CSE SCHOOL OF SUSTAINABLE FOOD SYSTEMS AAETI

NATIONAL CONCLAVE

SUSTAINABLE FOOD SYSTEMS

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Anil Agarwal Environment Training Institute, Nimli, Rajasthan

Livestock Mitigation and Adaptation
(*Session 4: GHG Emissions from Livestock and Mitigation Options*)

Climate-smart Dairying: NDDB's Initiative and its Impact

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Dairying in India

80 million rural households -
nutritional security to **1.4 billion people**

Milk production: **240 million tonne**
(2023-24) i.e. **25%** of global production

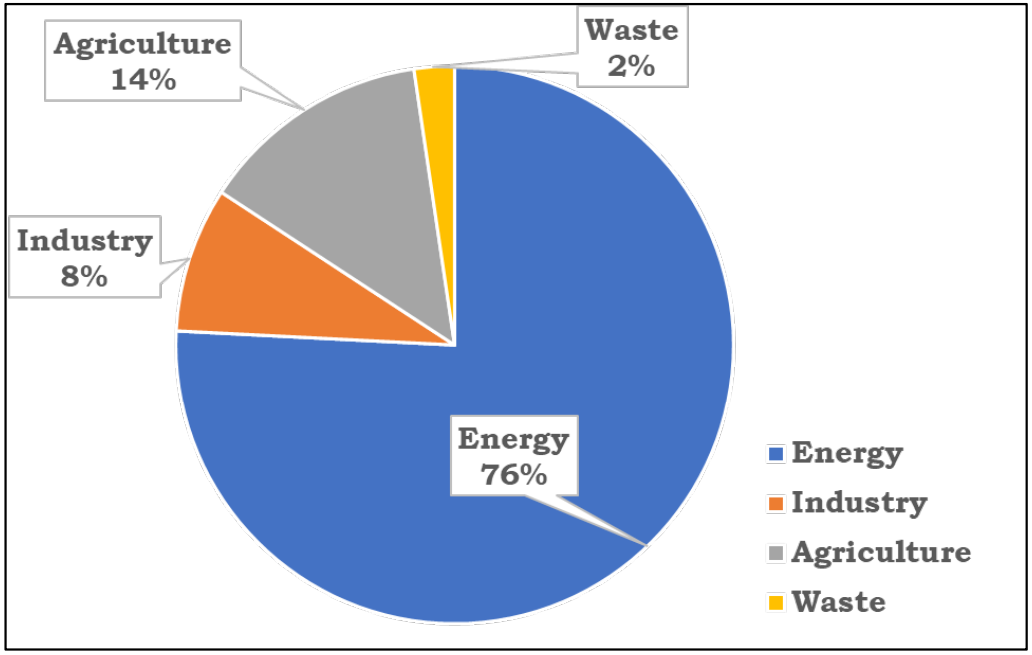
Per capita availability: **471 g/day**
(world average: 315 g/day)

Production growth: **6% per annum**
(3 times higher than global average)

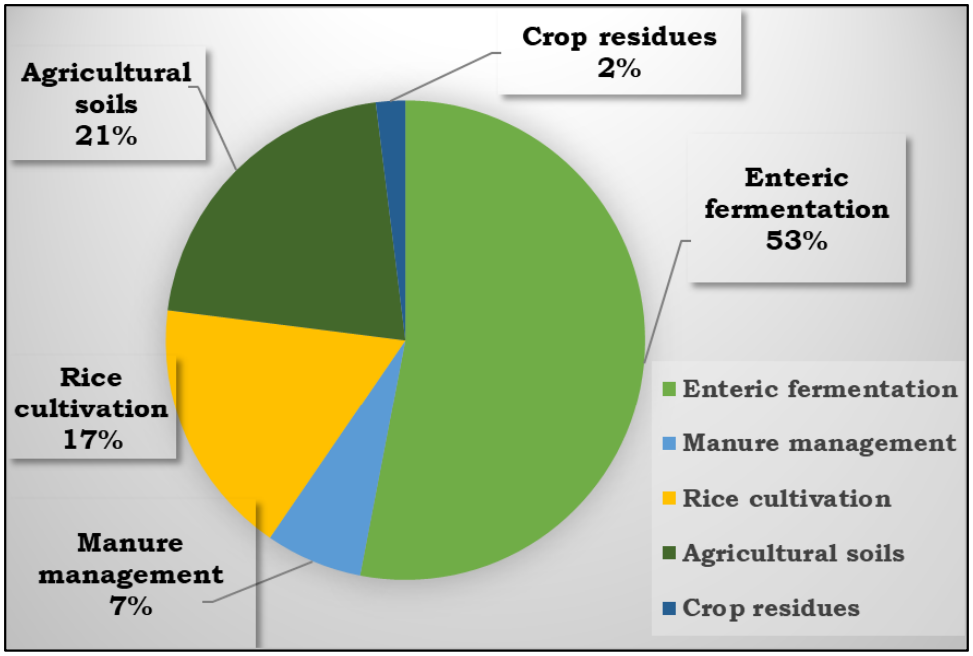
Single largest agricultural commodity (value of output > combined value of cereals & pulses)

Smallholder system: average
herd size is 2-3 animals

India: GHG emissions by sectors



Emissions by agriculture sector



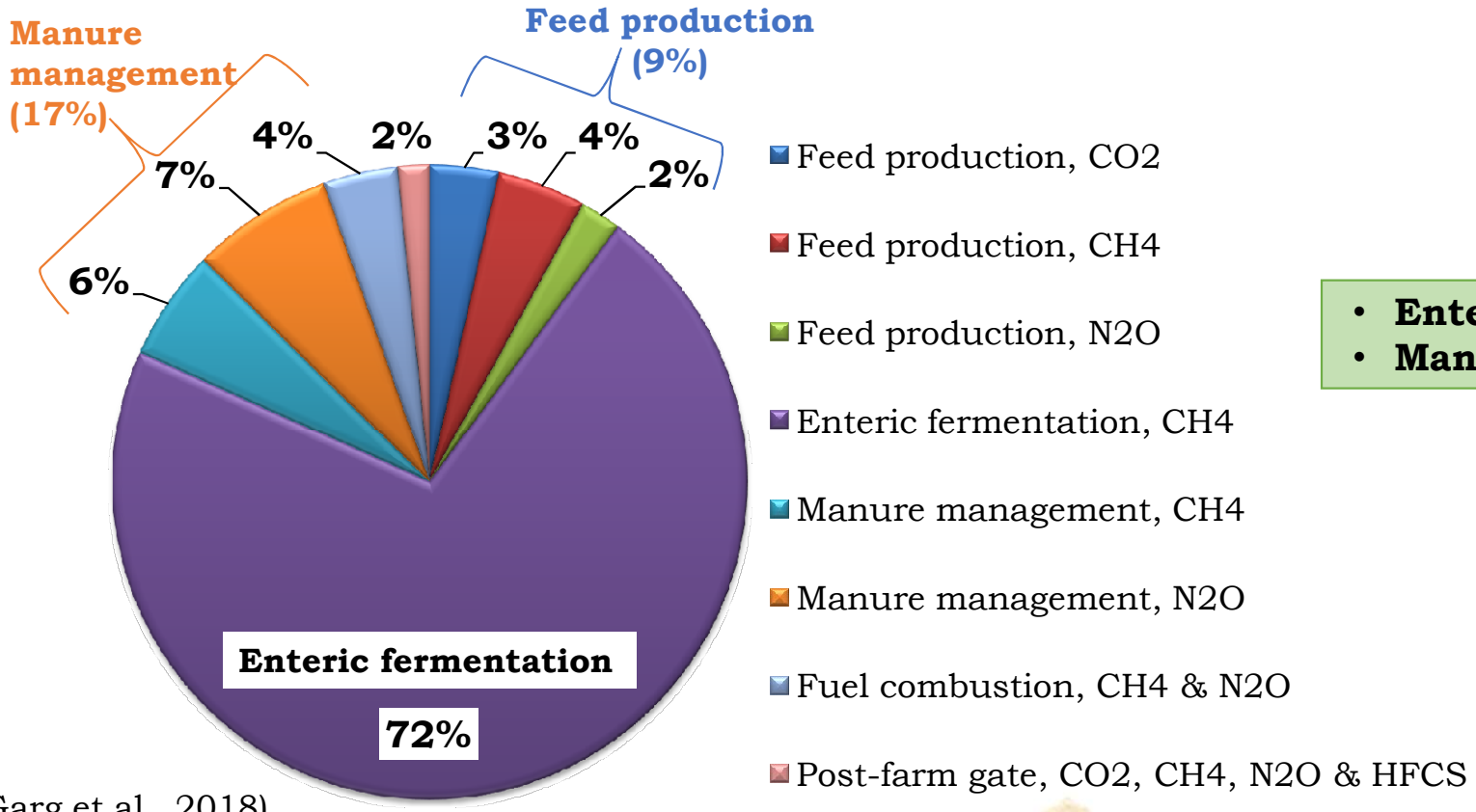
Total GHG: 3.13 Gt CO_2-eq./year

Livestock GHG: 0.25 Gt CO_2-eq./year

- **Enteric fermentation: 89%**
- **Manure management: 11%**

(MoEFCC, 2023)

GHG emissions by the Indian dairy sector



(Garg et al., 2018)

GHG Hotspots

- **Enteric Methane (72%)**
- **Manure Management (17%)**

Initiatives for Climate-smart Dairying

1. Scientific Feeding

- Ration Balancing
- Total Mixed Ration
- Forage Improvement
- Methane Inhibitors

2. Manure Management

- Decentralized models
- Centralized models

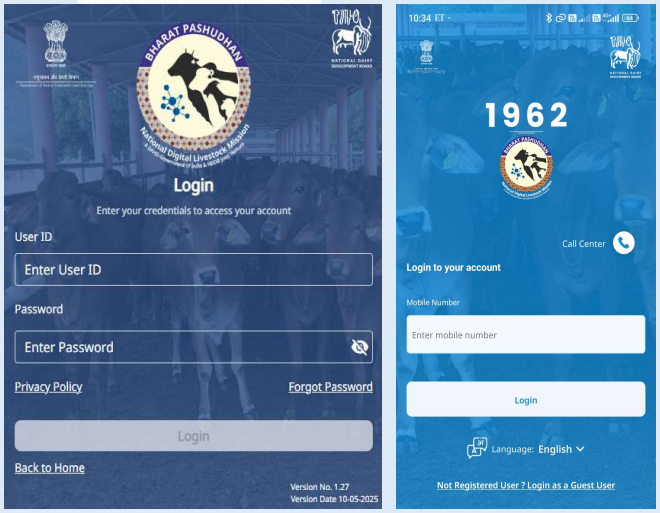
3. Productivity Enhancement

- Genetic Improvement

1. Ration Balancing Programme

Proof of Concept → ***Large-scale Implementation*** → ***Impact***

Bharat Pashudhan **1962 App**



https://bharatpashudhan.ndlm.co.in/

Feeding Balanced Ration

2.8 million

2.2 million

Doorstep Ration Advisory

- National Dairy Plan-I (2012-19)
- National Digital Livestock Mission
- A-Help Programme
- Japan International Cooperation Agency (JICA)
- Cooperatives, NGOs, Private organisations

Milk yield (kg/d) (4%)

Feeding Cost (₹/day/ani.) (12%)

Net Income (₹ 27/day/ani.)

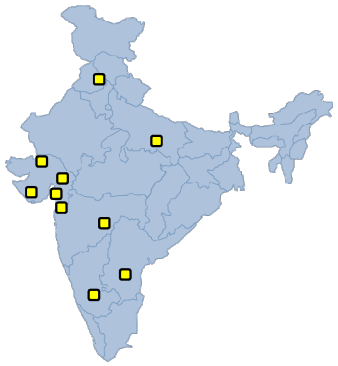
Methane emission (13.7%)

Impact of RBP on milk productivity, livelihood and methane emission

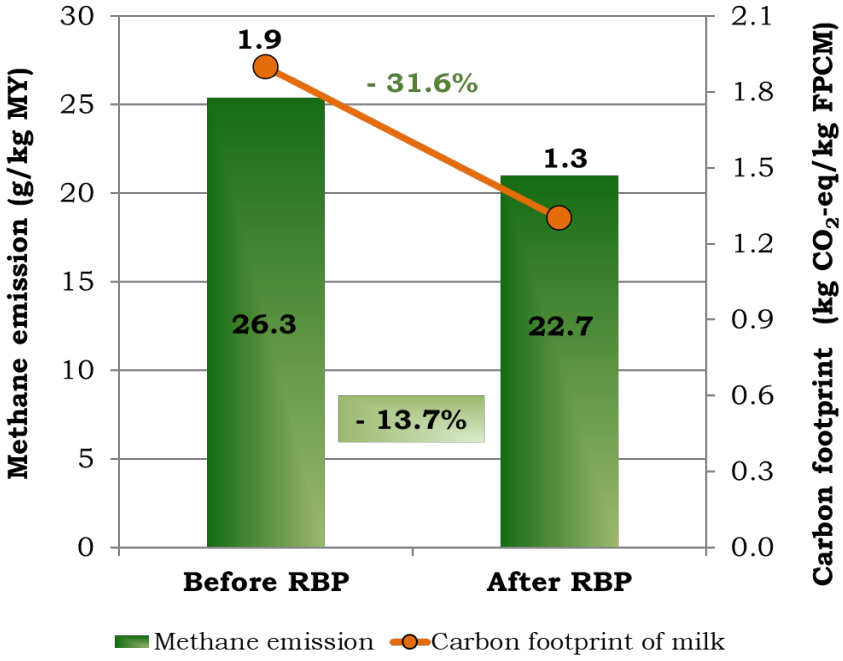
Parameter	Before RB	After RB	Change
Average milk production (kg/animal/day)	7.06	7.33	+0.27
Average fat % in milk	4.69	4.77	+0.08
Average cost of feeding (Rs./kg milk)	19.44	17.15	-2.29
Average cost of feeding (Rs./animal/ day)	135.10	118.81	-16.29
Increase in net daily income (Rs./animal)			**+27.26**
Reduction in feed cost per kg of milk			**11.80%**

RB: Ration Balancing

Methane measurement using ***SF_6 Tracer Technique***



➢ **13.7% reduction in methane emission**



Crop Residue Burning

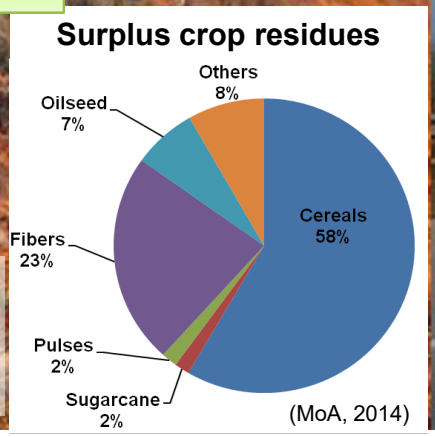
Reasons:

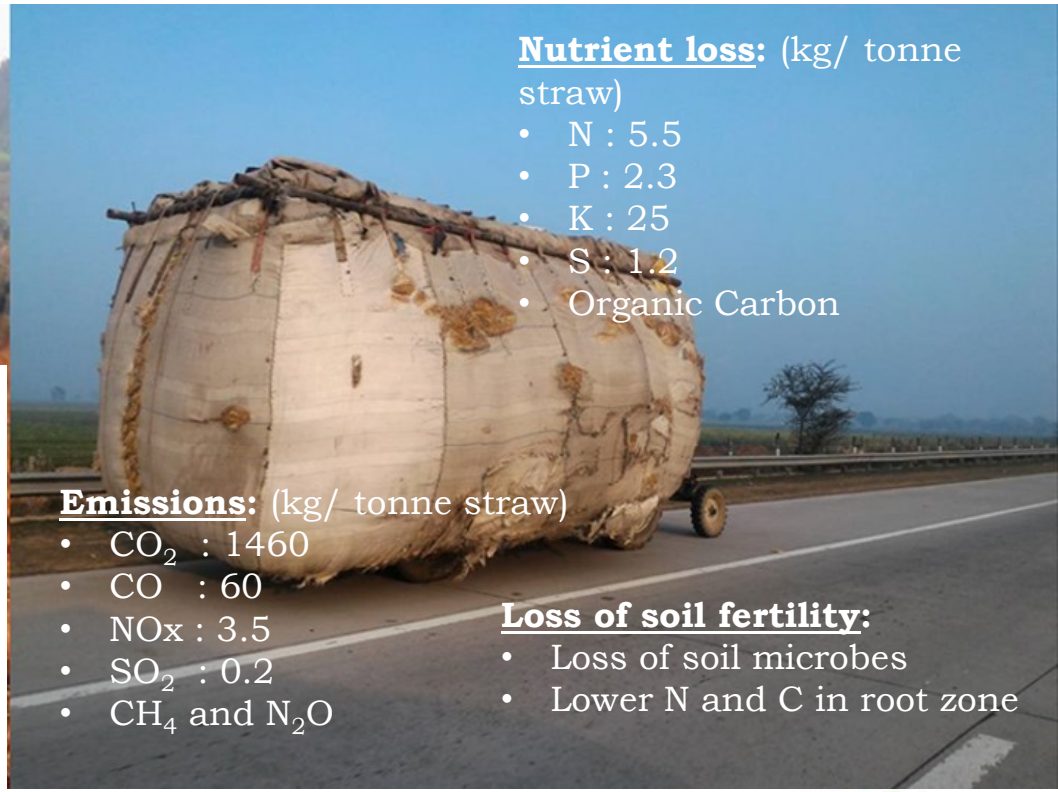
- Less time window (Paddy-Wheat)
- Labour shortage
- High cost of removal
- Mechanized harvesting
- Lack of mechanism for straw management

Crop residue generation: **502 MT/ year**
Crop residue burned: **84-140 MT/ year**

- **Punjab**
- **Haryana**
- **Uttar Pradesh**
- **West Bengal**

- **Paddy**
- **Wheat**
- **Sugarcane**





Nutrient loss: (kg/ tonne straw)

- N : 5.5
- P : 2.3
- K : 25
- S : 1.2
- Organic Carbon

Emissions: (kg/ tonne straw)

- CO_2 : 1460
- CO : 60
- NOx : 3.5
- SO_2 : 0.2
- CH_4 and N_2O

Loss of soil fertility:

- Loss of soil microbes
- Lower N and C in root zone

2. Total Mixed Ration (Dry-TMR)

- **Conventional feeding system:** Feed ingredients offered separately (nutrient imbalance)
- **Dry-TMR:** Densification and enrichment of crop residues (mixing with concentrates & feed supplements)

Straw conditioner

Concentrate mixer

TMR mixer

TMR Block

Dry-TMR types

- **Early Lactation** (16% CP, 35% straw)
- **Mid Lactation** (13% CP, 45% straw)
- **Late Lactation** (11% CP, 55% straw)

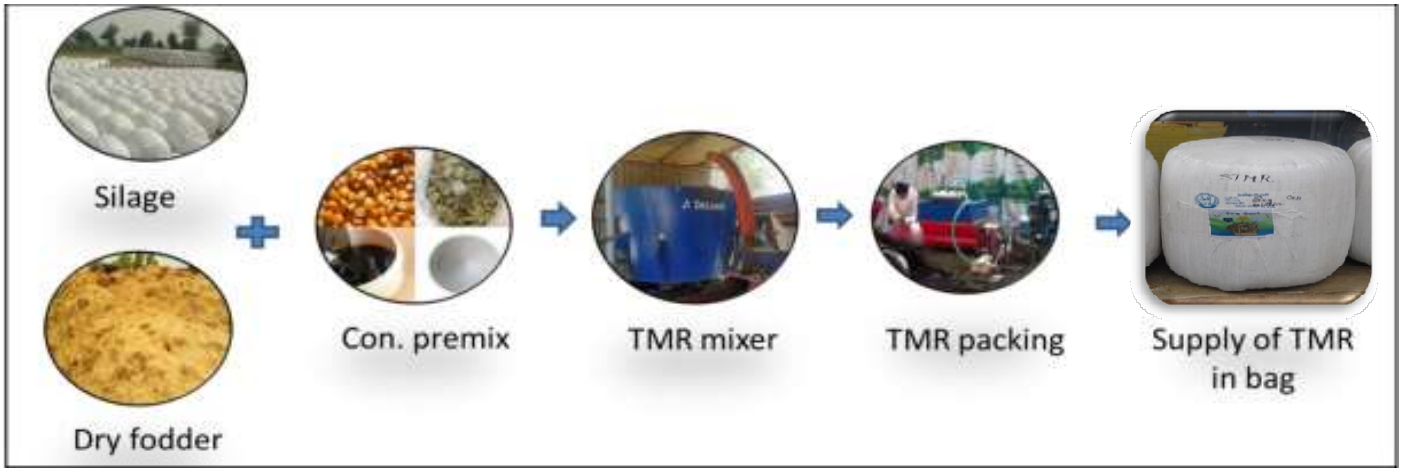
Establishment of Dry-TMR plant:

- Supported milk unions for **establishment of two plants** for production of dry-TMR blocks/pellets (50 tonne/day).
- About **3000 tonne crop residue** is utilised to produce 8000 tonne dry-TMR/year.

TMR block

TMR pellets

Total Mixed Ration (Conventional TMR)




Conventional TMR plant (30 tonne/day)

With silage
(60% silage, 20% dry fodder, 20% concentrate)

With green fodder
(70% green fodder, 10% dry fodder, 20% concentrate)

(45% DM, 13% CP, 39 Mcal ME)

Impact of TMR feeding

12%	Increase in **milk yield** (10.71 *vs.* 11.94 kg/d)
11%	Increase in **milk fat** (3.81 *vs.* 4.24 %)
11%	Reduction in **CH_4 Ei** (16.3 *vs.* 14.5 g/kg milk)
36%	Increase in **net daily income** (₹ 104 *vs.* 142/animal)

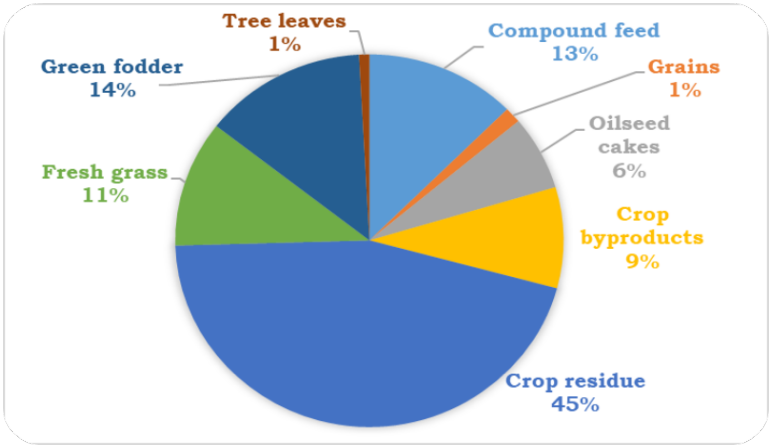
Impact of TMR feeding on profitability and methane emission

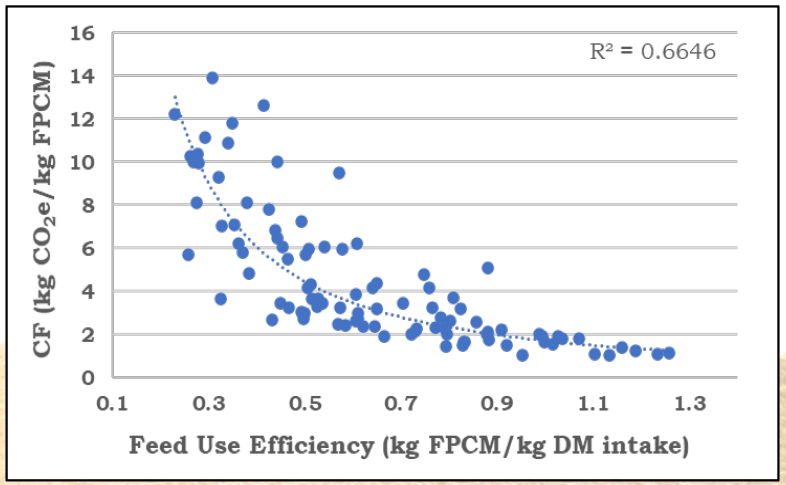
Particulars	Before TMR feeding	After TMR feeding	Change
Milk yield (kg/day/animal)	10.71	11.94	**12%**
Average Fat %	3.81	4.24	**11%**
Average SNF %	8.40	8.61	2%
Average protein %	3.04	3.17	4%
Feeding cost (Rs/day)	299	327	9%
Total income form sale of milk (Rs/day)	403	469	16%
Net daily income (Rs/animal)	104	142	36%
Increase in net income (Rs./day/animal)			**38.0**

- **11% reduction in methane emission (16.3 vs. 14.5 g/kg milk)**

3. Forage Production and Ration Quality

Ingredient composition of Rations





Ration composition & quality:

- NDF <u>required</u>: **32-33%** *vs.*
- NDF fed: **45-50%**

NDF: Neutral Detergent Fibre
- *Measure of plant cell wall content of feed*
- *Indicator of feed quality*
- *Help determine the digestibility*

➢ Every **1%** increase in **feed digestibility** results in **2-3%** reduction in enteric **methane emission**.

Incorporate cereal and legume fodders in ration of animals to improve digestibility.

Fodder Production Enhancement

➢ **National Livestock Mission**
- Certified seeds (30% higher yield)
- Facilitating fodder seed production (**22.4 thousand tonne**, 2021-22 to 2024-25)

➢ **100 Fodder Plus FPOs**
- Organized fodder & silage supply chain

➢ **Year round fodder production & Conservation**

4. Enteric Methane Inhibitors

Sr. no.	Mode of action	Examples
1	Inhibition of methanogens/protozoa	• Tannins • Saponins • Polyphenol extracts • Essential oils
2	Buffers/Hydrogen sink	• Microalgae • Nitrate • Malate
3	Terminal methane inhibitors/methane analogue	• 3-Nitrooxypropanol • Red macroalgae *(Asparagopsis spp.)*
4	Rumen modifiers	• Live yeast • Slow-release Nitrogen

- Many methane inhibitors are available but **no single inhibitor has dual benefits** (milk productivity and methane mitigation).
- Dairy farmers require methane inhibitors that can improve **milk productivity** as well as **reduce methane emission**.
- **NDDB's applied research** - identified suitable inhibitors with **18-20% methane mitigation potential.**
- Animal studies to be initiated.
- To be included in compound feed/ TMR or direct supplementation.

➢ Methane mitigation potential of inhibitors: **5 to 37%**

Manure Management

- **Disadvantage of conventional manure management system**

- Direct N loss
- NH_3 volatilization – air pollution
- Nitrate leaching – water pollution
- Loss of organic fertilizer (NPK)
- Methane emission (GWP_{100}: 27)
- N_2O emission (GWP_{100}: 273)

Innovative Manure Management Models

Decentralized models

Zakariyapura Model

Household level biogas based Manure Value Chain model sufficing cooking energy and organic fertilizer needs of farmers

2 cubic meter
(3-4 animals/farm)

Mid-size Model

Designed for large farms/ Gaushalas to produce renewable energy and organic fertilizer from manure

40 cubic meter
(80-100 animals/farm)

Centralized models

Banaskantha Model

Dung based large capacity biogas plant to produce CBG and organic fertilizer

2000 cubic meter
(~100 farms)

Varanasi Model

Dung based large capacity biogas plant to suffice steam and power needs of dairy plants, and produce organic fertilizer

4000 cubic meter
(~150 farms)

1. Decentralized (household level) – *Zakariyapura Model*

- Mujkuva village (37 plants)
- Zakariyapura village (368 plants)
- Model replicated in **9 states (35,000 plants)**
- India's 1st *Woman owned Manure Cooperative*

- **Mitigation: 3-5 tonne CO_2e/plant/year** (manure & fuel)
- **40%** reduction in manure GHGs
- **7-8%** reduction in farmgate carbon footprint

❑ **Anaerobic digestion of manure**

- 50 kg dung/day (3-4 animals)
- **2 cubic meter** biogas/day
- Captures most of the methane
- Biogas – as a renewable energy
- Digestate – valuable bio-fertilizer
- Avoids CH_4 and N_2O emissions
- Saving of LPG and firewood

❑ **Farmgate GHGs (t CO_2e/year) & Carbon Footprint (kg CO_2e/kg FPCM)**

	Solid Storage	Anaerobic Digester	Avoided GHGs
Manure GHGs	2.33	1.40	0.93 **(40%)**
Farm GHGs	14.74	13.68	1.05 **(7.2%)**
Carbon footprint	1.96	**1.81**	**7.6%**

2. Decentralized (farm level) – *Large farms/ Gaushalas*

Integration of sustainable farm management practices

- 80-100 animals/farm
- 800-1000 kg dung/day
- **40 cubic meter biogas/day**
- 35-40 kWh electricity/day
- 150-200 kg organic fertilizer/day
- GHG mitigation: **10.5 t CO_2e/year**

GHG emissions (t CO_2e/year) of mid-size farm

Particular	Baseline scenario	Improved scenario*	Avoided GHGs
Enteric CH_4	103.8	103.8	--
Manure CH_4	7.46	6.85	0.61 **(8.2%)**
Manure N_2O	12.55	4.88	7.67 **(61.1%)**
Electricity CO_2	12.2	10.0	2.2 **17.5%**
Total GHG	136.0	**125.5**	10.5 **(7.7%)**

** Biogas plant & renewable energy (electricity), at NDDB, Anand*

3. Centralized (milk union level) – *Banaskantha model*

Established at Banaskantha Milk Union (Gujarat State)

- Utilize 40 tonne dung/day
- **2000 cubic meter** biogas plant
- Biogas is purified and compressed to produce **CBG** for vehicles
- **Mitigation: 2,400 tonne CO_2e/year**
- Model is being replicated across Banaskantha (4 plants), Amul, Sabar & Dudhsagar dairies.

4. Centralized (milk union level) – *Varanasi model*

Established at Varanasi Milk Union (Uttar Pradesh State)

- About 100 tonne dung/day
- **4000 cubic meter** biogas plant
- Biogas is used to meet **thermal and electrical energy** need of dairy plant
- Organic fertilizer production from digested slurry
- **Mitigation: 3,000 tonne CO_2e/year**
- Model is being replicated at Barauni dairy (Bihar) and is under discussion with OMFED (Odisha).

Partnerships with stakeholders

1. **Suzuki R&D Centre India (SRDI)** – promote dung utilization and enhance rural mobility through biogas-based clean energy (NDDB & NDDB Mrida Ltd).

2. **Dairy Cooperatives** – NDDB signed **MoUs with 25 coops** to replicate manure management models in **15 states** (March 2025).

3. **Financial Incentivization Scheme by NDDB** – To accelerate adoption of sustainable practices

4. **NABARD & NDDB** – towards sustainable and climate-resilient dairy sector.

5. **Sustain Plus Energy Foundation (SPEF)** – Decentralized renewable energy solutions and scientific manure management practices. Monetization of **carbon credits** for 1,040 smallholder biogas beneficiaries (11,395 Verified Carbon Units by VERA)

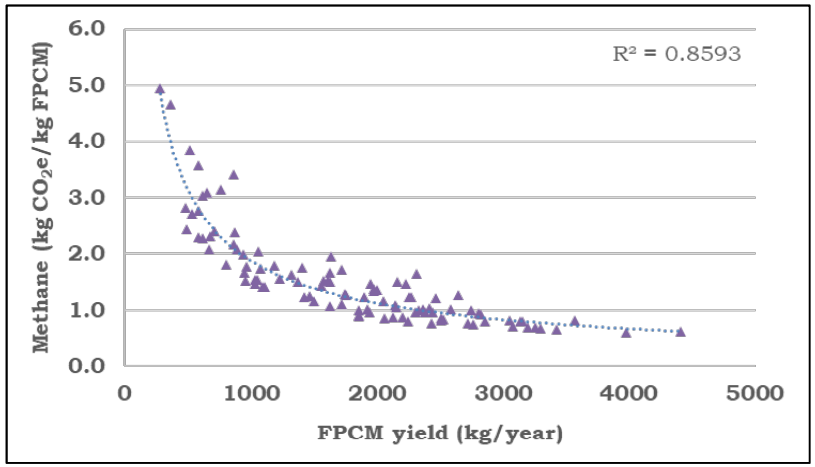
6. **NDDB Mrida Ltd.** – Climate financing mechanism under the *'Gobar Se Samriddhi'* programme.

*Enables wider **adoption of biogas**, promote **clean energy**, enhance rural **livelihoods**, and **reduce GHG emissions***

Improved Genetics – Productivity Enhancement & Methane Mitigation

❑ Productivity Enhancement:

- Performance recording programmes (PT & PS)
- **Genomic chips** (GAUCHIP and MAHISHCHIP)
- **GouSot™** – Indigenous semen sex-sorting technology
- IVF & Embryo Transfer



❑ Genetic Selection *(long term mitigation strategy)*

- Methane emission (low to moderate heritability, 0.10 – 0.45)
- Methane measurement using standardized portable devices (lactating animals under genetic improvement programmes)
- Estimate Genomic Breeding Value to facilitate **bull selection** capable of producing daughters with less methane emission
- About **8-10% mitigation potential** (10 years timeframe)

Key message

- Adoption of **scientific feeding** and **manure management** practices by smallholder farmers would help reduce GHG emissions up to **20 to 25%.**

- **Scope for additional mitigation** (improving ration quality, use of feed additives, selection of animals for low methane emission etc).

- Dairy farmers needs to be supported through appropriate **policy framework, incentive mechanism** for taking mitigation action, **climate finance,** awareness and extension programmes.