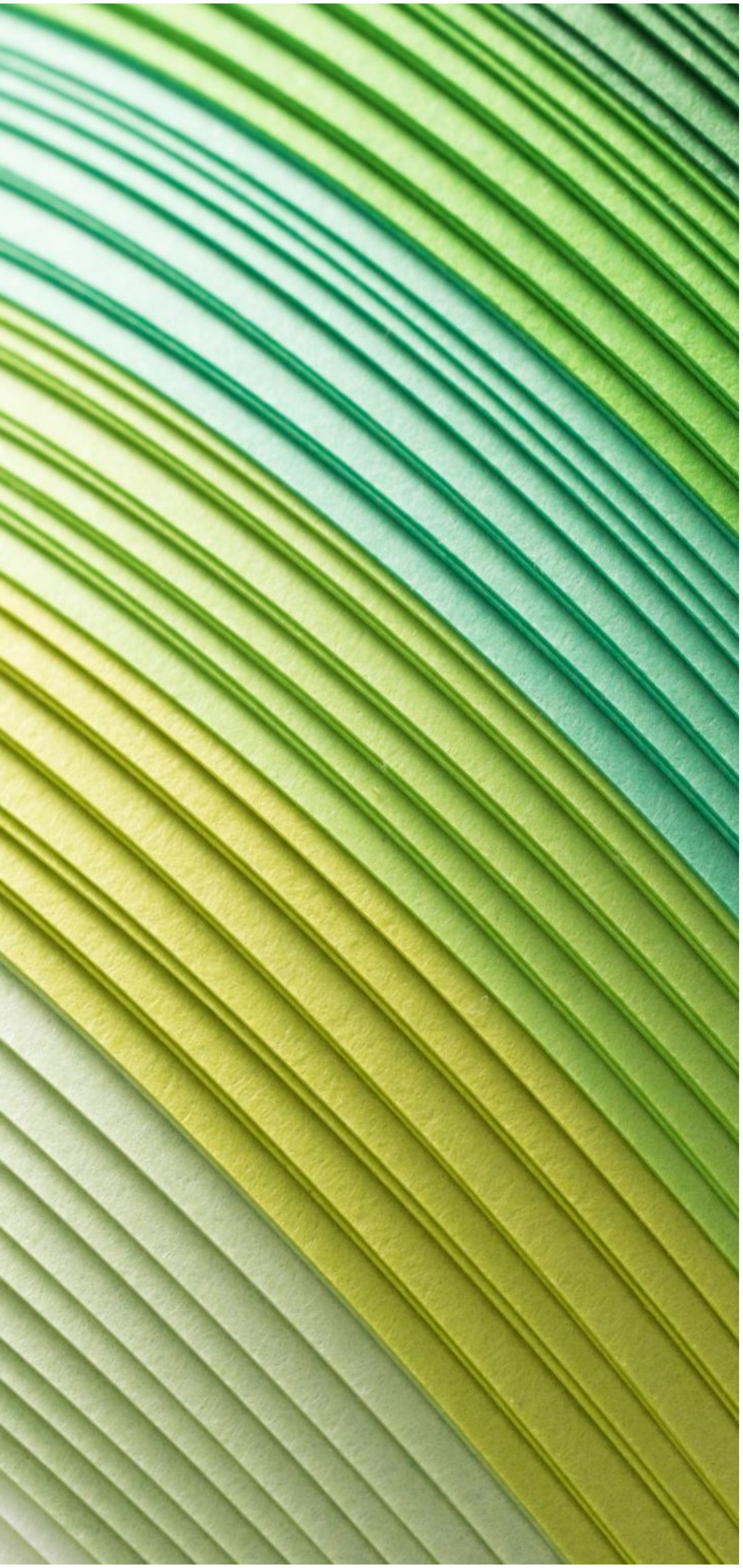
Measurement and Mitigation of GHG Emissions from Livestock

Pradeep Kumar Malik

Head
Bioenergetics and Environmental Sciences Division
ICAR-National Institute of Animal Nutrition and Physiology
Adugodi, Bengaluru
Email: pradeep.malik@icar.org.in

Environmental issues

- ❖ **GHG emissions**
  - ➢ Methane emissions
    - Enteric methane
    - Manure methane
  - ➢ Nitrous oxide emissions
- ❖ **NH3 volatilization**
- ❖ Antimicrobial resistance
- ❖ Pesticides residues
- ❖ Heavy metals



GHG Emissions from livestock

Major concerns

- Uncertainties in estimation
- Improper methodologies
- Consideration for variability
- Inconclusive validation
- Poor adoption of technologies
- Insufficiency of MRV protocols
- Lack of incentivization

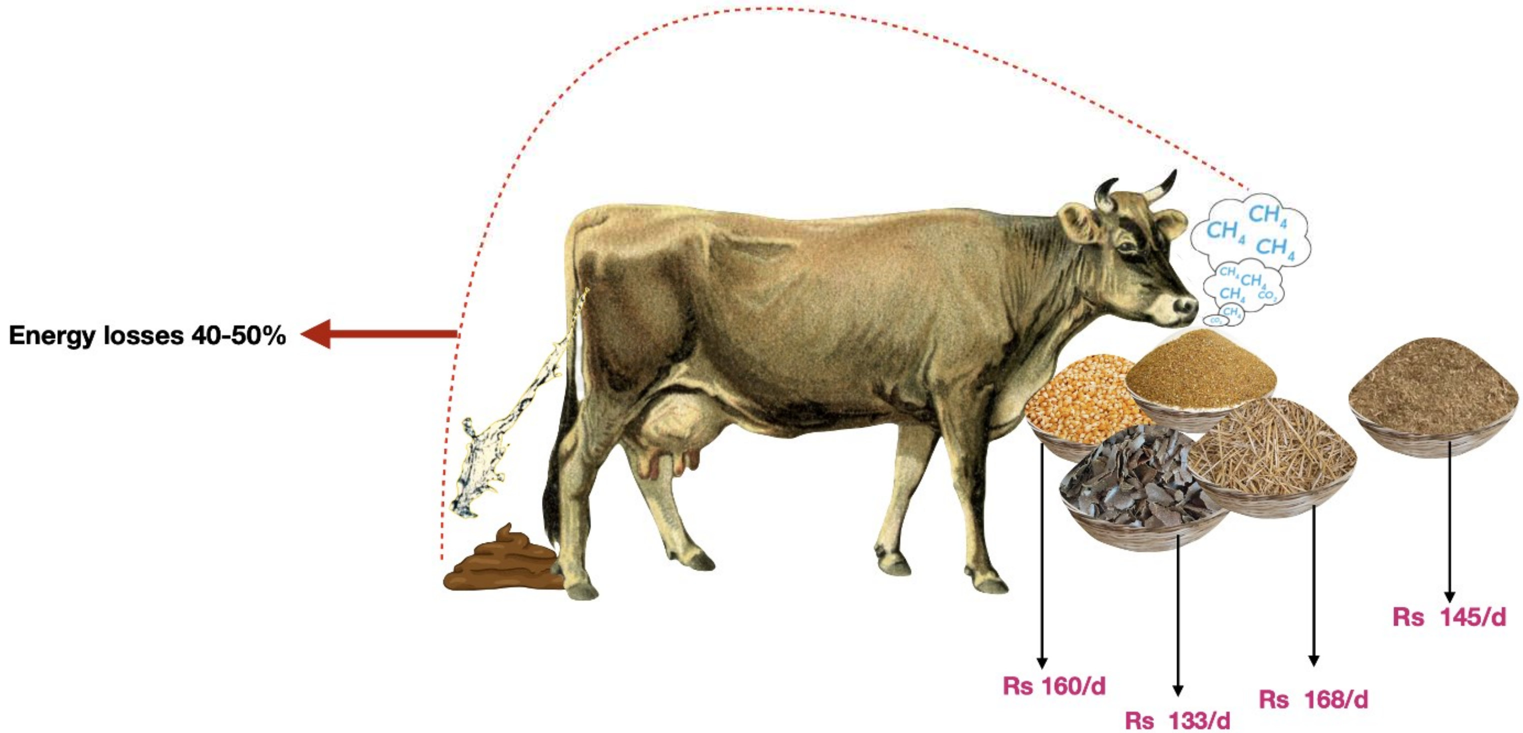
Atmospheric concentration of GHGs

GHG	Lifetime (years)	Atmospheric concentration* (~ 470 ppm overall)
CO_2	300-1000	441 ppm
CH_4	12	1880 ppb
N_2O	114	334 ppb
PFC	10000-50000	0.246 ppm
HFC	1.4-270	0.044 ppm
SF_6	3200	10.5 ppt
NF_3	740	0.86 ppt

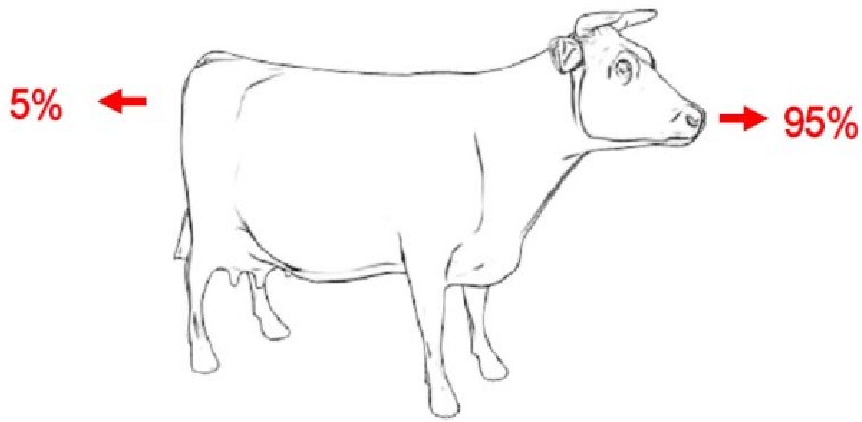
* Environmental Protection Agency (2021)

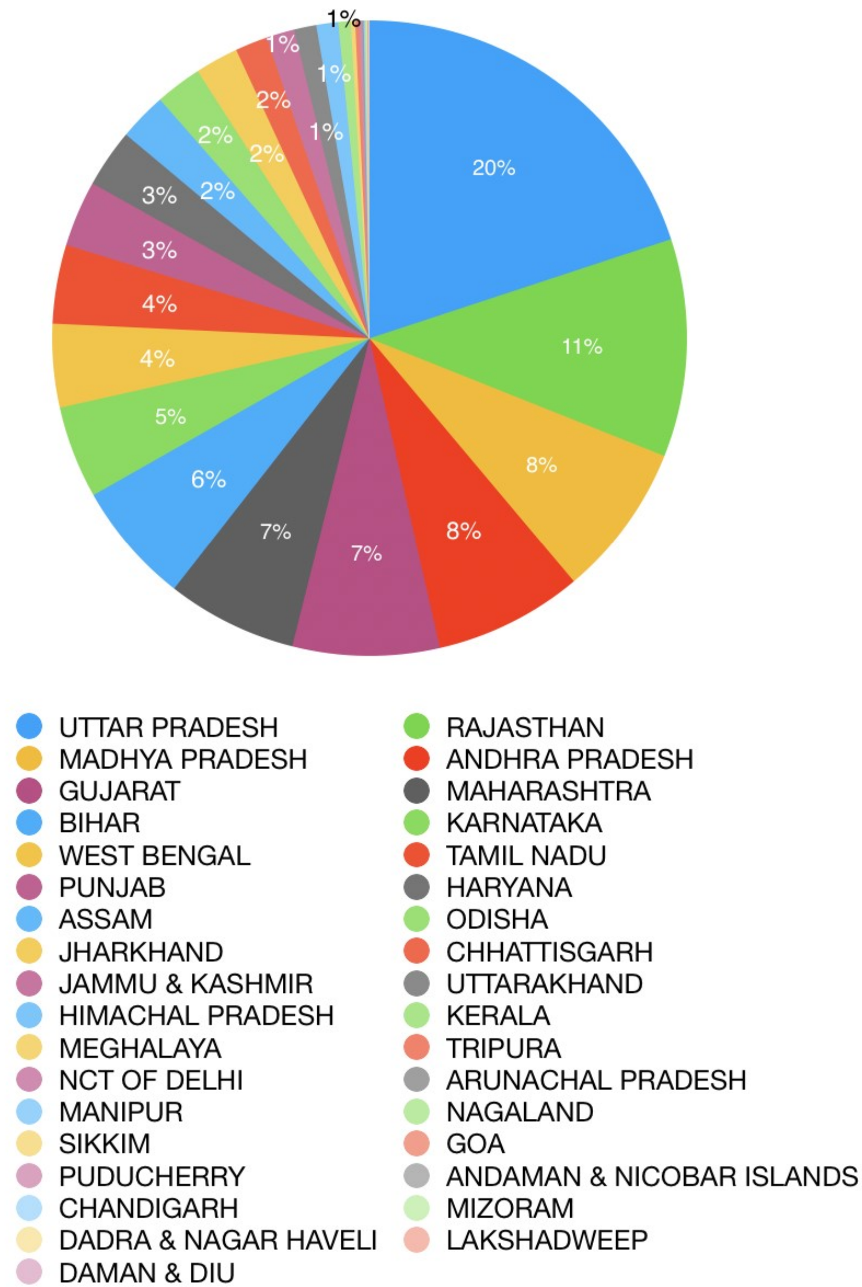
~ 180-190 ppm more than the pre-industrial time

GHG emissions represent production inefficiencies



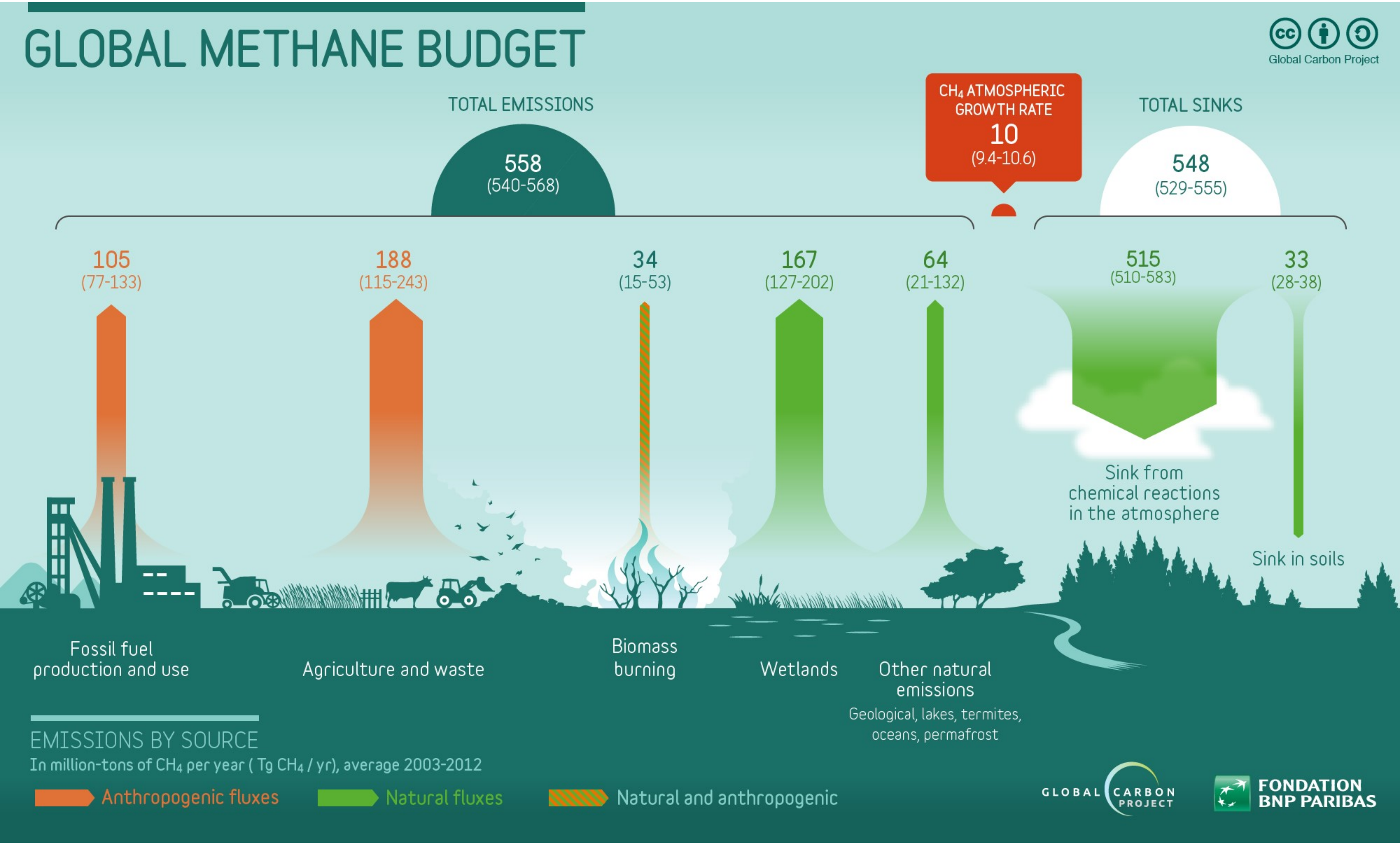
Wasteful process





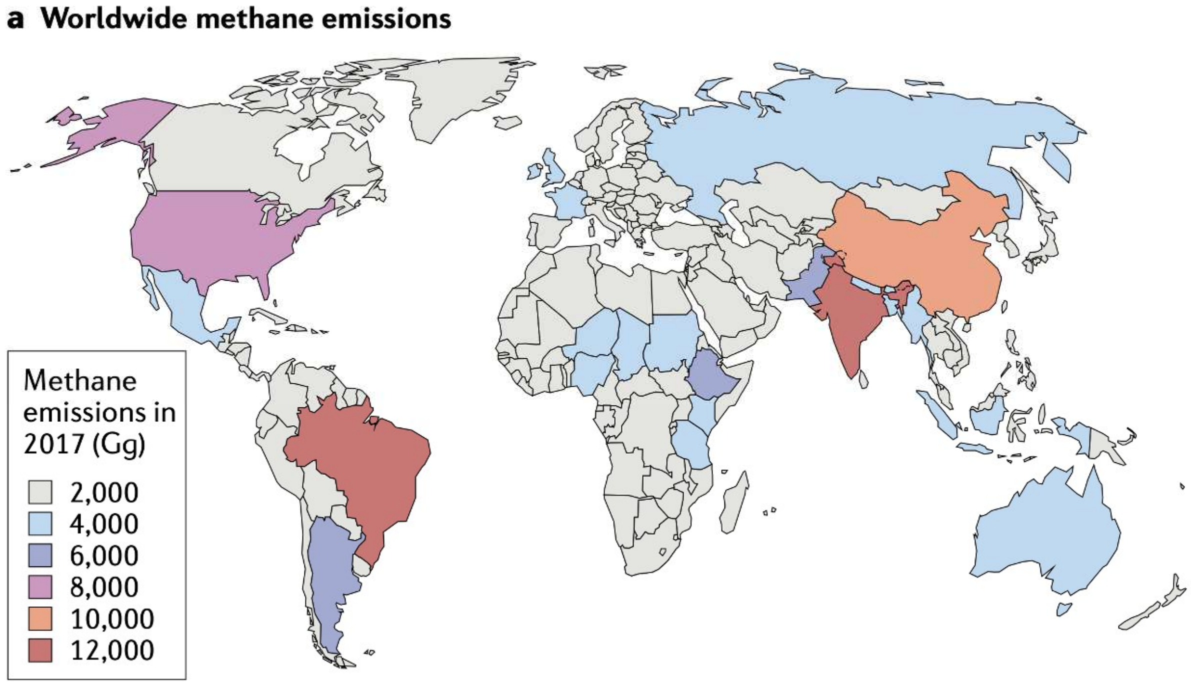
39.5 Kj/l methane
Energy loss in dairy animals- 37.8 x 10^8 giga

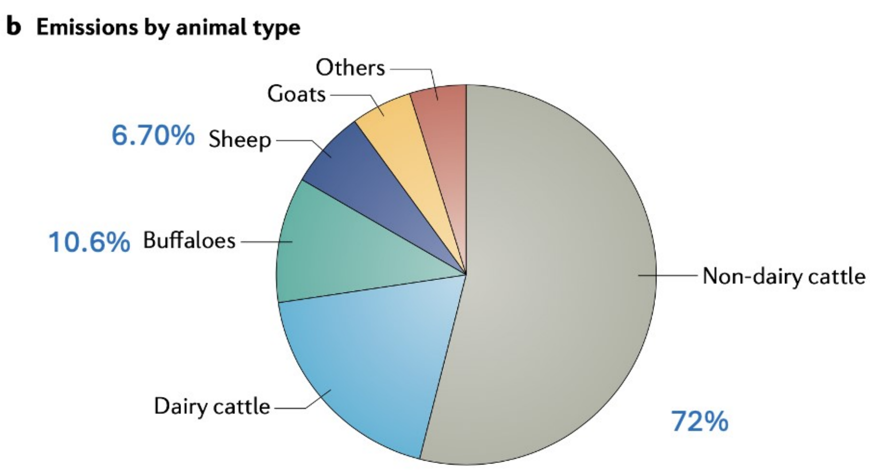
Global Methane Budget



http://www.globalcarbonatlas.org

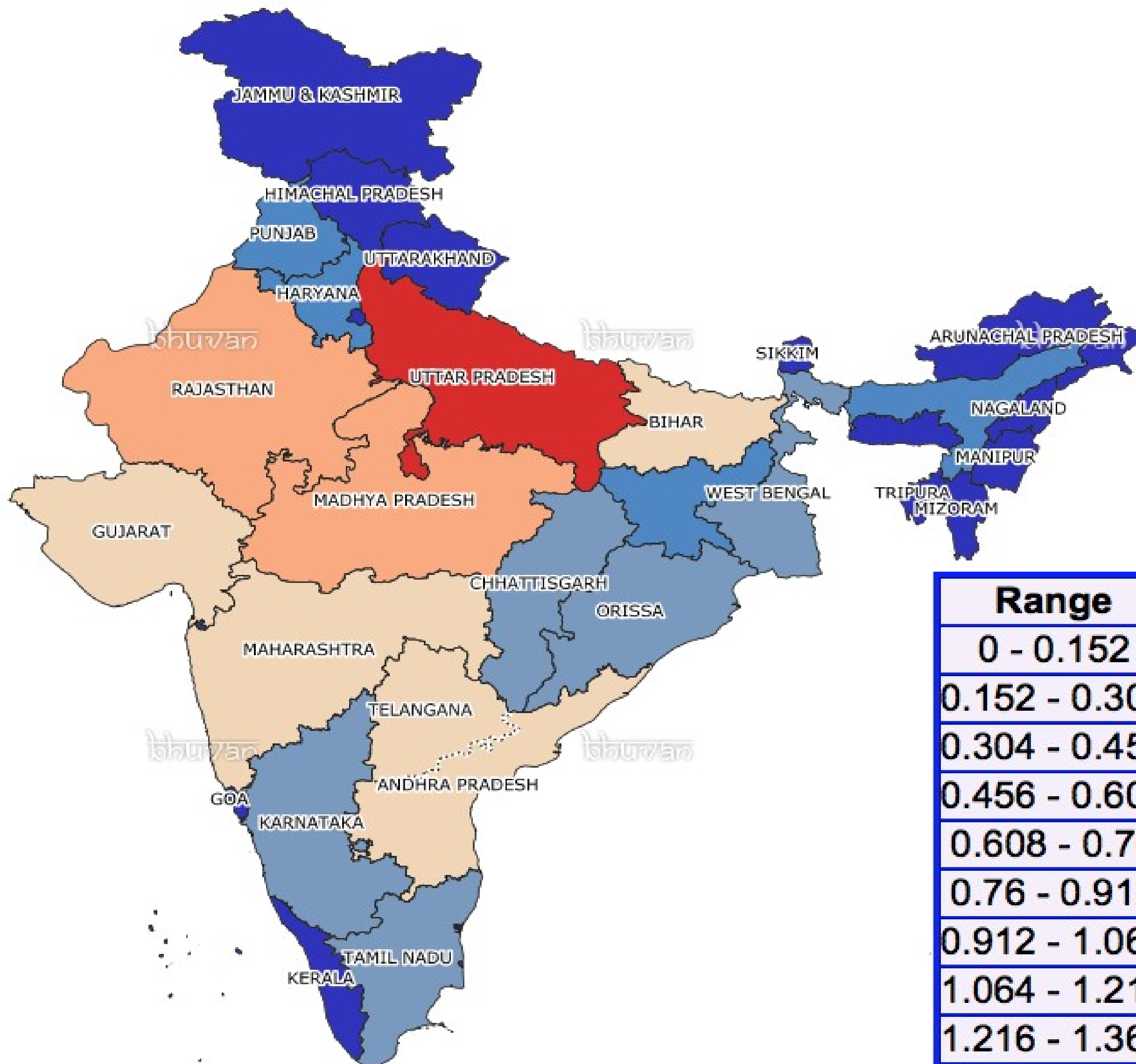
Enteric Methane Emissions- Global Scenario





Mizrahi et al. (2021)

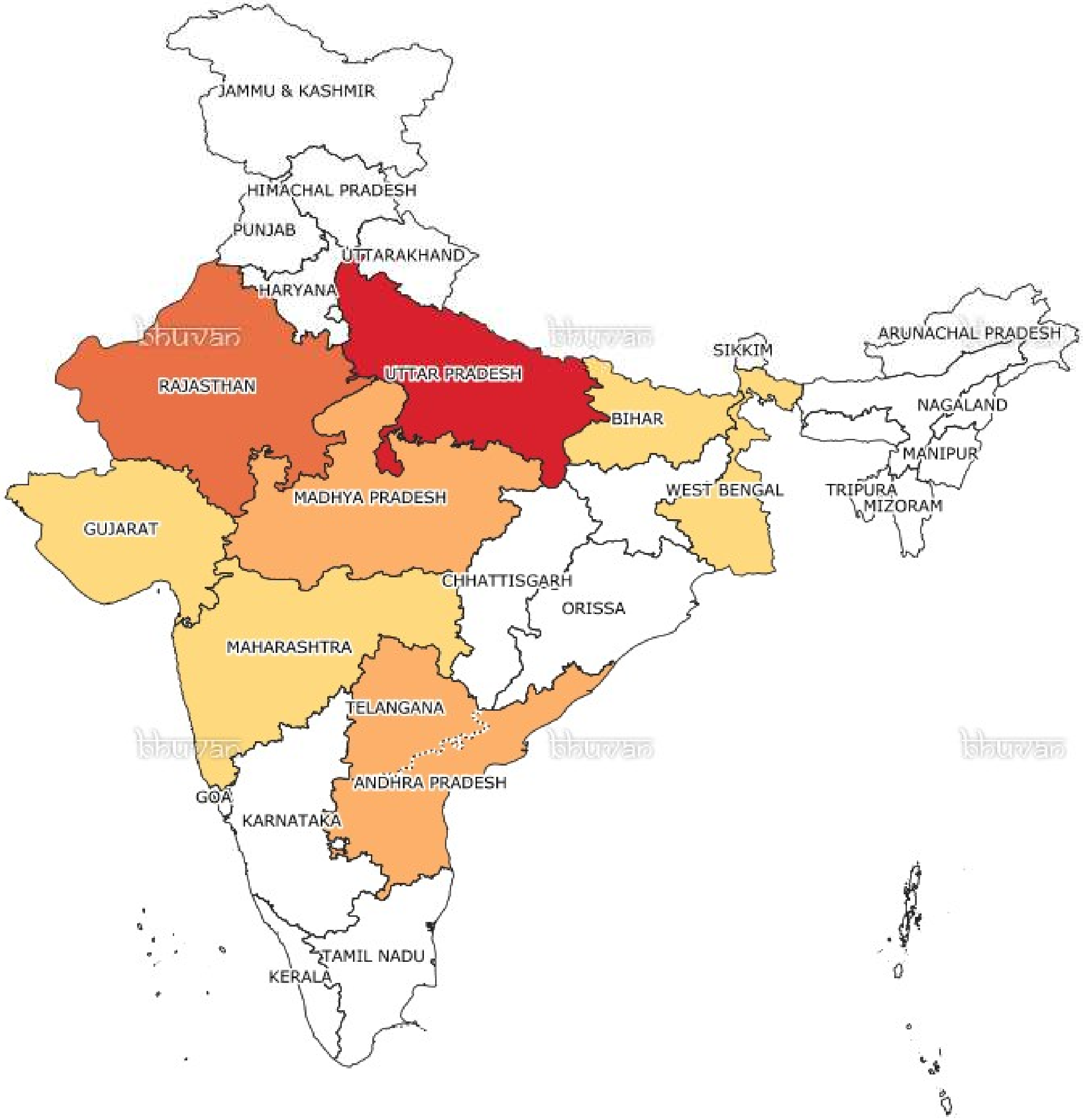
State wise enteric methane emission



Range	Color
0 - 0.152	
0.152 - 0.304	
0.304 - 0.456	
0.456 - 0.608	
0.608 - 0.76	
0.76 - 0.912	
0.912 - 1.064	
1.064 - 1.216	
1.216 - 1.368	
1.368 - 1.52	

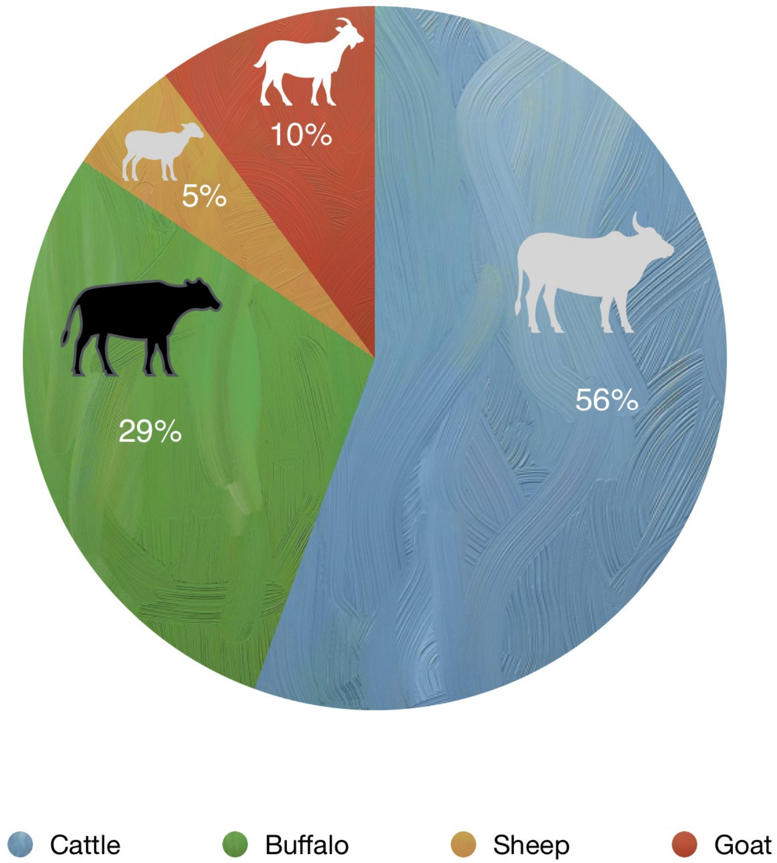
9.253 Tg per yea

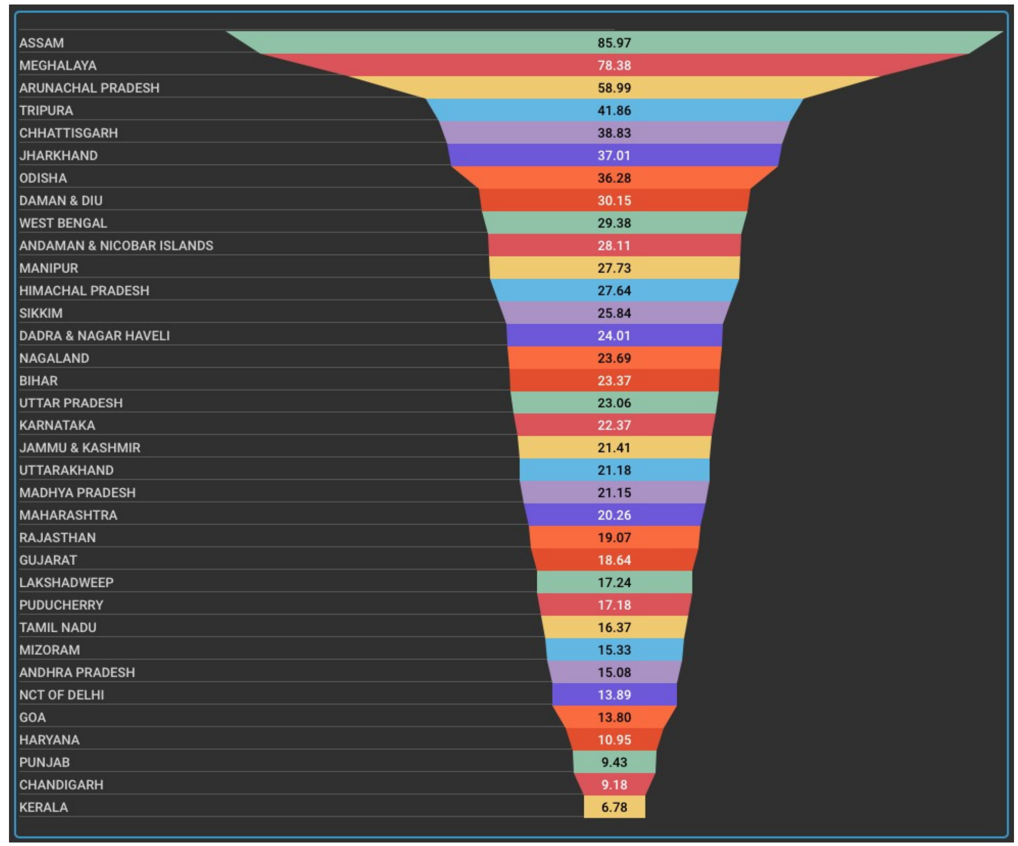
Hotspots of enteric methane emissions



Range	Color
0 - 0.45	
0.45 - 0.7	
0.7 - 0.8	
0.8 - 0.9	
0.9 - 1.52	

Species wise methane emission

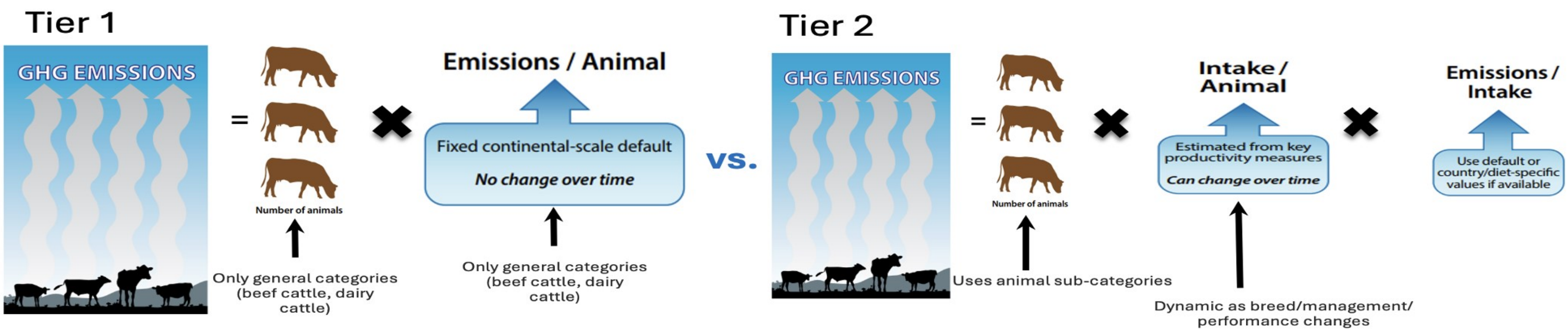




Methane Emission g/Liters of milk

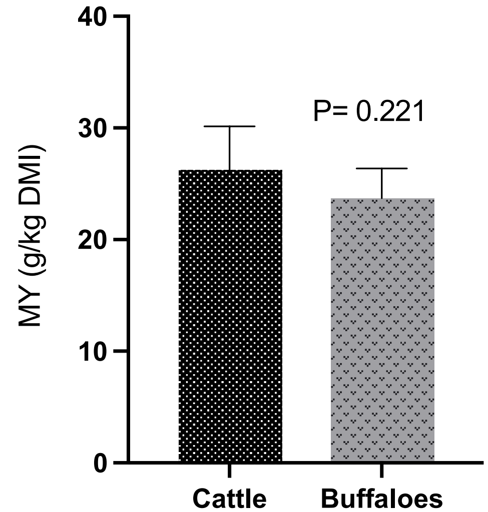
Methane measurement techniques: application & challenges

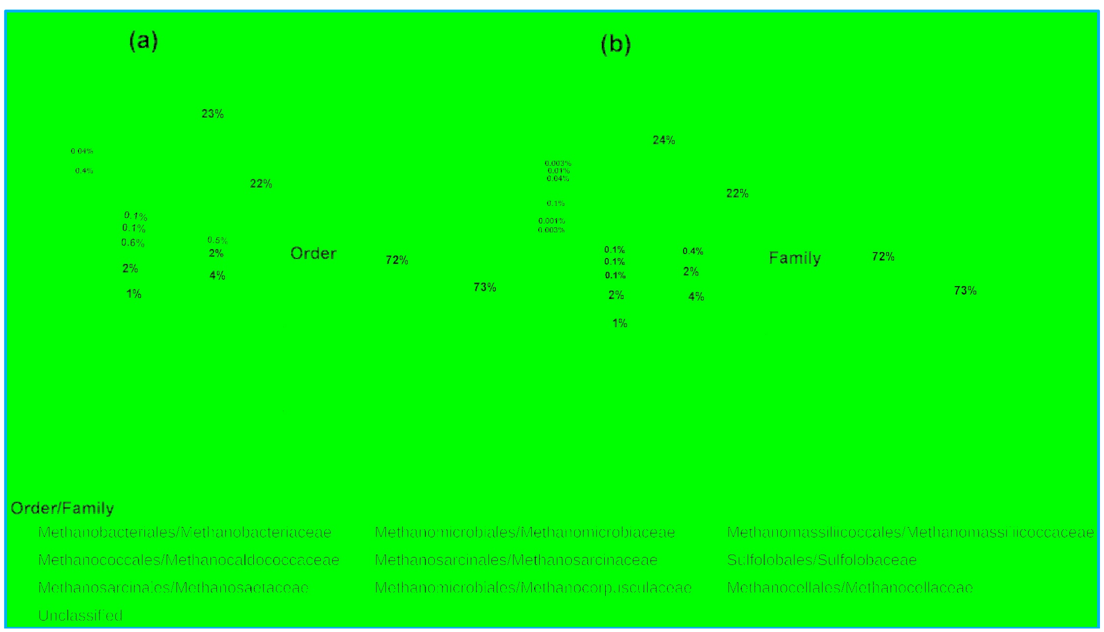
- Direct measurement
- Indirect measurement
- Proxy methods

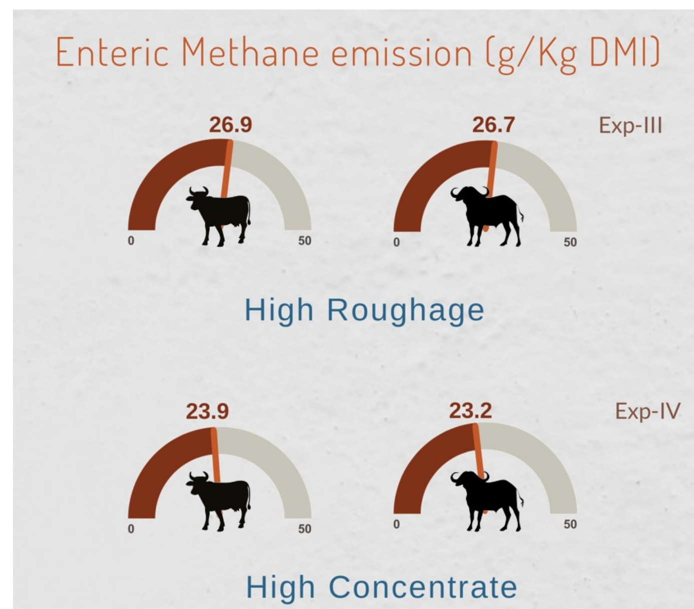


Direct measurement

Methane emissions: cattle vs buffaloes

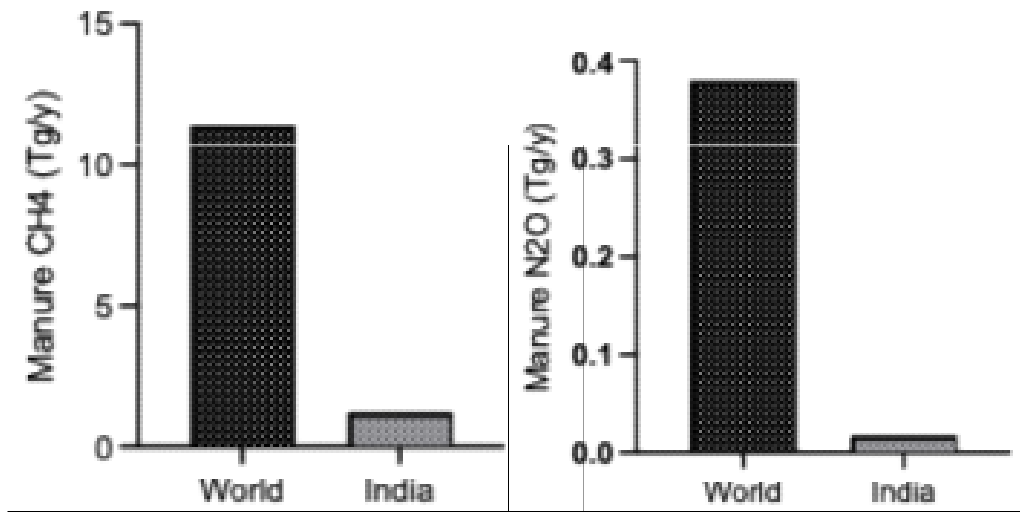






Manure methane and nitrous oxide emissions

- Calculative, based on IPCC tier systems
- Both the emissions are contrast
- Needs to develop country specific EF
- Consideration for type of storage, diet
- Consideration of VS in excreta



Mitigation options

Potential targets for methane mitigation

a) Modulation of the fermentation to decrease H_2 production

b) Direct inhibition of methanogens

c) H_2 redirection towards alternative electron incorporating pathways

d) Methane oxidation

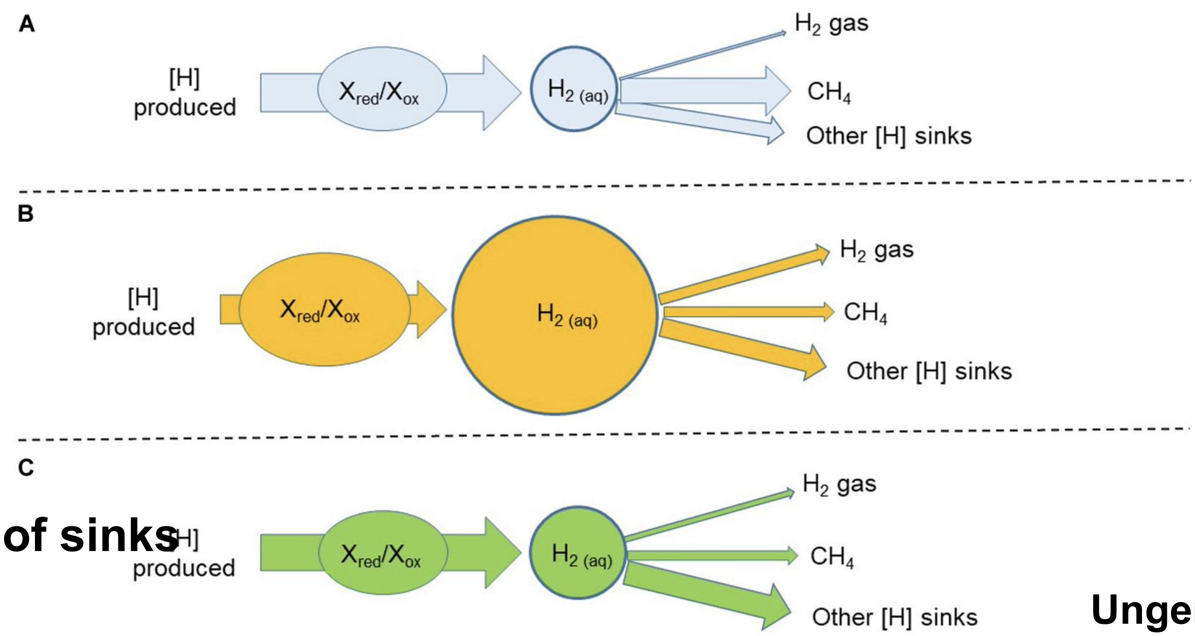
Belanche et al. (2025)

Flow of metabolic H_2 under *three* different scenarios

As usual

Mitigation

Mitigation & stimulation of sinks



Ungerfeld (2020)

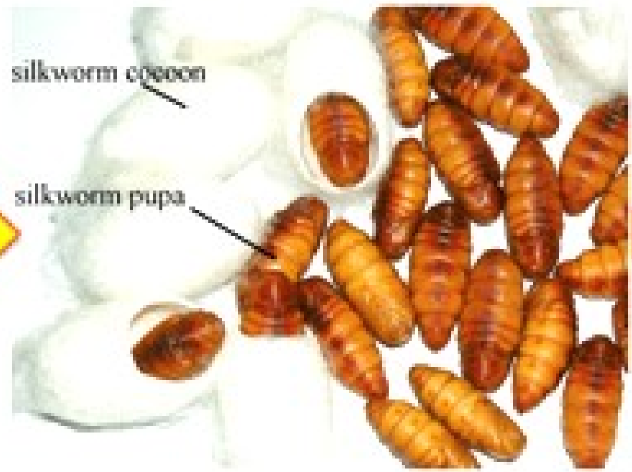
Dwindling livestock numbers

Ration balancing

Secondary metabolites: tannins/saponins/essential oils

Oil feeding


eggs
larva
adult moth
pupa


silkworm cocoon
silkworm pupa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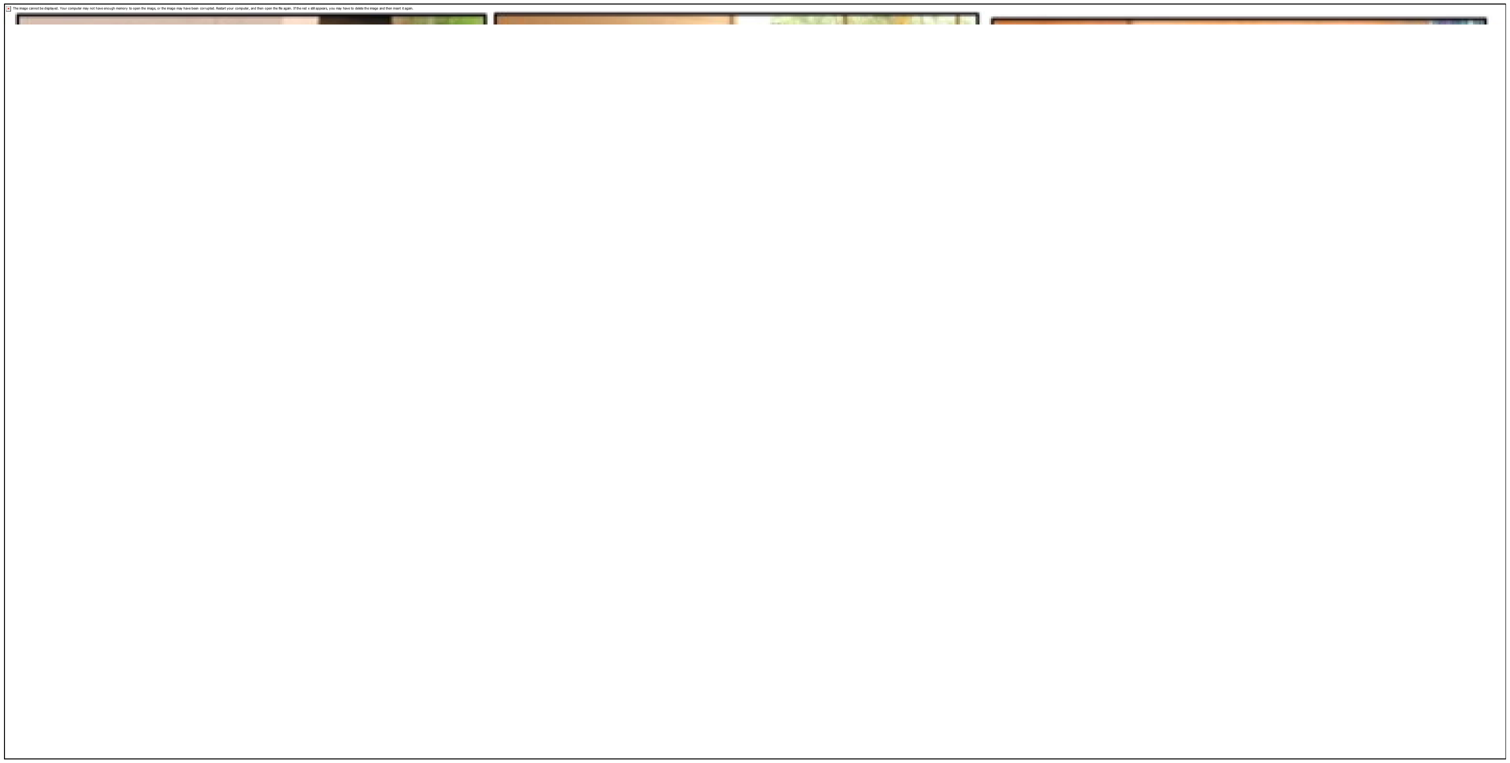
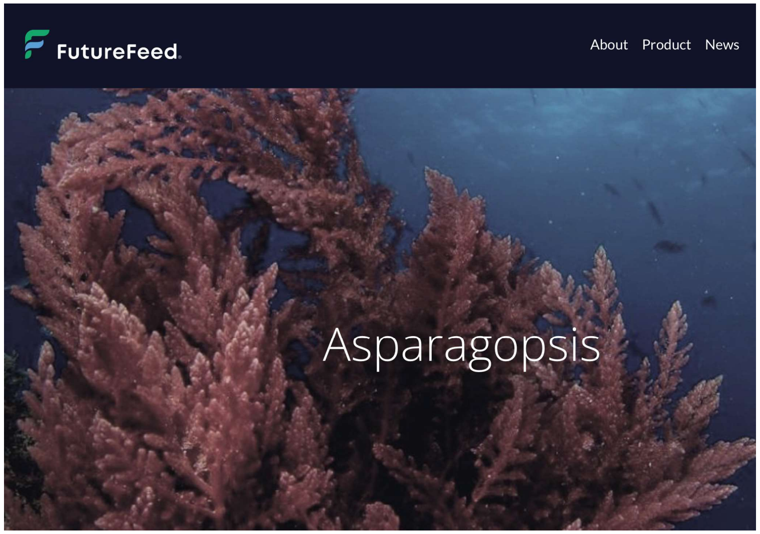


Seaweeds and their biowaste



- Seaweeds are rich source of bioactive compounds
- *Padina gymnospora* biowaste found to be very effective
- High ash content is a challenge in feeding seawe
- Bromoform needs to be monitored in milk

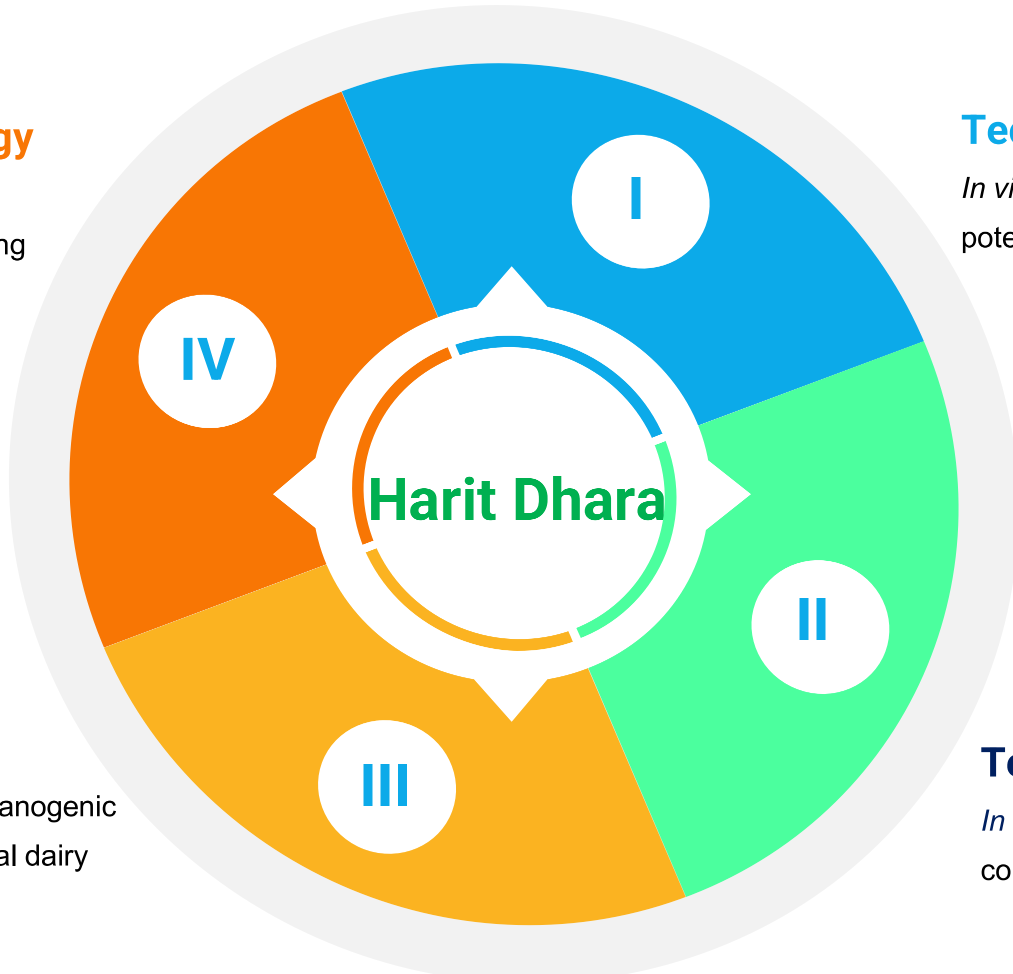
Anti-methanogenic supplement Harit Dhara

Upscaling of technology

Licensing of technology to feed manufacturers and carbon trading firms

Technology development

In vitro studies for determining anti-methanogenic potential and optimization of inclusion levels



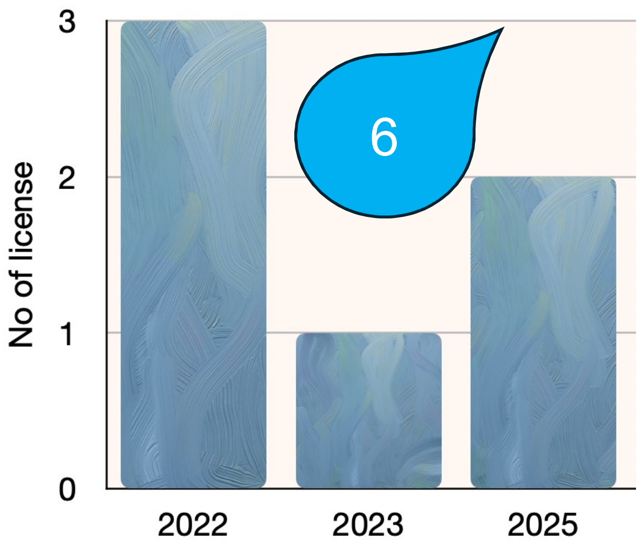
Technology validation

Third party evaluation of anti-methanogenic product and trials at the commercial dairy farms

Technology development

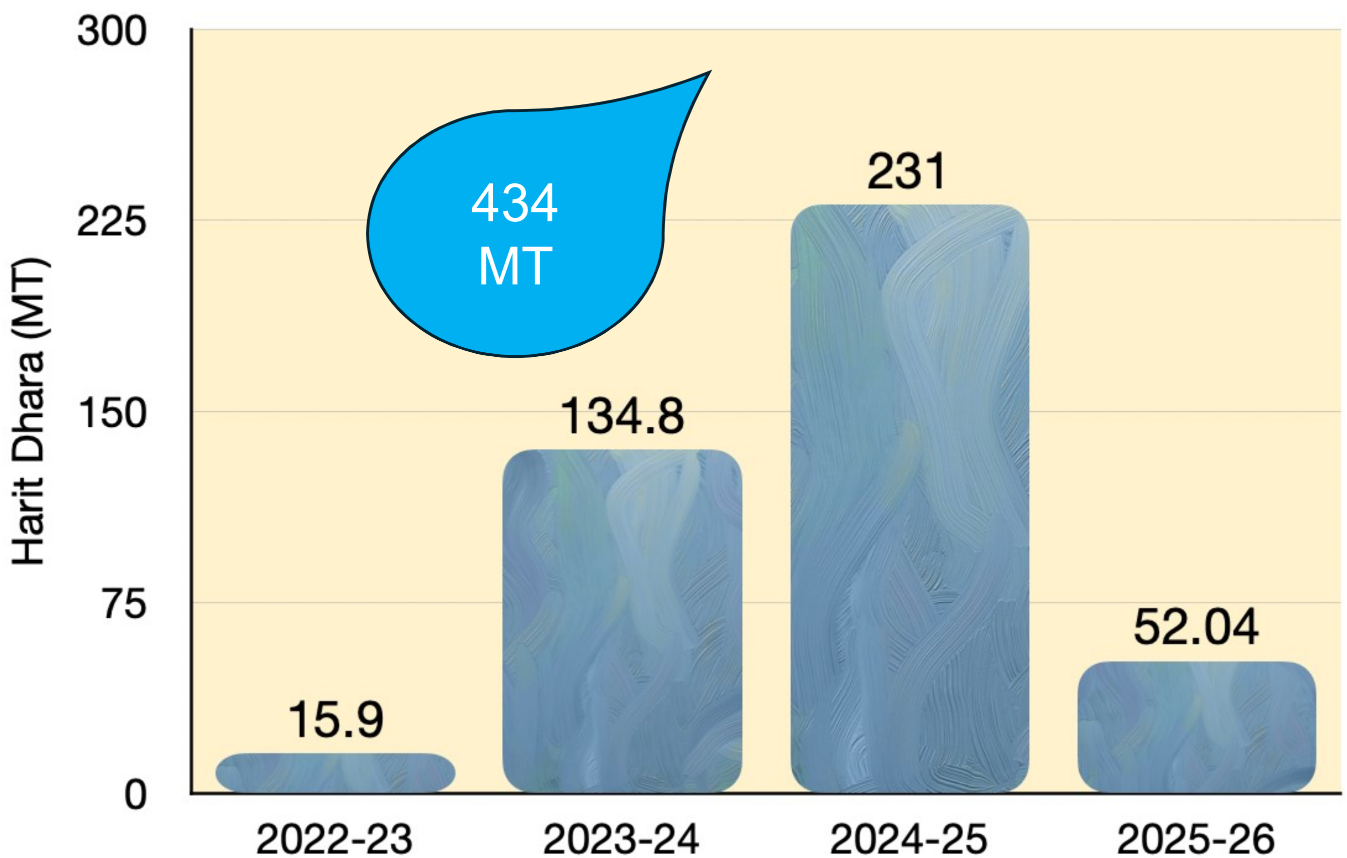
In vivo studies in small and large ruminants for confirming the efficacy of product

License & Licensee of Technology



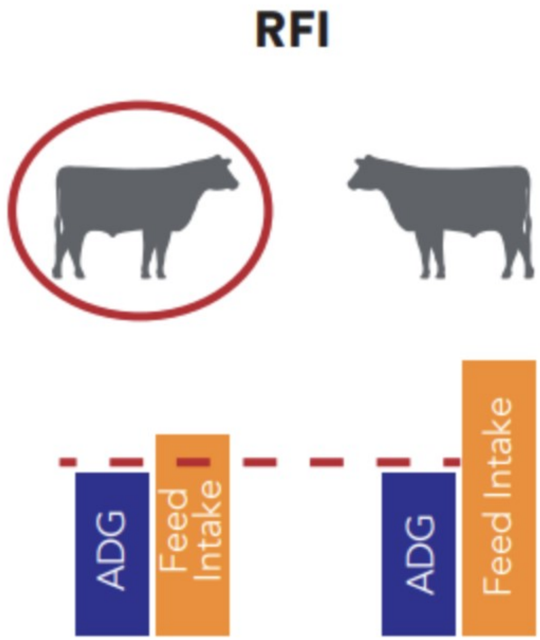
SN	Licensee	Business type
1	SaiDeep Exports Pvt Ltd., Bengaluru	Feed Manufacturing
2	BAIF Research Foundation, Pune	Feed Manufacturing
3	Unique Organic Inputs, Bardoli	Feed Manufacturing
4	Core CarbonX Solutions, Hyderabad	Carbon Crediting
5	eVerse.AI, Nagpur	Carbon Crediting
6	ZeroEarth, Thiruvananthapuram	Carbon Crediting

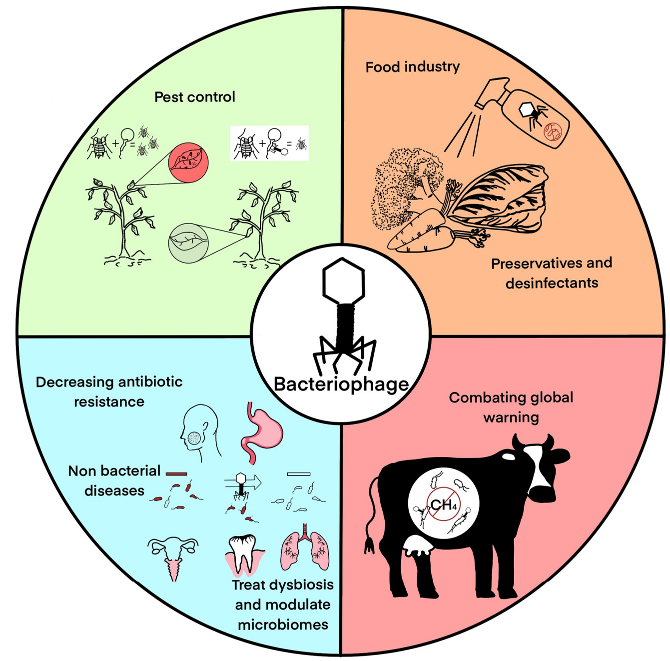
Harit Dhara supplied by BAIF, Pune



States where HD is supplied
Tamil Nadu, Telangana, Andhra Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Orissa, Bihar

Residual feed intake (RFI), archaea phages





Archaea-phage Therapy
Phages are natural denizens of rumen (>10^9 particles/ml)
Phages has successfully used against *S. bovis*
UQ, Australia has confirmed the "proof of concept".
Diversity and characterization of archaeaphage in livestock
Phage-like particles are known to infect *M. smithii* and *M. thermoautotrophicum*

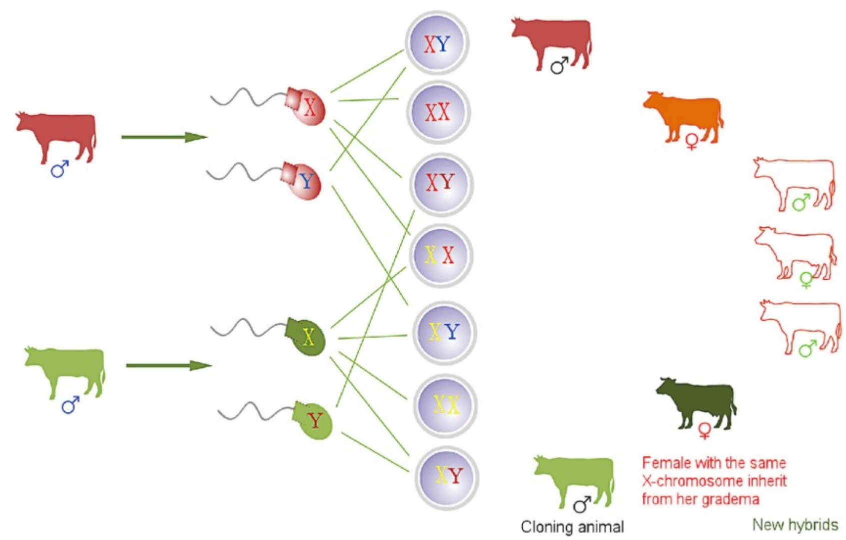
Breeding for low methane emission

- ❖ Hegarty *et al.* (2007) reported that feed conversion efficient animals produce 25% less methane

- ❖ Trials at NSW DPI (2010) confirmed that progeny of low methane emission bulls produced up to 24 per cent less methane than control groups (29 g vs. 38 g /kg DMI).

- ❖ Data from large herd may be used to calculate methane indices for estimated breeding values (EBV).

- ❖ Different feeding regimes and selection of bulls with genetically superior methane traits may be deleterious to other desirable traits



ECONOMIC IMPACT

- Annually 2000 Gg less methane from the Indian livestock
- Shrinking of carbon footprint of livestock production equivalent to 54,000 Gg

- About 75 x 10^7 Gcal energy can be saved
- Fulfill energy requirement of 7 million cattle
- About 16 MMT milk worth ~ 50000 crores

1/3rd of spared H_2 is only redirected towards VFA (Morgavi et al., 2023)