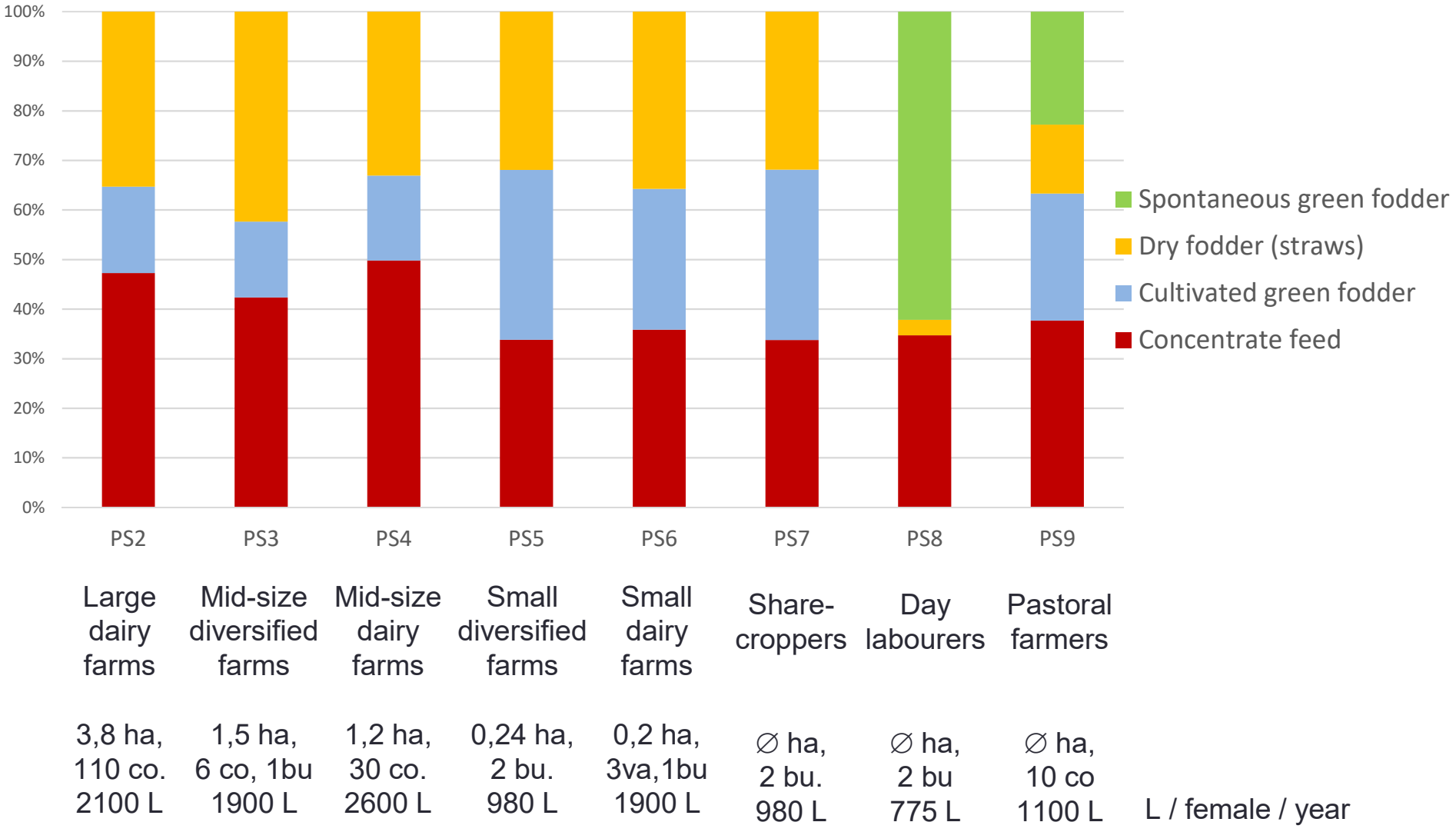
Small dairy farms 6
0,1-0,4ha, 3 cows,1 buffalo

Sharecroppers 7
∅ ha, 0-2 buffalo

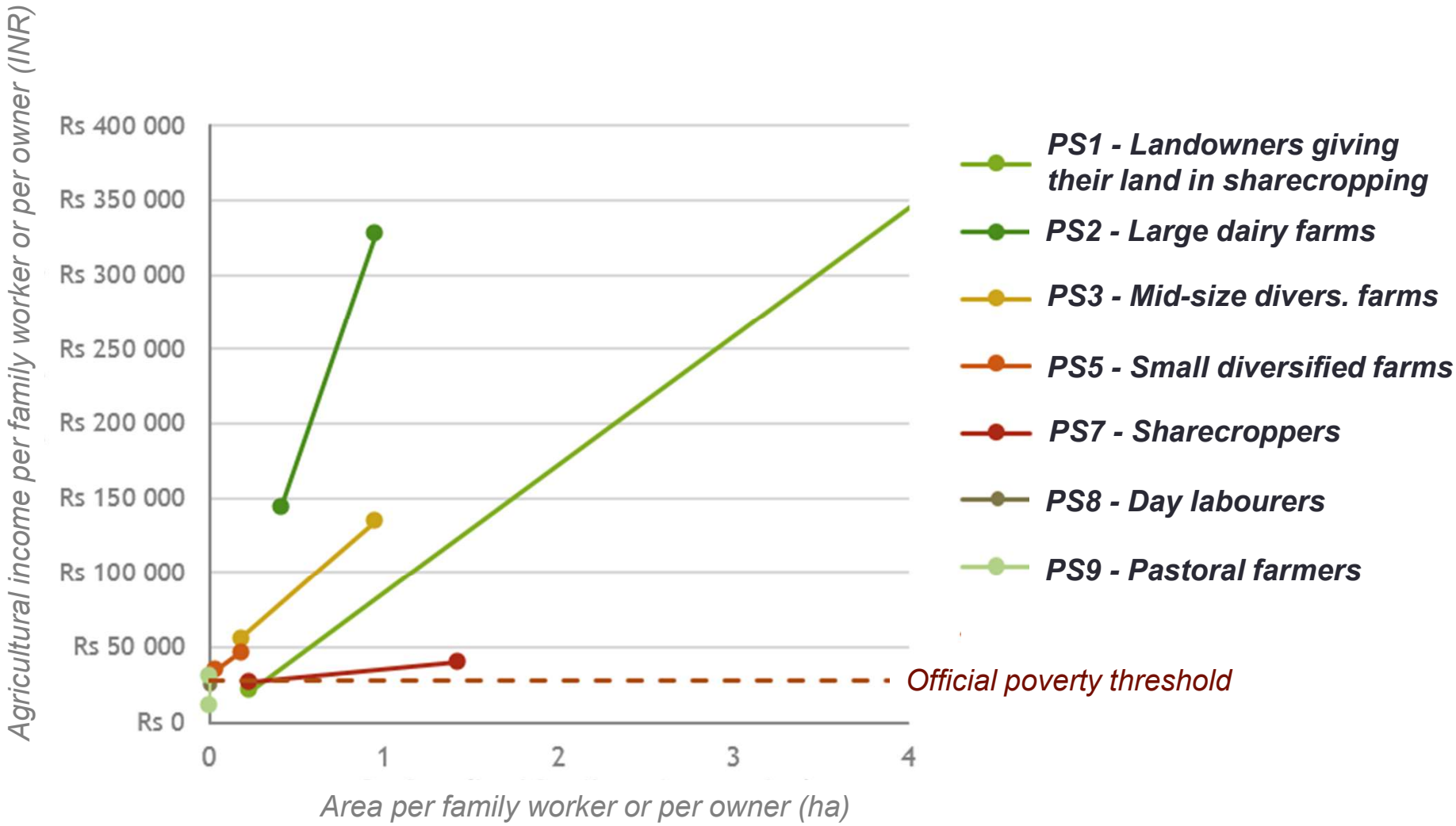
Day labourers 8
∅ ha, 0-1 buffalo

Pastoral farmers 9
∅ ha, 5-20 buffalo or cows

Today diversity of feeding practices (ration provided in trough)



Agricultural incomes according to farm type

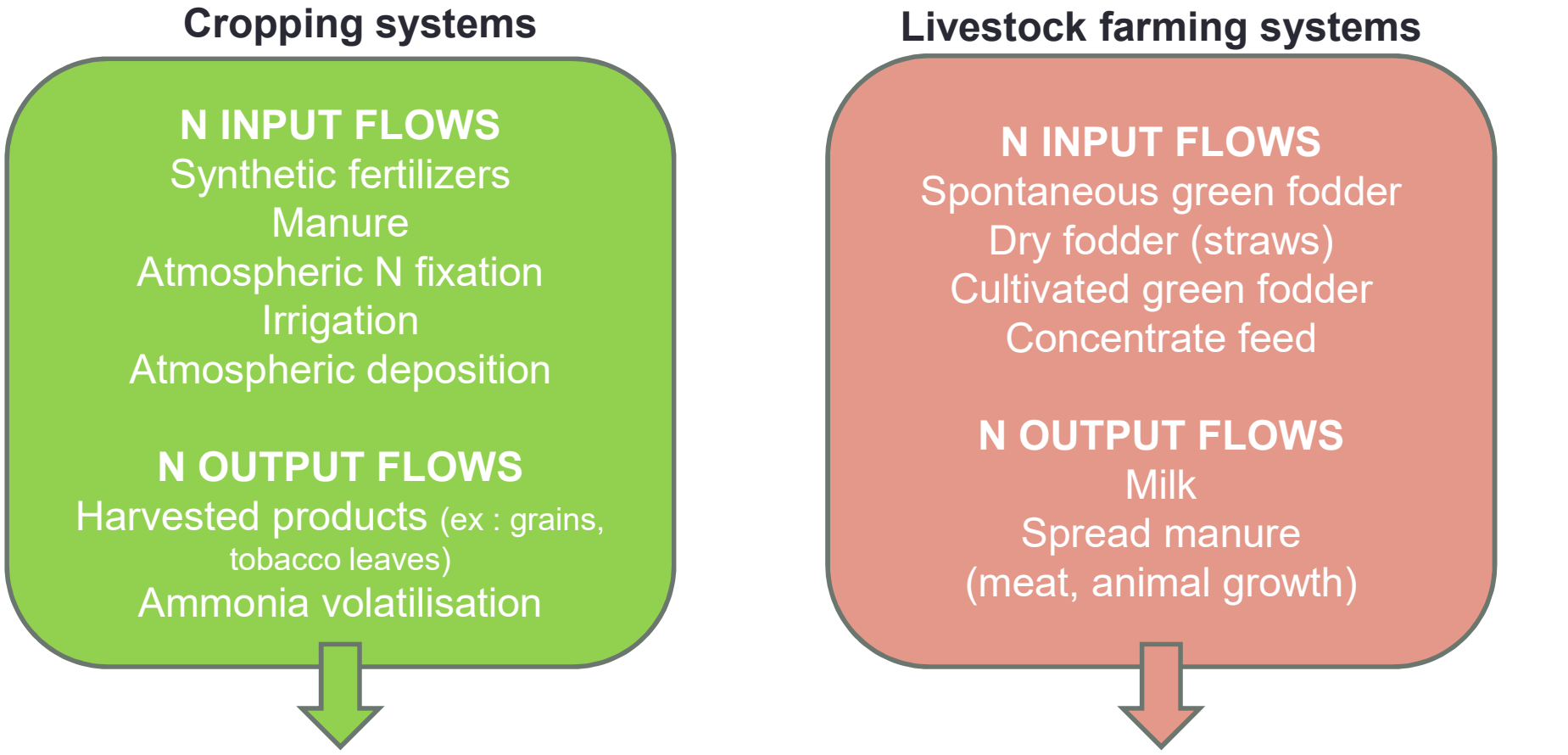


Nitrogen balances at different levels

- ✓ N balances at cropping systems *(x13)*, livestock systems *(x8)* and farming system levels *(x9)*: **converting material flows in nitrogen flows**

- ✓ N balances at Davalpura's village scale : **assigning farming systems to cadastral and census entities** *(218 ha cultivated - 915 cadastral entities, 249 censed farms)*

Nitrogen input and output flows at cropping and livestock farming systems levels



Balance =N brought to the soil and not taken up by plants

Balance = N contained in urine and nitrogen lost during manure storage

… joining hydrosphere or atmosphere

N balances

- ✓ Large **N surplus** at CS, LS and PS (except some fodder cropping systems)

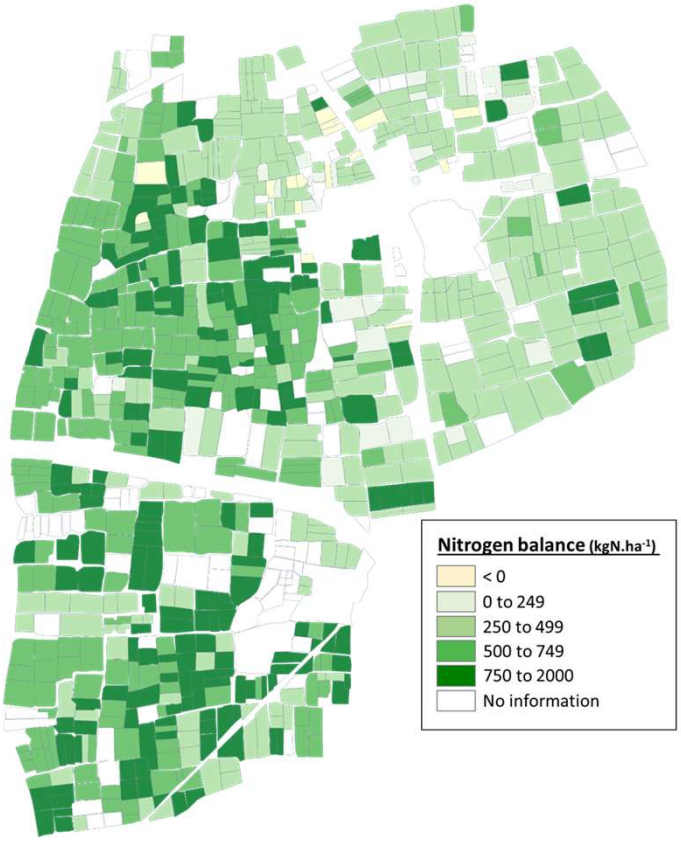
- ✓ At village scale, annual surplus of **1,040 kgN.ha^{-1}**
  - ✓ Pre-industrial Europe (*Garcia Ruiz et al, 2012 ; Gizicki-Neundlinger et Güldner, 2017*), Africa currently (*Billen et al., 2014*) : ≤ 10 kgN / ha
  - ✓ 30 times higher than French average (*Peyraud et al., 2012*)
  - ✓ 4 times higher than China, world highest value from FAO data (*Billen et al., 2014*)

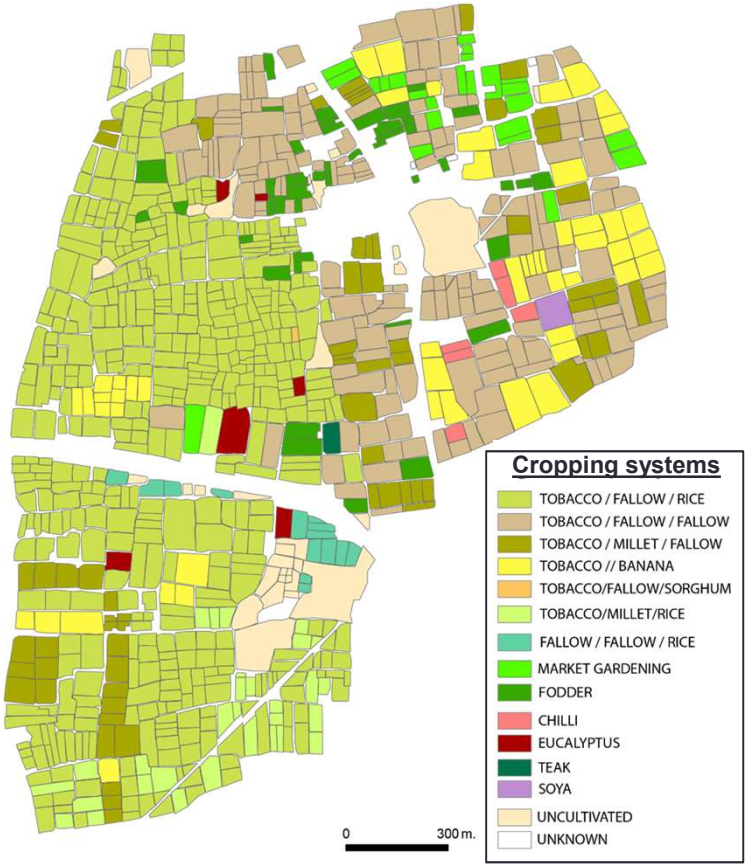
N losses for **livestock systems** close to literature values

Production systems	**PS2**	**PS3**	**PS4**	**PS5**	**PS6**	**PS7**	**PS8**	**PS9**
Description	**Large dairy farms 3,8 ha 110 co.**	**Mid-size diversified farms 1,5 ha 6 co, 1bu**	**Mid-size dairy farms 1,2 ha 30 co.**	**Small diversified farms 0,24 ha 2 bu.**	**Small dairy farms 0,2 ha 3va,1bu**	**Share-croppers ø ha 2 bu**	**Day labourers ø ha 2 bu**	**Pastoral farmers ø ha 10 co**
INPUT flows *(kgN)*	14,541	742	3984	197	548	198	137	794
OUTPUT flows *(kgN)*	4,972	351	1,805	106	207	106	102	410
N LOSSES (%)	***66***	***53***	***55***	***46***	***62***	***46***	***26***	***48***

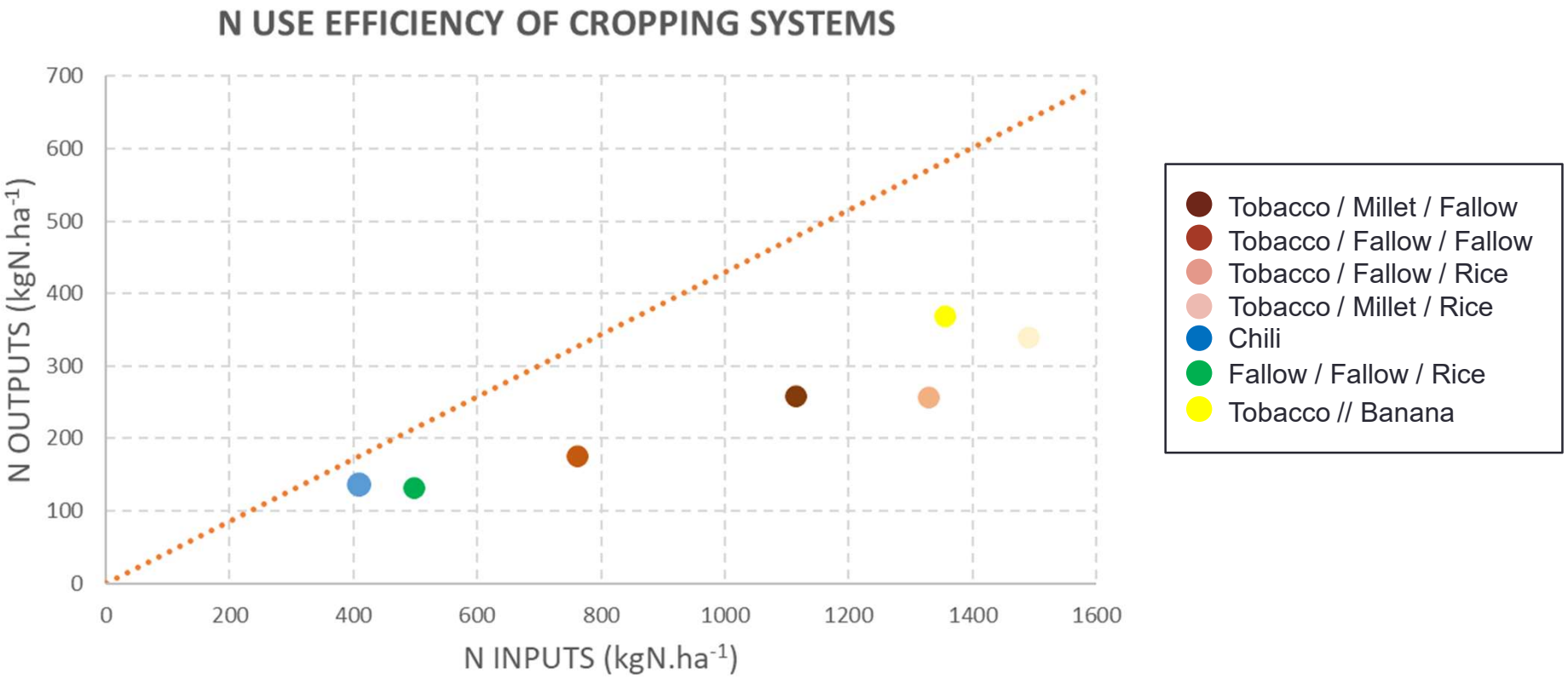
- ✓ Nitrogen losses through manure storage and spreading in pre-industrial Europe: **27 to 60%** (*Krausmann, 2004; Güldner et al., 2016*)
- ✓ Currently N lost through manure management (non-used, stored and spread) **in India**: **70 %** of N excreted (*Billen et al., 2014*)

Spatialization of cropping systems and crop nitrogen balances in Davalpura's village



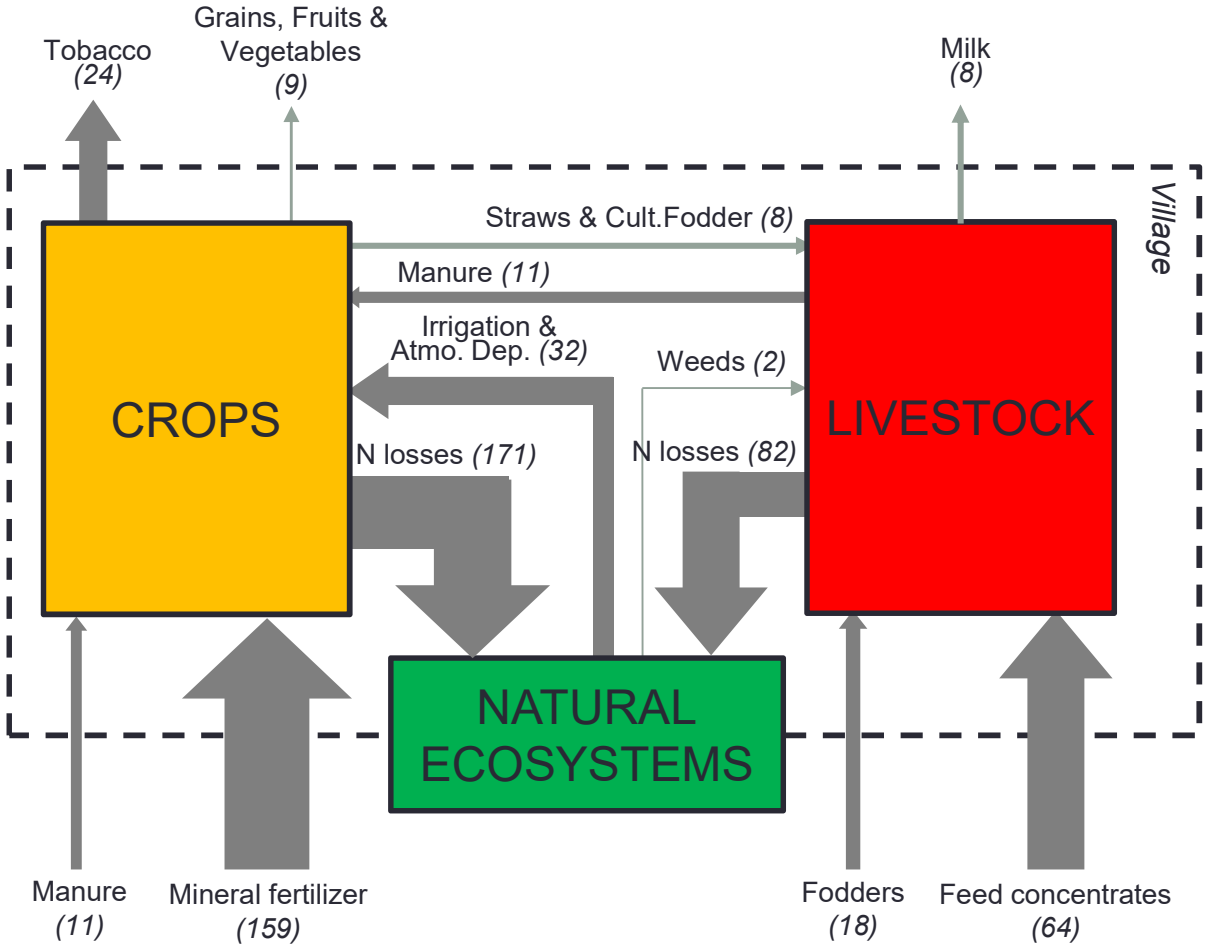


Nitrogen-use efficiency for **cropping systems** is low compared to literature values



N use efficiency for Tobacco-based CS are far from threshold value at world level (***43%***) calculated by Billen *et al.* (2014)

Nitrogen flows in Davalpura village:
under-exploiting the crop-livestock integration potential



- ✓ **N surplus: 1,040 kgN.ha^{-1}**
- ✓ **Strong external inputs dependence** (mineral fertilizers & feed concentrates = 71% N use on farms)
- ✓ **Large N losses** to natural ecosystems (hydro and atmosphere – **83%**) from both LS and CS
- ✓ **Untapped crop-livestock integration**
  - ✓ N manure could cover a large part of crops N needs (2-4x more of mineral N)
  - ✓ Fodder crops: 3% of croplands
  - ✓ Tobacco cropping produce non-feed residues

Differentiated contribution to nitrogen flows and surplus according to farm type

	Landowners with sharecropping	Large dairy farms	Mid-size diversified farms	Mid-size dairy farms	Small diversified farms	Small dairy farms	Day labourers		
							Share-croppers		Pastoral farmers
Categories and Flows	**PS1**	**PS2**	**PS3**	**PS4**	**PS5**	**PS6**	**PS7**	**PS8**	**PS9**
Input flows	**28**	**12**	**38**	**8**	**6**	**6**	**3**	**<1**	**<1**
Feed Concentrates	-	37	20	21	1	10	10	<1	<1
Mineral Fertilizer	39	1	45	3	8	4	-	-	-
Output flows	**33**	**8**	**35**	**6**	**10**	**6**	**2**	**<1**	**<1**
Fruits&Vegetables	49	-	45	-	1	5	-	-	-
Grains	41	<1	38	2	16	3	-	-	-
Tobacco	43	2	38	2	11	4	-	-	-
Milk	-	32	22	22	2	12	9	<1	<1
Contribution to nitrogen surplus at village scale	++++	++	++++	++	+	+	0+		0

Conclusion

- Petlad's metabolism very similar to the one observed today in Europe – heavy reliance on imported external inputs resulting in nitrogen surplus joining the hydrosphere and the atmosphere – with two differences

- Many environmental, agronomical and even economic reasons to reintegrate crops and livestock but changes in policies and in socio-economic differentiation appear necessary for this to occur