CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

МОНГОЛ УЛСЫН ЗАСГИЙН ГАЗАР

БАЙГАЛЬ ОРЧИН,
АЯЛАЛ ЖУУЛЧЛАЛЫН ЯАМ

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"Орон нутгийн мал аж ахуйн уур амьсгалын өөрчлөлтөд тэсвэртэй чадвар, эдийн засгийн тогтвортой байдлыг сайжруулах" төсөл

Дорнод аймаг, Баянтүмэн сум
2022 оны 12 дугаар сарын 8

Хэрэгжүүлэгч:

alinea

Хамтран хэрэгжүүлэгчид:

ABMI

УУР АМЬСГАЛЫН ӨӨРЧЛӨЛТ, ТОГТВОРТОЙ ХӨГЖЛИЙН СУДАЛГАА ХӨГЖЛИЙН ТӨВ

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Feasibility Assessment & Business Models

Approach

- Demand Driven, Quality Focus
  - Target Markets
- Value Chains
  - New production approaches
- Business models
  - Ownership (private, cooperatives)
  - Strategy

Selection Criteria

- Decision Tools - Readiness
- Gross Margin Analysis
- Capital Requirements
  - Financial (Investment, Operating)
  - Human (management, marketing, skilled labour)
- Risks

Assessing Feasibility:

Market/Technical	Financial	Business Strategy
MARKET **PRODUCTION SYSTEM** - **feed and water** - **livestock and breeding** - **animal health, traceability, food safety, HACCP** **INFRASTRUCTURE & EQUIPMENT** **HUMAN RESOURCES** - **Management, marketing** - **Production** - **Food safety/HACCP** **ENVIRONMENTAL** - **Safeguards, Monitoring**	Can the business make a profit? Is there enough investment capital? Is there enough operating credit? Can you manage the financial risks caused by changes in input and market prices?	Type of ownership? (private/coop) Marketing management Value system coordination - distributors, processors, herders and farmers communicate and coordinate Scale - sufficient volume to access markets and compete on price Value-added traits - location (“Dornod meat”), attractive “story” about the product and/or producers, organic certification Production system - “push”– produce then find a buyer - “pull” – find a buyer then produce Relationship with the customer - Need to have a good understanding of your customer base.

Feedlot Model

Feedlot – basic assumptions

Feeder Cattle - Feedlot Worksheet

Based on:

[Souce: Alberta Agriculture Breakeven Analysis for Feeder Cattle]

Mongolia Feedlot Handbook

	Breakeven Analysis per Head		
Date in/out and days on feed	01-Nov	125	06-Mar
Number of cattle fed/year		500	
Investment in feedlot excl crop equip (250 hd; adj'd to 2022)		560,169,717	
Interest Rate		18.6%	
Production Information:	**kg**	**price**	**MNT/hd**
Calf Value (xxx kg live wt x MNT xxx/kg)	220.0	3,000	660,000
Projected Sale Value (xxx kg live wt x MNT xxx/kg)	400.0	5,000	2,000,000
Total Gain, Value of Gain	180		1,340,000
Daily Gain (kg/day):	1.4		

Feed Rations and Days on Feed

Average Ration - based on Mon. Feedlot Guide

Day on feed	**grain**	**Silage/hay**	Days	**DM kg/day**	barley **DM Grain**	hay **DM Hay/Silage**	**Total DM**
D1-10	20%	80%	10	10	20	80	100
D11-14	30%	70%	4	10	12	28	40
D15-21	40%	60%	7	10	28	42	70
D22-30	50%	50%	9	10	45	45	90
D30+	60%	40%	95	10	570	380	950
				Total DM:	675	575	1250
				DM%	90%	90%	TOTAL
				Total:	750	639	1,389
				kg/day	6.0	5.1	11.1
				Total gain:	180	F:G ratio:	7.72

Gross Margin (= sales revenue – variable costs)

COST OF PRODUCTION	Ave/day/hd	Total units	Cost/unit	T MNT/Hd
VARIABLE COSTS				
Cost of Calf				**660,000**
Feed Costs (MNT/day) - based on total feed over feeding period				
Green fodder (xx kg/day x dof)/ MNT/kg)	5.1	638.9	500	319,444
Grain (xx kg/day * dof)/ MNT/kg)	6.0	750.0	500	375,000
Total Feed Cost (MNT/head)				**694,444**
Other Variable Costs ($/head)				
Death loss (loss% x (Calf value + 50% x total feed cost/hd))		1.5%	1,007,222	15,108
Paid Labour (1 full time/# animals fed per year)			9,600,000	19,200
Veterinary, medicine		1.0	30,000	30,000
Utilities and fuel (l/d * 365 * MNT/l)/# animals on feed))	10	3,650.0	3500	25,550
Repairs ((repair % * investment)*(DoF/365))/# on feed)		3%		11,510
Interest on feeder (%/yr x calf value x (days on feed/365))		18.6%	226,027	42,041
Interest on feed (%/yr x (feed costs x 0.5) x (days on feed÷365 days))		18.6%	118,912	22,118
Total Other Variable Costs				**165,527**
Marketing Costs				
Trucking from farm to auction		1.0	20,000	20,000
Total Marketing Costs				**20,000**
TOTAL VARIABLE COSTS INCLUDING CATTLE AND FEED				**1,539,972**
GROSS MARGIN				**460,028**

Profit after fixed costs and financing

GROSS MARGIN					**460,028**
FIXED COSTS					
Depreciation ((1/lifespan years) * investment cost)/fed in one year		20	5%		56,017
Financing costs					
Principle (75% of 2022 investment)	420,127,287		interest	18.6%	156,287
TOTAL FIXED COSTS					**212,304**
TOTAL COST OF PRODUCTION (Total variable + total fixed)					**1,752,276**
Total Revenue					**2,000,000**
PROFIT/LOSS before tax					**247,724**
Tax		**10%**			24,772
PROFIT/LOSS after tax					**222,951**
Debt repayment	**420,127,287**		repayment-yrs	5	168,051
Remainder after debt repayment					54,901

Feedlot Profits – A Risky Business

Full Farm Analysis	**Case A**		**Case B**	
	/hd sold	**Full Capacity**	**/hd sold**	**Full Capacity**
Number of calves in:	1	500	1	500
Death loss	1.5%	1.5%	1.5%	1.5%
Calves sold	1	493	1	493
Total cost of calves	660,000	330,000,000	660,000	330,000,000
Total sales revenue	2,000,000	985,000,000	1,600,000	788,000,000
Cost of Gain				
Total Feed Costs	694,444	342,013,889	694,444	342,013,889
Total Other Costs	165,527	81,522,218	165,527	81,522,218
Total Selling Costs	20,000	9,850,000	20,000	9,850,000
Total Cost of Gain:	879,972	433,386,107	879,972	433,386,107
Total Variable Cost (calf cost + cost of gain)	1,539,972	758,436,107	1,539,972	758,436,107
Gross Margin = Sale Value – Total Variable Cost	**460,028**	**226,563,893**	**60,028**	**29,563,893**
Fixed Costs	212,304	**104,559,879**	212,304	**104,559,879**
PROFIT/LOSS before tax	**247,724**	**122,004,014**	- **152,276**	- **74,995,986**
Tax	24,772	12,200,401	-	-
PROFIT/LOSS after tax but before debt and living	**222,951**	**109,803,613**	- **152,276**	- **74,995,986**
(USD)	85	41,910	- 58	- 28,624
After debt repayment (over 5 years)	**54,901**	**27,038,537**	- **320,327**	- **157,761,061**
(USD)	21	10,320	- 122	- 60,214
Assumptions	**Feeder calf**	220 kg * 3000 MNT	220 kg * 3000 MNT	
	Finished calf	400 kg * 5000 MNT	400 kg * 4000 MNT	
	Grain price	500 MNT/kg	500 MNT/kg	
	Fodder price	500 MNT/kg	500 MNT/kg	

Slaughterhouse Model

Slaughterhouse Assumptions

Operating Period	Days/week	5		Weeks/year	50	(1 wk Tsagaan Sar; 1 wk maintenance)				
		Head/ Day		/Week	/Year	Carcass weight KG	kg/year			
Meat Plant	Capacity	50	Sheep	250	12500			100%	80% capacity	
	Sheep	40		200	10000	20	200,000	40	32	sheep
	Cattle	2		10	500	200	100,000	2	1.6	cattle

Revenues

PROFITABILITY	MNT/UNIT	DESCRIPTION	UNITS	TOTAL
REVENUE				
Mutton	9000	MNT/kg * kg per year	200,000	1,800,000,000
Beef	12000	MNT/kg * kg per year	100,000	1,200,000,000
By Products		MNT/kg * kg per year		-
Total Revenue				**3,000,000,000**

Cost of Livestock and Labour Costs

EXPENSES	MNT/UNIT	DESCRIPTION	UNITS	TOTAL
Live animal Costs				
Sheep	150,000	MNT/hd * head per year	10000	1,500,000,000
Cattle	2,000,000	MNT/hd * head per year	500	1,000,000,000
Total				**2,500,000,000**
Labour	5	five plant workers	*800,000*	*4,000,000*
	1	vet	*800,000*	*800,000*
	1	driver	*800,000*	*800,000*
	1	accountant/booker/off mgt	*1,000,000*	*1,000,000*
	1	manager/marketing	*2,000,000*	*2,000,000*
			Cost/mo	*8,600,000*
			Annual	**103,200,000**
Total Livestock and Labour:				**2,603,200,000**
Ratio to Total Revenue:		*(target = 60%)*		
Margin after Livestock and Labour				**396,800,000**

Other Operating Costs & Gross Margin

Operating costs	MNT/UNIT	DESCRIPTION	UNITS	TOTAL
power	12	months per year	750,000	9,000,000
water	12	months per year		-
materials	5000	MNT/hd processed	10,500	52,500,000
waste disposal	1000	MNT/kg waste	10,000	10,000,000
other ….				-
Subtotal				**71,500,000**
Ratio to Total Revenue:		(target = 20%)		
marketing	12	promo/advertising monthly	1,500,000	18,000,000
sales - delivery	100	km/day * milage * 200 d/yr	1,500	30,000,000
training/food safety	12	training/compliance	500,000	6,000,000
other ….			500,000	-
Subtotal				**54,000,000**
TOTAL VARIABLE COSTS				**2,728,700,000**
GROSS MARGIN				**271,300,000**
Ratio to Total Revenue:				

Fixed Costs and Net Profit

FIXED COSTS	MNT/UNIT	DESCRIPTION	UNITS	TOTAL
Adminstration/office	5%	estimated at 5% of revenue		150,000,000
Regulatory costs				-
interest on debt	3%	on 75% of capital investment	393,000,000	11,790,000
depreciation	5%	of investment - 20 yr lifespand	524,000,000	26,200,000
other ….				-
TOTAL FIXED COSTS				**187,990,000**
TOTAL COSTS				**2,916,690,000**
PROFIT/LOSS BEFORE TAX				**83,310,000**
Tax	10%			8,331,000
PROFIT AFTER TAX				**74,979,000**
after tax return on investment				14%
debt repayment	10	term loan over xx years	393,000,000	39,300,000
remainder after debt payment				35,679,000

Meat Plant

Case	Capacity Utilization	Interest Rate	Profit After Tax (M MNT)	After Debt Repayment (M MNT)
A	100%	18.6%	19.8	-19.5
B	100%	3%	75.0	35.7
C	75%	3%	21.4	-17.9

ISSUES

Financing: interest rate and repayment terms

Capacity utilization and seasonality of livestock slaughter

Lack of **by-product markets**

No **price differentiation** by Grade or Cut

Scale of operation to cover fixed costs

Business Model Options

	Strategy	Ownership & Collaboration
End Market	**Medium Term:** Develop higher value markets as volume and relationships grow. **Short Term:** Local markets. Sell direct to food processors.	Ownership: Private
Meat Plant	**Short to Medium:** Small facility to minimize costs. Target high value markets to make-up for lack of economy of scale.	Ownership: Private Contract with and/or own feedlot for direct connection with herders. Contract with herders for "Grassfed Beef / Sheep"
Feedlots	**Short to Medium:** Most feedlots run by crop farms with land, equipment. Crop rotations and manure improve soil fertility. Risk is diversified.	Ownership: Private. Collaborate with or own meat plant to secure sales and value added. Contract with herder coop to secure supply of calves.
Feeding on Pasture	**Medium Term:** Some herders with hay land and equipment begin to background. Some crop farms begin buy calves crop residues and feed grains.	Private ownership of animals. Individuals sell directly to feedlots. If coop members are backgrounding, coop could handle sales.
Primary	**Short Term:** Restructure herds and begin selling young stock to existing feedlots and/or direct to slaughterhouses.	Private ownership of herds Coop to manage contracts, coordination and collect uniform animals. Link to PUGs. se a % of sales to for pasture and breed improvement.

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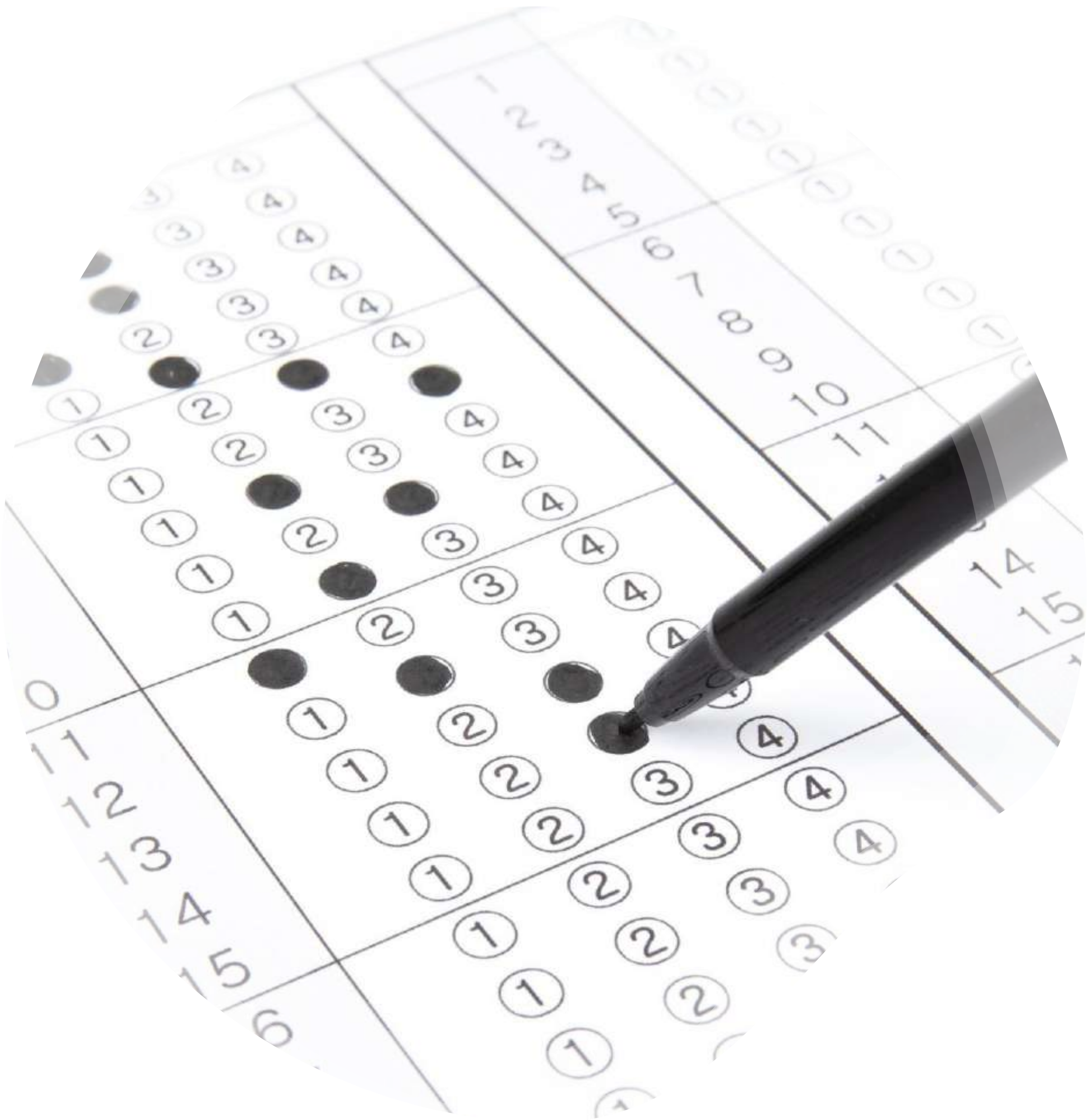
Enhancing Climate-Resilience and Economic Sustainability of Livestock Farming in a Rural Community in Mongolia

Slaughterhouse Feasibility Checklist



Purpose of the checklist

- An assessment-tool allows a standardized analysis
- Provides transparency when considering the decision to select on project from a range of options.
- The generic tool can be used in any location.

Structure of the Checklist

- Based on a checklist of success factors
- Looks at two scenarios
  - Current situation
  - Potential improvements
- 10 categories with sub-categories and criteria

Layered approach:

- Category
  - Sub-category
    - Criteria
    - Criteria
  - Sub-category
    - Criteria
    - Criteria
- Category
  - Sub-category
    - Criteria

Criteria are reviewed using:

- project description
- supporting documents
- interview, if necessary.

The criteria are divided in two parts:

- current level of fulfilment
- potential to improve.

Gradation of assessment of criteria

Requirements fulfilled now

- ⑤ completely
- ④ mostly
- ③ partially
- ② low
- ① very low
- ⓪ none

Potential to improve

- ❺ easily possible
- ❹ possible
- ❸ uncertain
- ❷ hardly possible
- ❶ at present,not possible
- ⓿ not possible

		Requirements Fulfilled	Increasing Measures Possible	Remarks
1	**Management**			
	General • Is there somebody who is responsible for the whole project? • Does this person have experience in leading and maintaining a meat-company? • Does this person invest their own money? • Is this person reliable?	⑤ ④ ③ ② ① ⓪	⑤ ④ ③ ② ① ⓪	
	Business plan • Is the business plan complete and believable? • Is it likely that the project described in business plan or another document will work?	⑤ ④ ③ ② ① ⓪	⑤ ④ ③ ② ① ⓪	
	Financial resources • Have investment costs been calculated? • Are the financial resources sufficient? • Is there a calculation about the ongoing costs?	⑤ ④ ③ ② ①	⑤ ④ ③ ② ①	

Category and Sub-Categories		Category and Sub-Categories	
1	**Management** • General • Business plan • Financial resources	6	**Animals** • Number of animals for slaughtering • Livestock transport • Animal treatment and animal health
2	**Site** • Locations • Infrastructure • Environmental Management	7	**Slaughtering facilities** • Building • Equipment and handling • Cooling facilities / equipment • Staff • Hygiene
3	**Staff, employees** • Number of employees • Training	8	**Cutting, Deboning and Packing** • Building • Staff • Hygiene
4	**Food health, legislation** • Legislation requirements • Veterinary service Veterinary checks • Traceback and labelling	9	**Processing** • Building • Staff • Hygiene
5	**Energy, water, environmental** • Supply • Safeguards	10	**Selling facilities and selling possibilities** • Building • Staff • Hygiene

Example of Category Scoring using Project Site

	Category	Current score	Potential to Improve	
	Locations …	4	4	
	Infrastructure …	4	3	
	Environmental Management …	5	2	
	Total Points	13	9	
	Score = Points / rated categories	4.3	3	

		Site 1 – Soum Center			Site 2 – Remote Location		
		Req Fulfilled	Improv. Possible	Remarks	Req Fulfilled	Improv. Possible	Remarks
1	Management						
	Score = Points / rated categories	0	4		2	4	
2	Site						
	Location	5	5	Size adequate. Already approved in soum plan. Needs water.	3	5	Land size adequate but not yet approved. Grid uncertain. Water unknown. Poor road.
	Infrastructure	4	5		3	4	
	Environmental Management	3	5		3	5	
	Points	12	15		9	14	
	Score = Points / rated categories	4	5		3	4.7	
3	Staff, employees						
	Number of employees	0	5	Staff available in town. Training required.	0	4	Staff would have to drive. Training required.
	Training	0	5		0	5	
	Score = Points / rated categories	0	5		0	4.5	
4	Food health, legislation						
	Score = Points / rated categories	0	4.3		0	4.3	
5	Energy, water, environmental						
	Supply	3	5	Power in place. Water well required. Safeguards can be met.	2	4	Power unreliable. Water well required. Safeguards can be met.
	Safeguards	0	5		0	5	
	Points	3	10		3	9	
	Score = Points / rated categories	1.5	5		1.5	4.5	
6	Animals						
	Score = Points / rated categories	2.7	4		2.7	4	
7	Slaughtering facilities						
	Score = Points / rated categories	0	4		0	4	
8	Cutting, Deboning and Packing						
	Score = Points / rated categories	0	4		0	4	
9	Processing						
	Score = Points / rated categories	0	4		0	4	
10	Selling facilities and selling possibilities						
	Points	0	12		0	12	
	Score = Points / rated categories	0	4		0	4	
	TOTAL SCORE OUT OF 50	8.2	43.3		9.2	42.0	
	Percentage score	16.4	86.6		18.4	84.0	

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Decision Support Tools for Value Chain Assessment:

Category	Sub-category
Market	Export, urban (Ulaanbaatar), regional and local
Natural resources	feed (pasture, natural hay, grain, green fodder) and water
Livestock health	Animal health, traceability, DFZ, SPS, food safety and HACCP
Livestock genetics	Improved genetics and breeding management
Infrastructure/equip	Land, power, water, facilities, equip, vehicles, roads
Management and HR	Management, marketing, production, food safety, HACCP
Environment	Safeguards and monitoring of slaughterhouse and feedlot wastes
Economics	Potential returns

Scoring Grid for Value Chain Feasibility Analysis

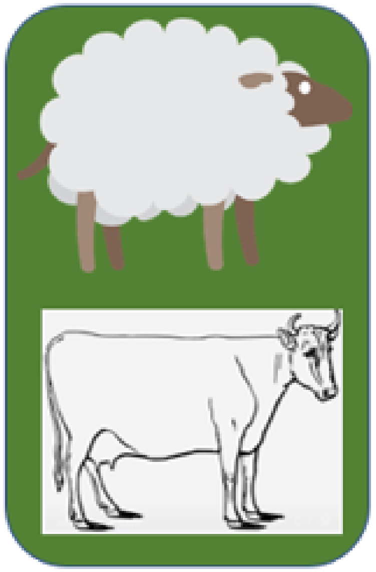
Current Condition		Future Possibility	
Complete	5	Easily	5
Most	4	Possible	4
Partial	3	Uncertain	3
Low	2	Hardly possible	2
Very Low	1	Not possible now	1
None	0	Not possible	0

Criteria	Current System		Young Stock Sales		Backgrounding		Feedlot		Slaughterhouse	By-Product	Further
	Sheep	Cattle	Sheep	Cattle	Sheep	Cattle	Sheep	Cattle	Mixed	Sales	Processing
MARKET											
Export	1	1									
UB / other provinces	4	4									
Local	5	5									
FEED AND WATER											
Water and water wells	4	4									
Pasture	4	4									
Hay	3	3									
Green fodder – planted	2	2									
Concentrate feed	2	2									
LIVESTOCK HEALTH											
Animal Health	3	3									
Traceability	2	2									
Disease-free zone	0	0									
Sanitary-Phyto Sanitary -export	1	1									
Food Safety Systems/HACCP	1	1									
BREEDING											
Methods	3	3									
Improved genetics	2	2									
INFRASTRUCTURE & EQUIPMENT											
Land	3	3									
Power	2	2									
Water											
Buildings (production, storage)	4	4									
Production & handling equipment	4	4									
Vehicles	4	4									
Roads (onsite, to market)	3	3									
MANAGEMENT & HUMAN RESOURCES											
Management Skills	3	3									
Marketing Skills	2	2									
Production Skills (feedlot/plant)	3	3									
ENVIRONMENTAL											
Safeguards	2	2									
Monitoring	2	2									
ECONOMICS											
Potential Returns	2	2									

Criteria	Baseline		Young Stock Sales		Feedlot		Slaughterhouse	By-Product Sales	Further Processing
	Sheep	Cattle	Sheep	Cattle	Sheep	Cattle	Mixed		
MARKET									
Export									
UB / other provinces									
Local									
FEED AND WATER									
Water and water wells								--	--
Pasture					--	--		--	--
Hay								--	--
Green fodder – planted								--	--
Concentrate feed								--	--
LIVESTOCK HEALTH									
Animal Health									
Traceability									
Disease-free zone									
Sanitary-Phyto Sanitary -export									
Food Safety Systems/HACCP									
BREEDING									
Methods					--	--	--	--	--
Improved genetics							--	--	--
INFRASTRUCTURE & EQUIPMENT									
Land									
Power									
Water									
Buildings (production, storage)									
Production & handling equipment									
Vehicles									
Roads (onsite, to market)									
MANAGEMENT & HUMAN RESOURCES									
Management Skills									
Marketing Skills									
Production Skills (feedlot/plant)									
ENVIRONMENTAL									
Safeguards									
Monitoring									
ECONOMICS									
Potential Returns									

New Herd Structure

Resources	Critical Skills/Inputs	Key Risks	ESG
Land is adequate but pastures are degrading. Little new capital investment needed.	New herd management skills: - Culling - Breeding management - Improved breeding stock New marketing skills and/or coop.	Market for selling younger animals. Need access to feedlot: - Own - MCS - Bayandelger - Lavia - *Dornod Meat*	• Strong positive on pasture • Better climate resilience • Improved herder incomes • Greater inclusion in markets



Criteria	Now	Future
Market		
Feed and water		
Livestock health		
Breeding		
Infrastructure/Equip		
Human resources		
Environmental		

Complete 5	Most 4	Partial 3	Low 2	Very Low 1	Non 0

NOTE:
If animal # and pasture management don't change, the future for feed and water is ORANGE, not GREEN.

Beef Feedlot

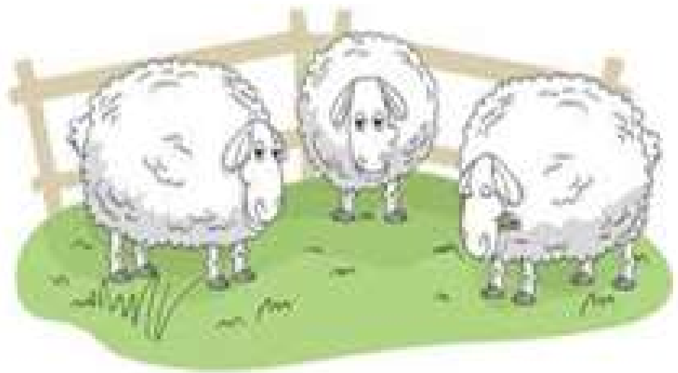
Resources	Critical Skills/Inputs	Key Risks	ESG
250 hd = 2 ha Capital Invest (2022) Feedlot only: • 560 m MNT Crop 40 ha irrigated and 100 dryland: • 1,064 m MNT Total: • 1,624 m MNT	• Animal nutrition and feeding • Animal health • Marketing • Record-keeping • Risk management • Livestock handling and feeding •	High risk business • Price risk – cattle and feed • Operational risk • Livestock disease risk • Profits vary greatly from year to year as cattle and grain prices change	Positive: • Less pressure on pastures • organic fertilizer Negative: • risk of water contamination by manure • High water use: 30-75 l/hd/d or 7500 – 18750/d @ capacity

Criteria	Now	Future
Market		
Feed and water		
Livestock health		
Breeding		
Infrastructure/Equip		
Human resources		
Environmental		

Complete 5	Most 4	Partial 3	Low 2	Very Low 1	Non 0

Sheep Feeding

Resources	Critical Skills/Inputs	Key Risks	ESG
Feed on Pasture Land for fodder. Equipment, feed storage, fencing. **Feedlot:** Capacity 1600-2000 Water: 4.7 l/hd/day =7,571 – 9,464 l/day	New herd management skills: - Feeds and feeding - Marketing New marketing skills and/or coop.	Studies in Mongolia and abroad show sheep feedlots to have marginal returns. Supplementary feeding on pasture can get sheep to market weight faster with less risk. *More info is needed*	• Improved herder incomes



Criteria	Now	Future
Market		
Feed and water		
Livestock health		
Breeding		
Infrastructure/Equip		
Human resources		
Environmental		

Complete 5	Most 4	Partial 3	Low 2	Very Low 1	Non 0

Greenhouse Gas (GHG) Emissions Reductions and Carbon Sequestration Potential of Climate-Resilient Livestock Farming Practices

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Dec 8, 2022; UB, Mongolia

alinea ABMI M@NN CTCN CLIMATE TECHNOLOGY CENTRE & NETWORK БАЙГАЛЬ ОРЧИН, АЯЛАЛ ЖУУЛЧЛАЛЫН ЯАМ UN environment UNIDO

Alberta Biodiversity Monitoring Institute (ABMI)

Full service "research to action" organization: track changes in Alberta's biodiversity, habitats and ecosystems to support natural resource and land-use decision making.

Birds
Mammals
Vascular Plants
Mosses
Lichens
Mites
Aquatic Vascular Plants
Aquatic Invertebrates

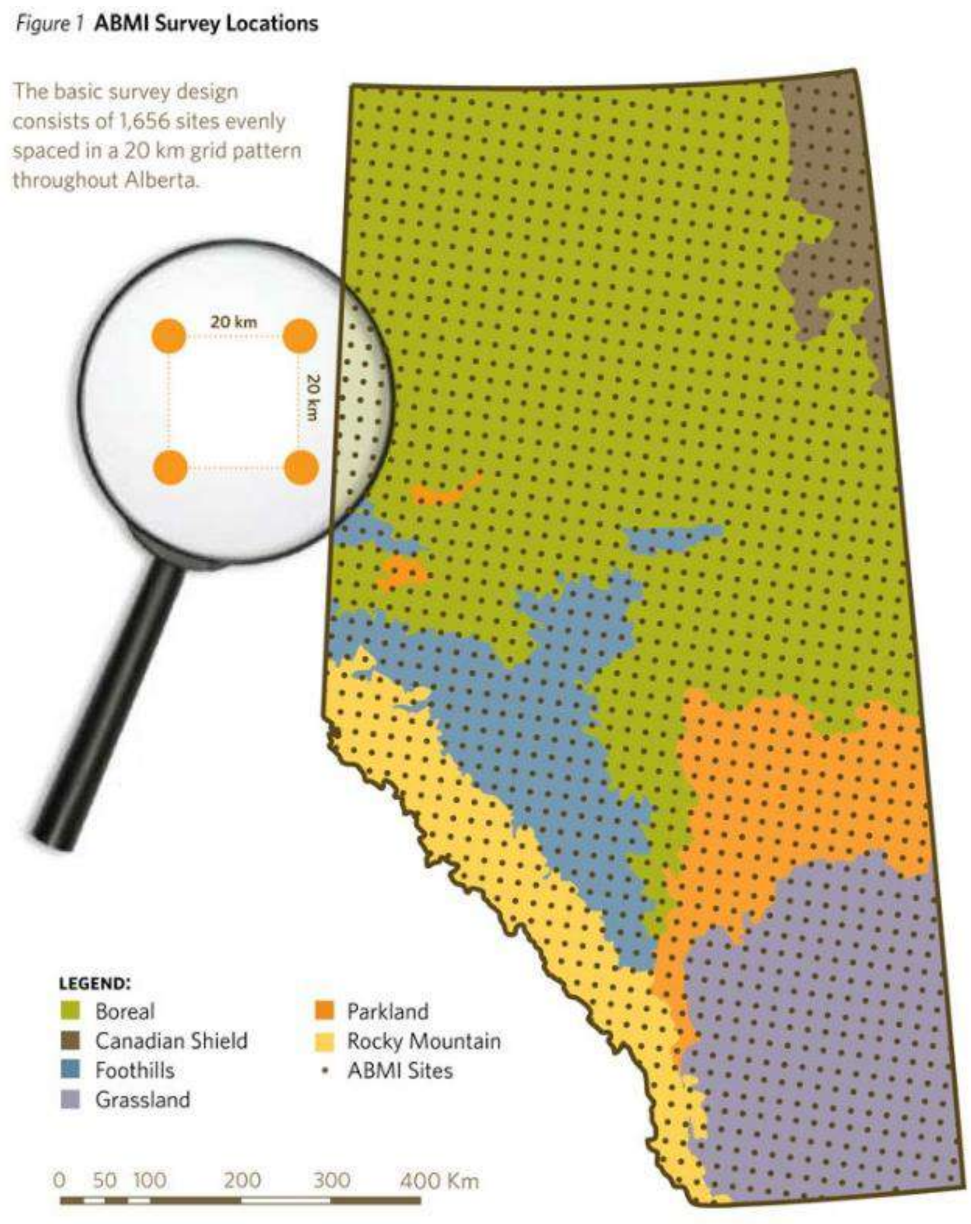
Data collection

Sample processing

Data verification & storage

Data Analyses

Reporting and Communications



Presentation Outline

- Introduction
- Direct and Indirect GHG Emissions Sources
- Potential for GHG Emissions Reductions
- Potential for GHG mitigation through Carbon Sequestration
- Implications for Policy and Programs
- Open Discussion

Livestock Production Contributes to Climate Change?

Some key literature influencing wider debate on livestock and climate change

REPORT TITLE	ORGANISATION	AUTHOR	DATE
Farming for Failure: How European Animal Farming Fuels the Climate Emergency	Greenpeace	Greenpeace	2020
Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems	IPCC	Shukla et al.	2019
Food in the Anthropocene: the EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems	EAT–Lancet Commission	Willet et al.	2019
Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050	World Resources Institute (WRI)	Searchinger et al.	2019
Less is More: Reducing Meat and Dairy for a Healthier Life and Planet	Greenpeace	Greenpeace	2018
Grazed and Confused: Ruminating on Cattle, Grazing Systems, Methane, Nitrous Oxide, the Soil Carbon Sequestration Question – And What It All Means for Greenhouse Gas Emissions	Food Climate Research Network	Garnett et al.	2017
Changing Climate, Changing Diet: Pathways to Lower Meat Consumption	Chatham House	Wellesley et al.	2015
Tackling Climate Change through Livestock	United Nations FAO	Gerber et al.	2013
Livestock's Long Shadow	United Nations FAO	Steinfeld et al.	2006

Houzer, E. and Scoones, I. (2021) Are Livestock Always Bad for the Planet? Rethinking the Protein Transition and Climate Change Debate. Brighton: PASTRES.

Livestock Production Contributes to Climate Change?

Ten claims about livestock and climate change

Emission from agriculture are projected to increase to 52% of global emissions in the next decades, with approximately 70% of the increase coming from animal production(Greenpeace 2020).

Livestock production is responsible for approximately 33% of global methane emissions and 66% agricultural emissions (IPCC/Shukla et al. 2019).

Livestock produce approximately 18% of global calories consumed, but use 83% of all farmland (Poore and Nemecek 2018)

An estimated 33% of global cropland is used to grow animal feed (Poore and Nemecek 2018).

Animal-sourced foods have the highest impact, between 20 and 100 times more than plant- based alternatives (Clark and Tilman 2017).

Animal and feed production contributes significantly to deforestation and land use change, accounting for nearly one-third of global deforestation and associated emissions (Wellesley et al. 2015)

Pastoral livestock systems are associated with higher GHG emissions due to low production efficiency and higher methane emissions from low-quality diets (Steinfeld et al. 2006; Garnett et al. 2017)

Red meat consumption needs to reduce by 50% by 2050 for the food system to remain in a 'safe operating space' (Willet et al. 2019).

A 75% reduction in animal farming would save an equivalent of 376 million tonnes of CO_2 emissions (Greenpeace 2020).

A 50% global reduction in the production and consumption of animal-sourced foods is needed by 2050 (Greenpeace 2018).

Houzer, E. and Scoones, I. (2021) Are Livestock Always Bad for the Planet? Rethinking the Protein Transition and Climate Change Debate. Brighton: PASTRES.

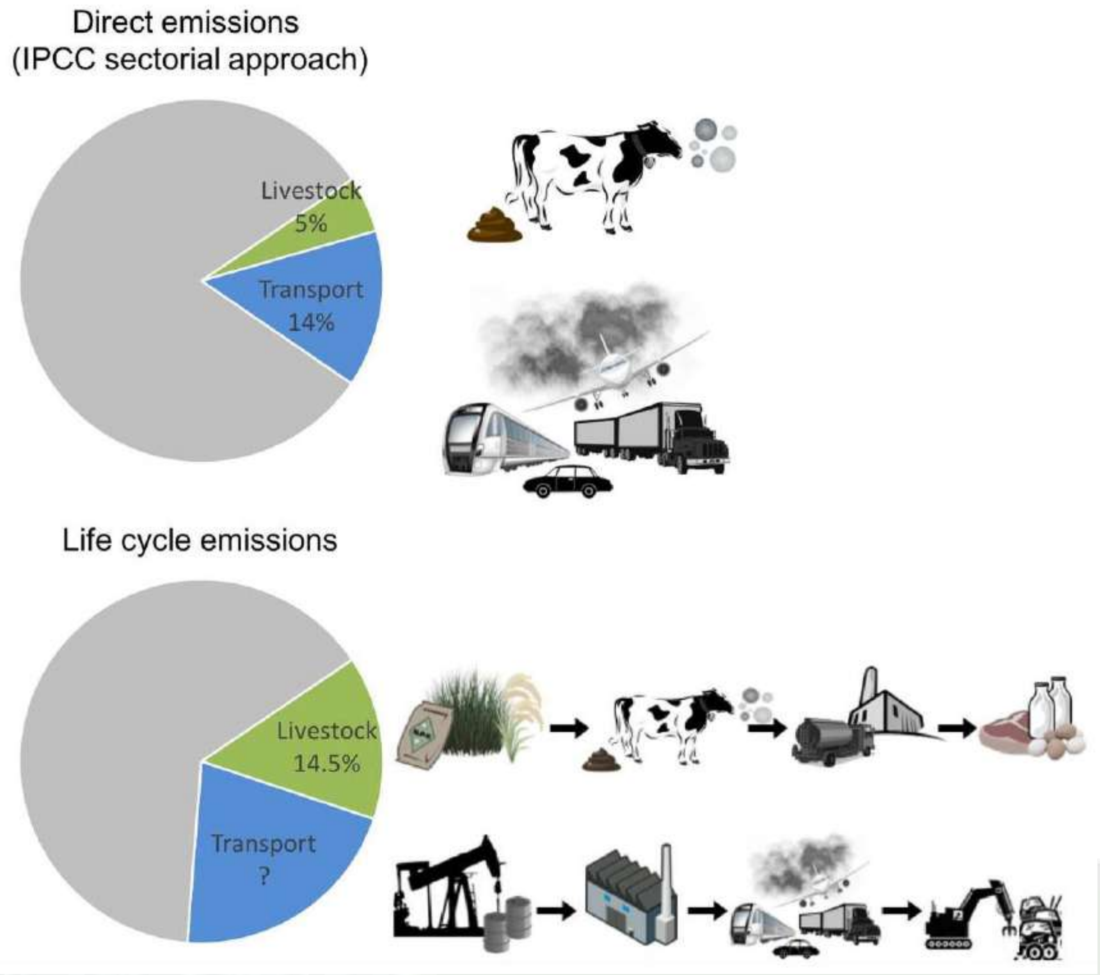
Environmental Concerns over GHG Emissions from Livestock Sector

Cars or livestock: which contribute more to climate change?

GHG emissions from livestock and transport are often compared, but in a flawed way.

The world needs both consumers that are aware of their food choices and producers and companies that engage in low carbon development.

Livestock can indeed make a large contribution to climate change mitigation, food security and sustainable development in general.

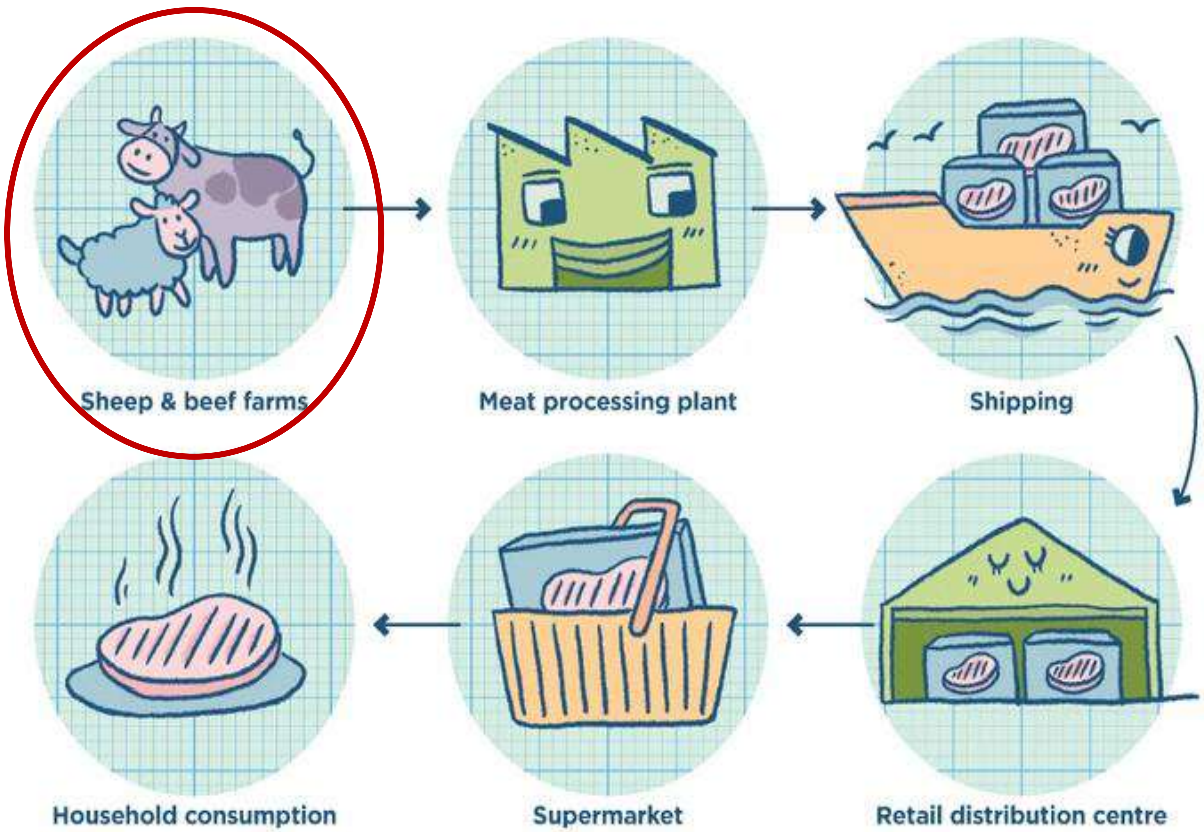


Source: International Livestock Research Institute (ILRI)

GHG Emissions across the Entire Livestock Production Chain

- Edible (meat and milk) *vs.* non-edible products (natural fiber, hides and skin and manure).

- Cradle to retail:
  - ✓ Cradle to farmgate: All processes up to the farmgate where the animals or products leave the farm.
  - ✓ Farmgate to retail: processing and transport of animals and product to market and the retail distributor.



(Illustration: Marc Conaco)

GHG Emissions from Livestock Farming Practices

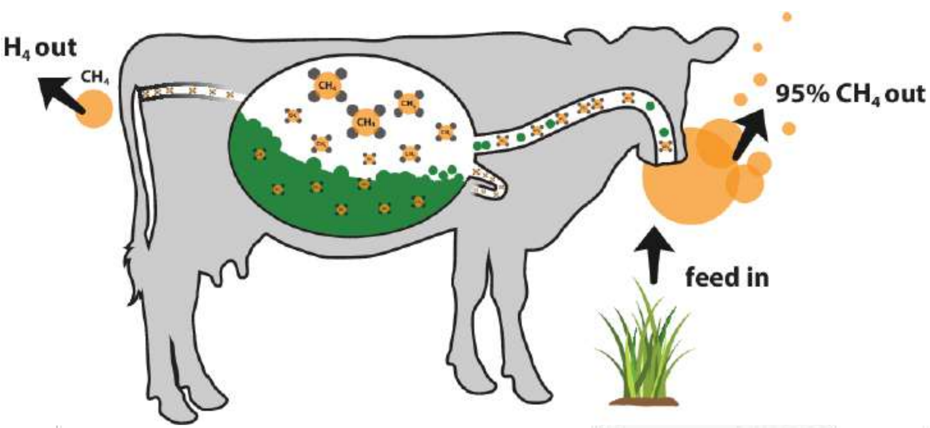
CO_2 and CO_2e are two different things!

CO_2e allows “bundles” of greenhouse gases to be expressed as a single number.

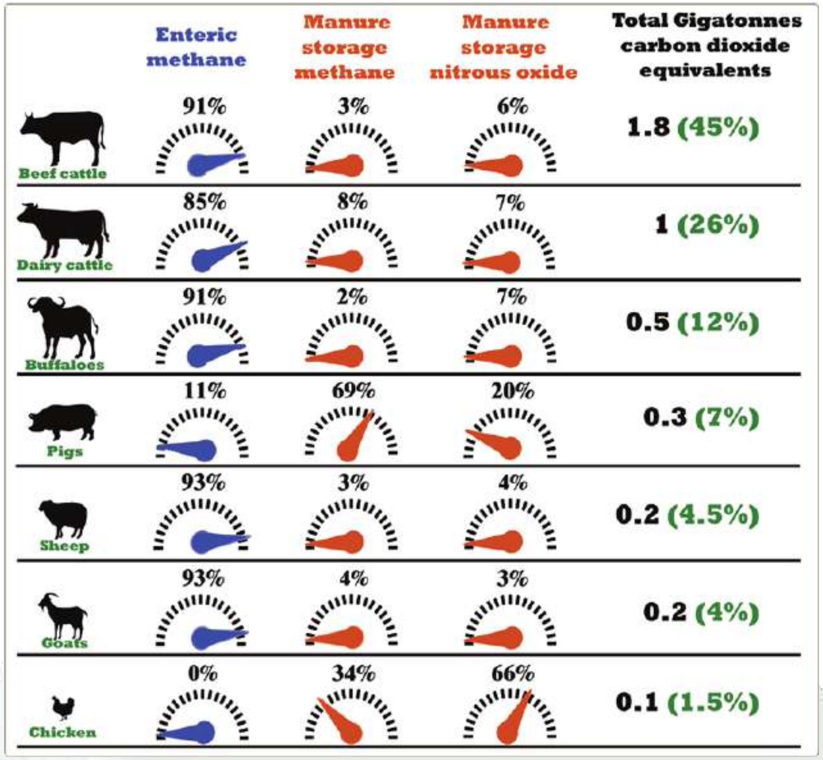
Greenhouse Gas	GWP over 100 years
Carbon dioxide	1
Methane	25
Nitrous oxide	298

GWP: Global warming potential

Complex microbial interactions in the livestock’s rumen that are critical to the animal’s basic function.



Aguirre-Villegas et al., 2017. Sustainabledairy.org



Methane is a potent greenhouse gas with a warming effect much greater than carbon dioxide.

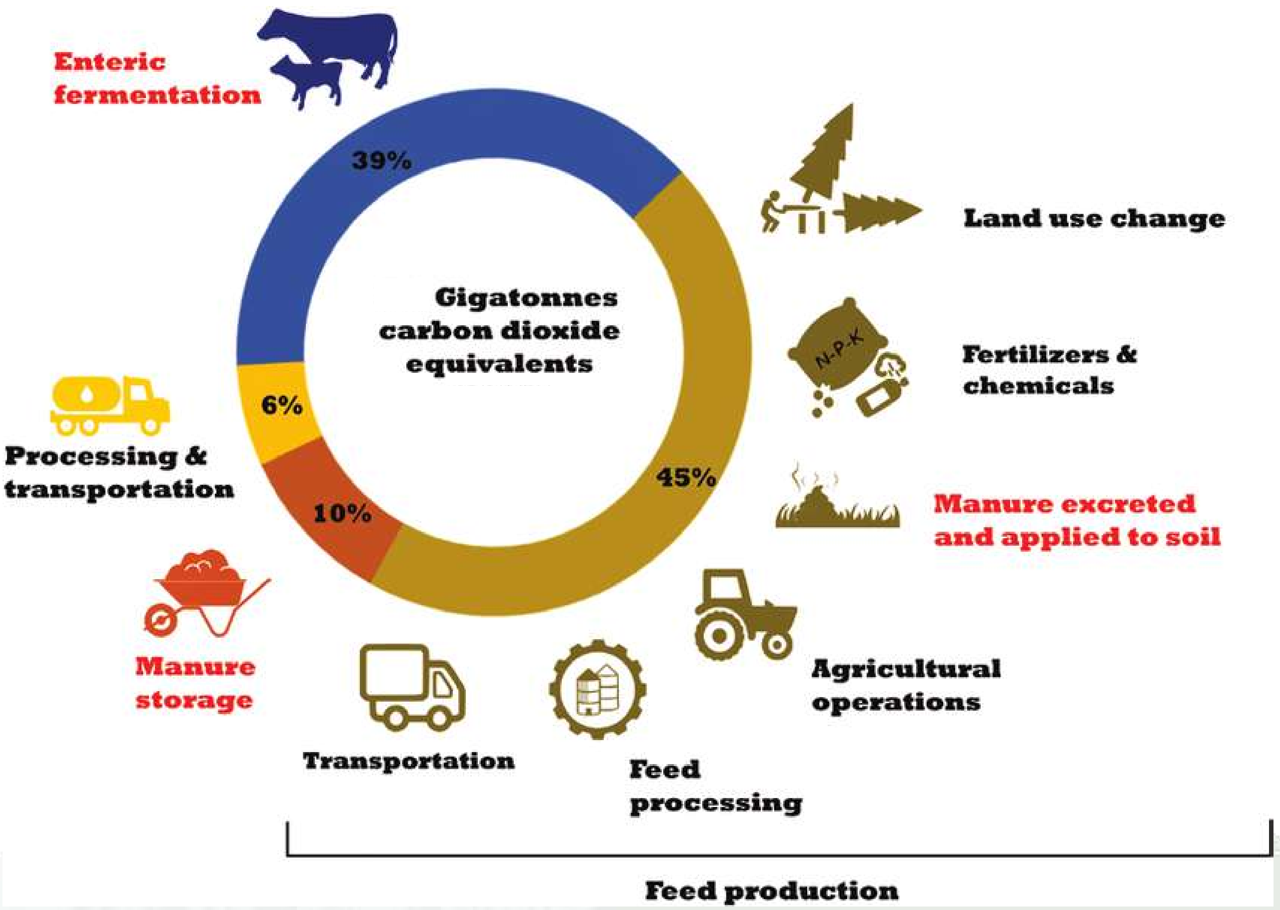
GHG Emissions from Livestock Farming Practices

Direct sources

- Enteric fermentation during digestive process (mainly methane CH4).
- Dung and urine decomposition (both nitrous oxide N2O & methane).

Indirect sources

- Haymaking or production of supplementary livestock feed and fodder (mainly carbon dioxide CO_2 & nitrous oxide).
- Use of fossil-fuel-based agricultural inputs like fertilizers and pesticides (mainly carbon dioxide CO_2 & nitrous oxide).



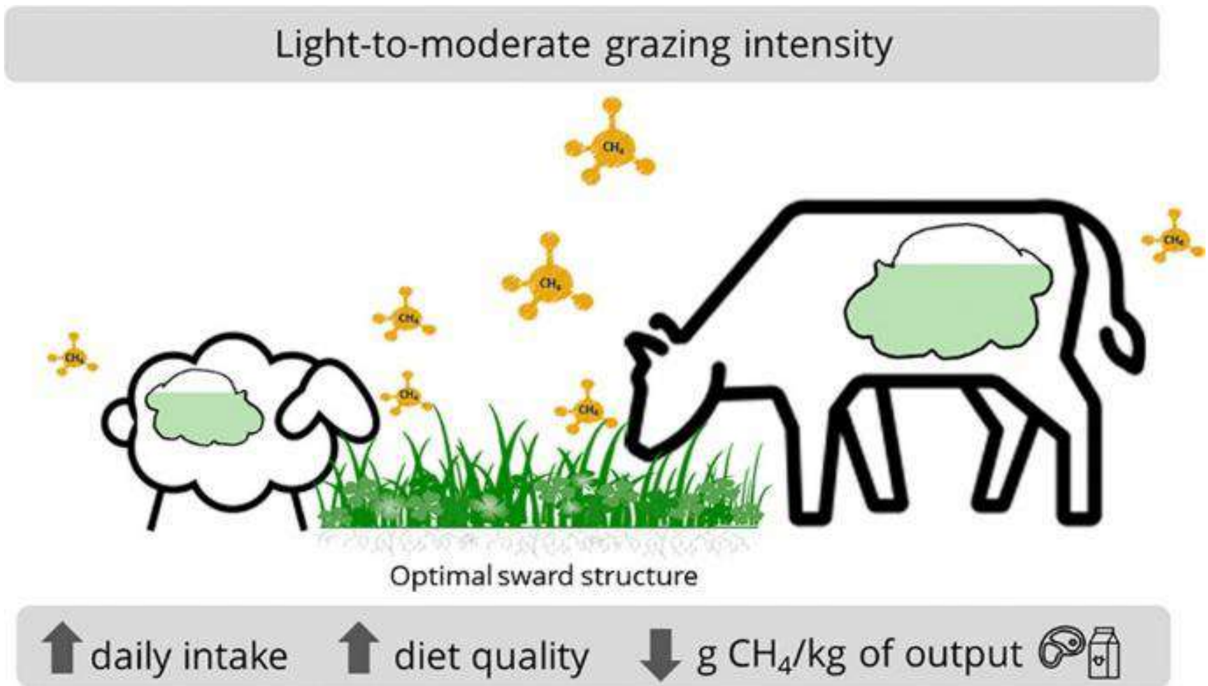
Grossi et al., 2019, Animal Frontiers 9(1).

GHG Emissions from Livestock Farming Practices

Grazing pressure is a driver of land degradation across Mongolia.

GHG emissions from pasture vegetation and soil degradation (mainly carbon dioxide CO_2 & nitrous oxide).

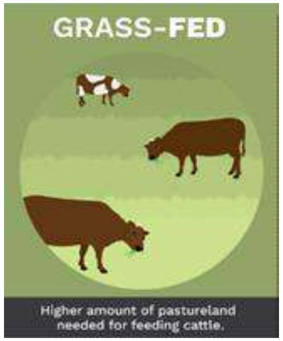
- High grazing intensity shifts pasture vegetation composition towards less desirable plant communities.
- Lowers pasture forage availability and quality, reduces livestock productivity and performance, and intensifies GHG emissions annually and per unit of live weight gain by livestock.

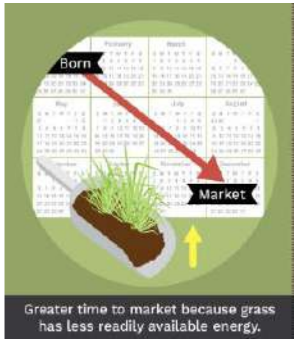


Sánchez Zubieta et al., 2021, STOTEN 754 (142029)

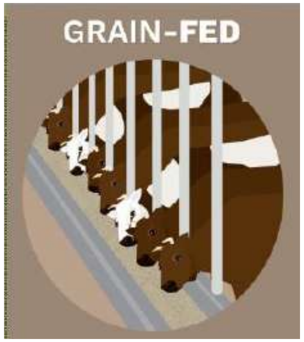
Overgrazing accelerates carbon loss from soil by increasing erosion and deterioration of soil structure.

GHG Emission from Livestock Farming Systems



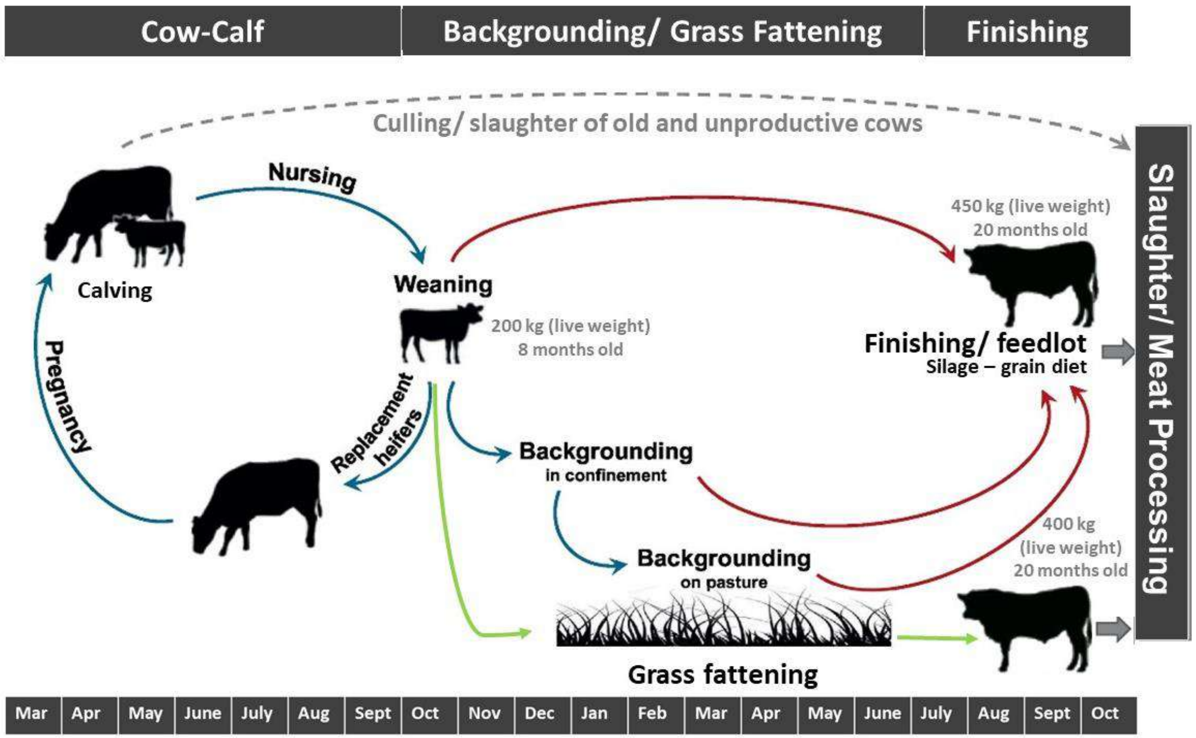


Livestock in Mongolia raised on pastures year-round and is mainly grass-fed and finished.



Pasture-raised livestock

- Grass forage and hay ingestion emit more methane.
- Methane emissions happen over a longer time.

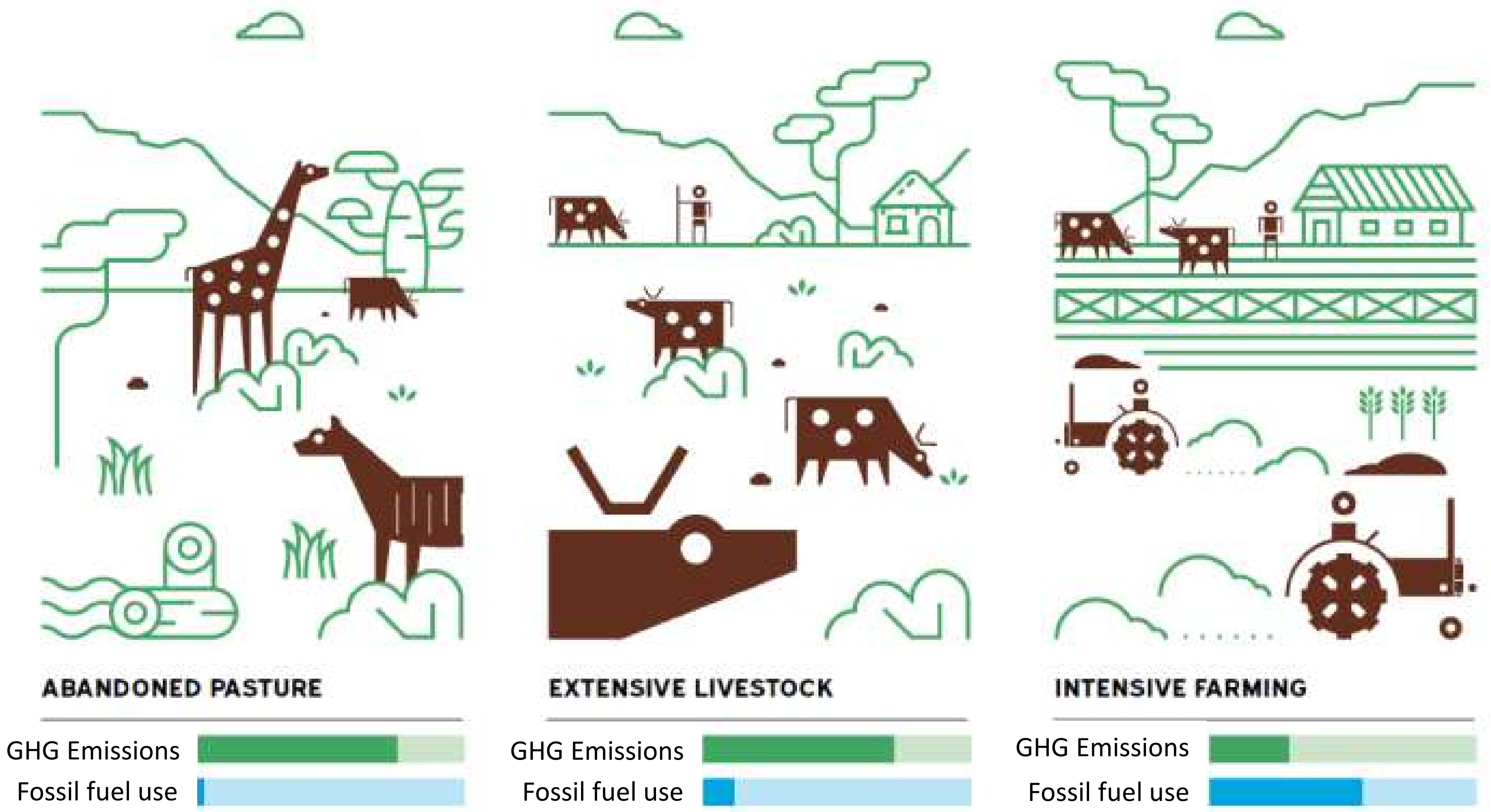


Feedlot-raised livestock

- High-quality feed ingestion emit much less methane.
- Methane emissions happen over a shorter time.

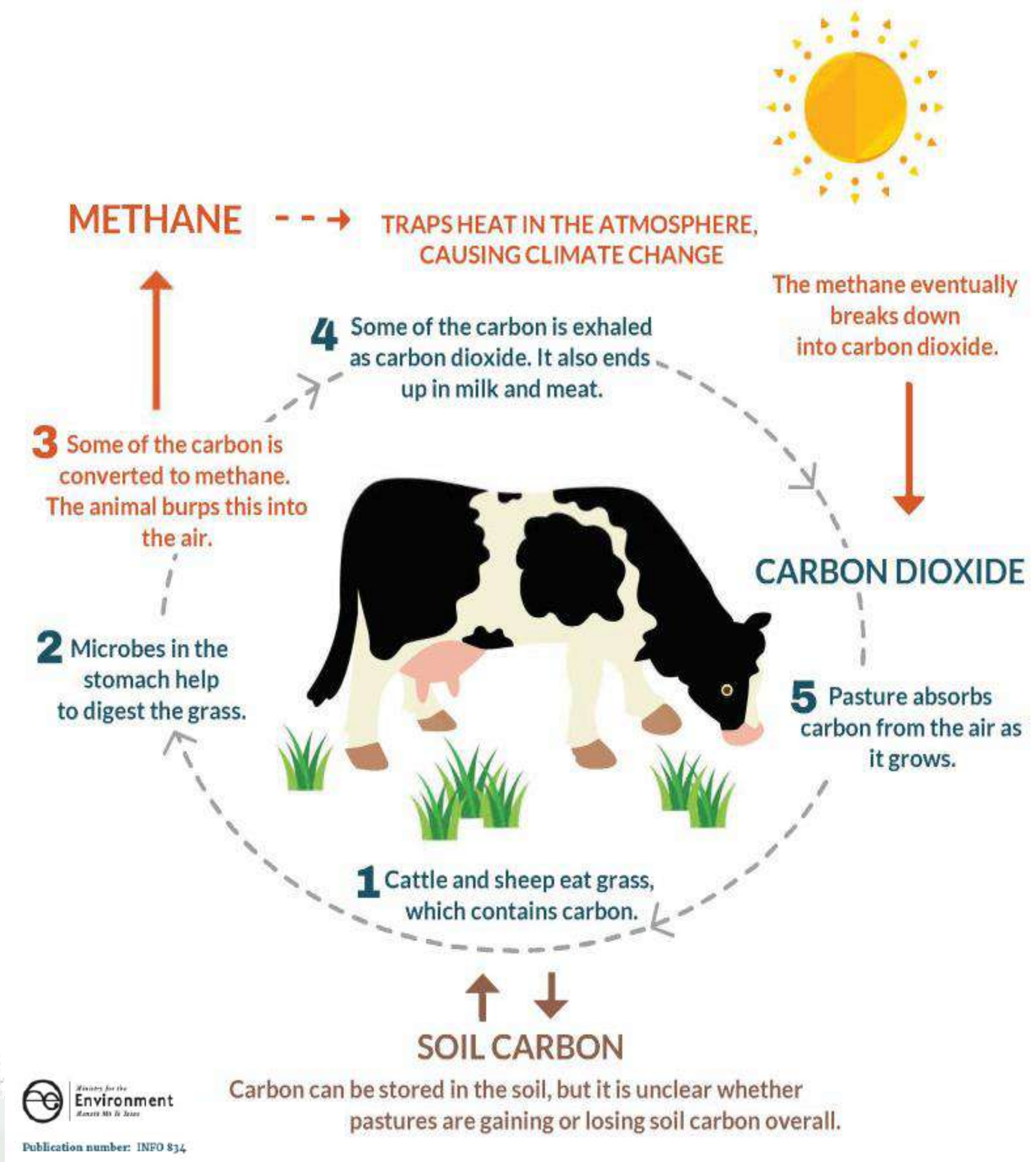
GHG Emissions from Livestock Farming Systems

- Conventional or extensive: mostly pasture-based
- Feedlot or intensive: animals fattened on a feedlot after weaning

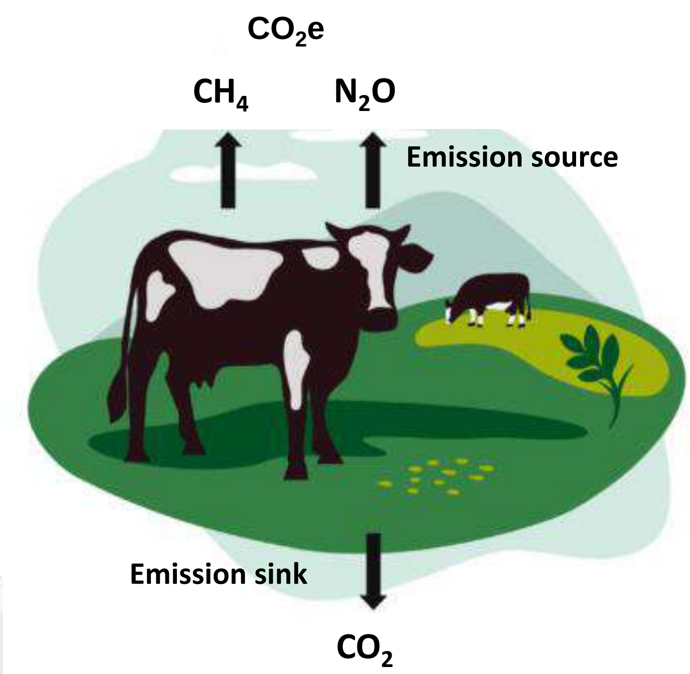


Houzer & Scoones, 2021.

GHG Emissions from Livestock Farming Systems



from a carbon footprint standpoint, this comparison of pasture-raised and feedlot raised livestock may be misleading!



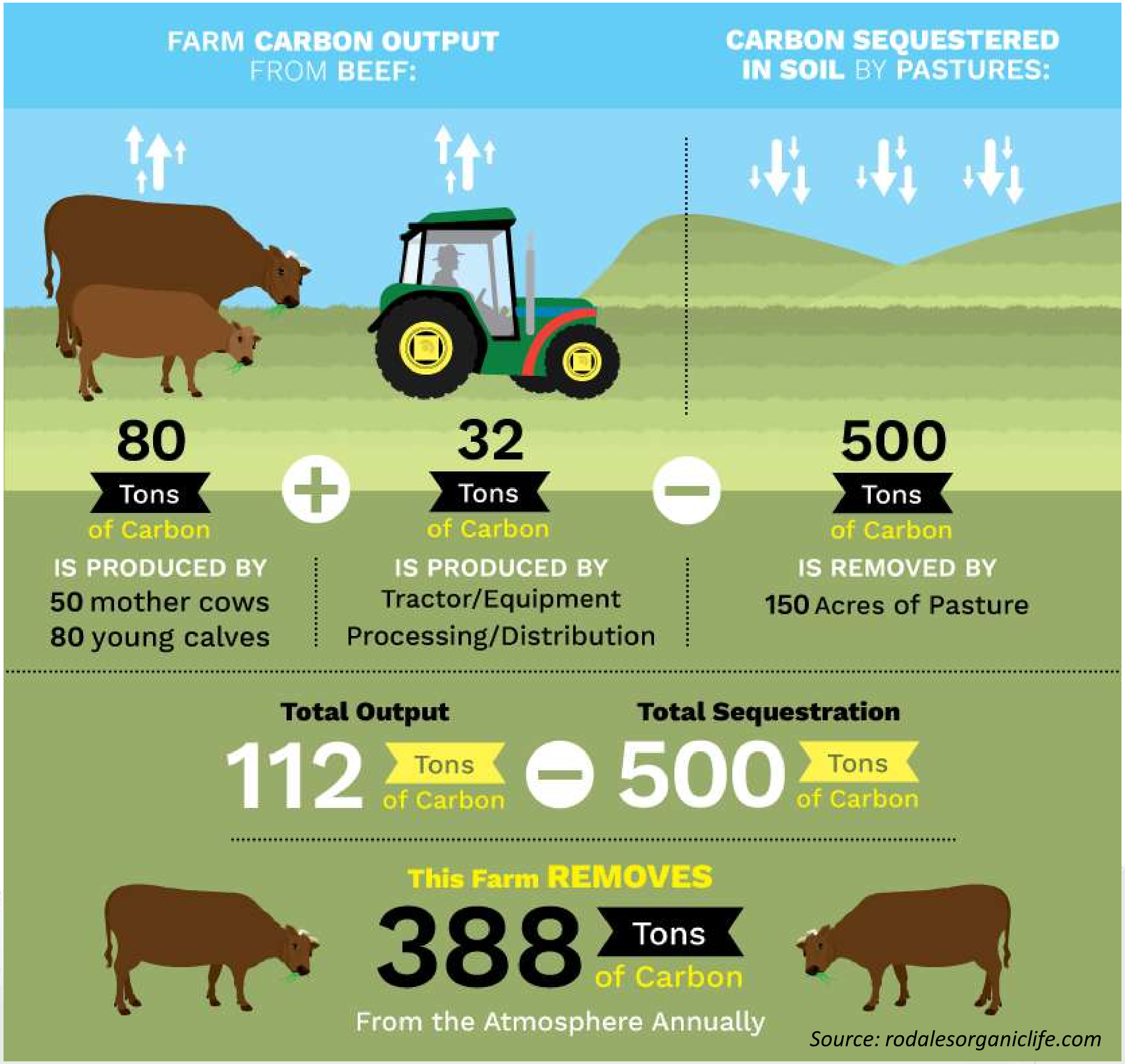
GHG Mitigation Capacity of Traditional Livestock Herding

Livestock as both part of problem and the solution.

Can sustainable livestock production deliver climate adaptation, mitigation, and food security?

We need to understand the diversity of livestock systems.

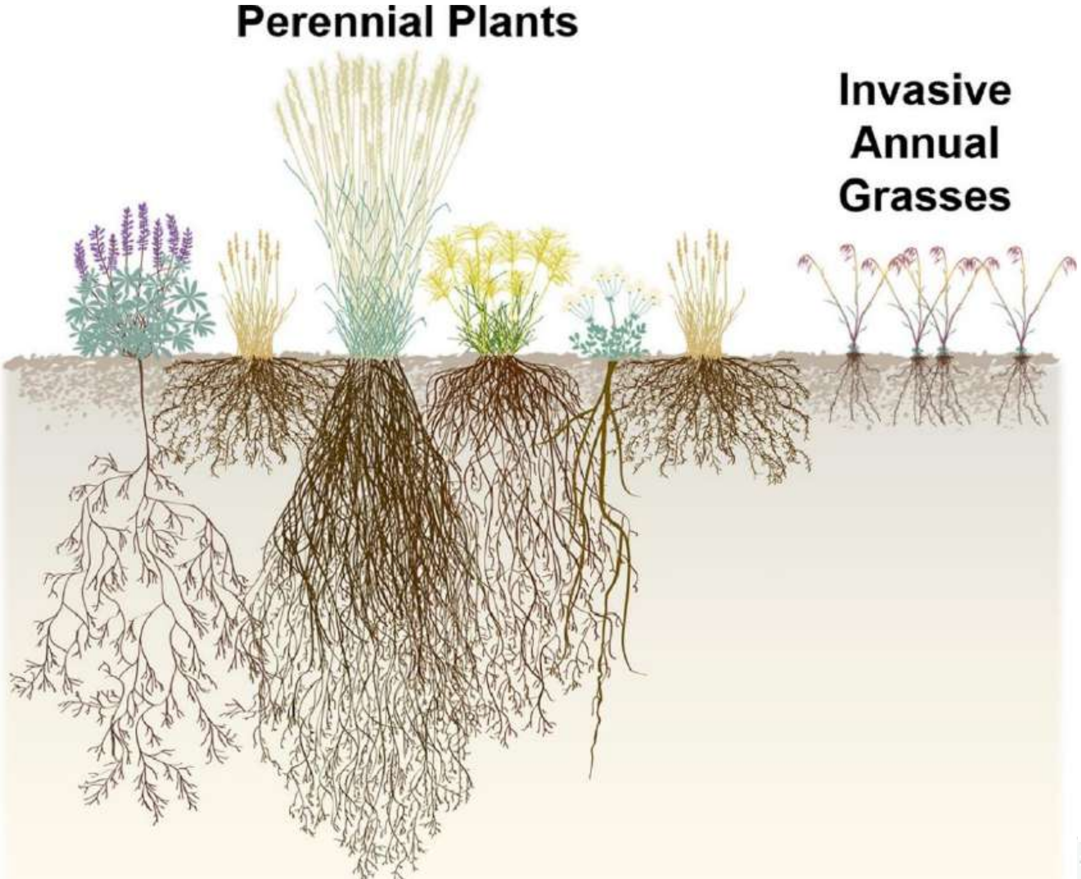
The low-input, extensive and mobile systems, including those managed by pastoralists, can potentially offer a low-carbon alternative that is environmentally beneficial.”



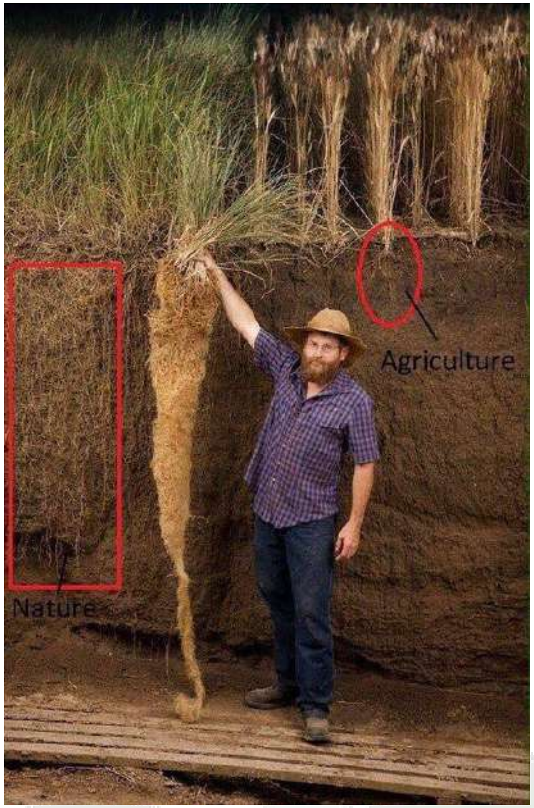
Source: *rodalesorganiclife.com*

GHG Mitigation Capacity of Traditional Livestock Herding

Diversity of plants and their root structures in a healthy pasture increases resilience against challenges such as climate change and invasion.



Tilley et al., 2022, Rangelands, 44 (4), Pages 270-280



Land conversion leads to the loss of 30-55% of grassland soil carbon storage!

GHG Mitigation Capacity of Traditional Livestock Herding

Illustration: Marc Conaco

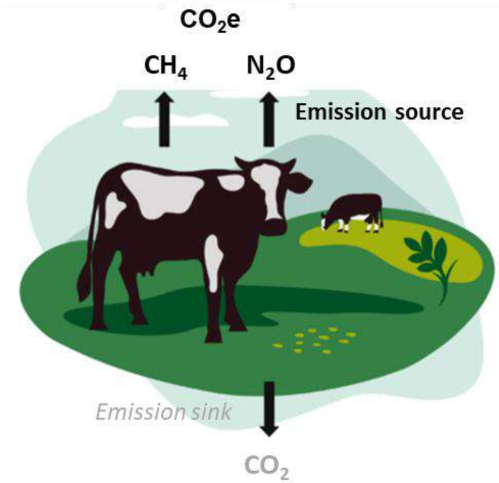
New Zealand's average carbon dioxide equivalent (CO2-e) per kilogram of sheep meat is less than half the international average, and about 30% lower than the international average for beef.

when taking into account sequestration on farms absorbing emissions – New Zealand's sheep meat is arguably "climate neutral" and New Zealand beef is also well on the way towards that.

For this number to remain low in future, it's dependent on either **no increase in sheep numbers**, or **reductions in greenhouse gas emissions per kg of live weight stock** on our farms.

GHG Emissions Reductions Strategies

At animal level, GHG emission intensity can be reduced by increasing livestock productivity through improving feed quality and feeding practices, genetics, animal health, reproduction strategies (age at first calving), and herd restructuring (reducing the relative number of unproductive animals in the herd).



Livestock rotation

Livestock Health and Productivity Improvement

Feed Management and Nutrition

- Increase production (less methane per unit of product)
- Increase forage intake
- Improve feed supplementation

Genetics

- Improve breeding (more productive cows)
- Improve cow health
- Genetic selection based on microorganism population in the rumen

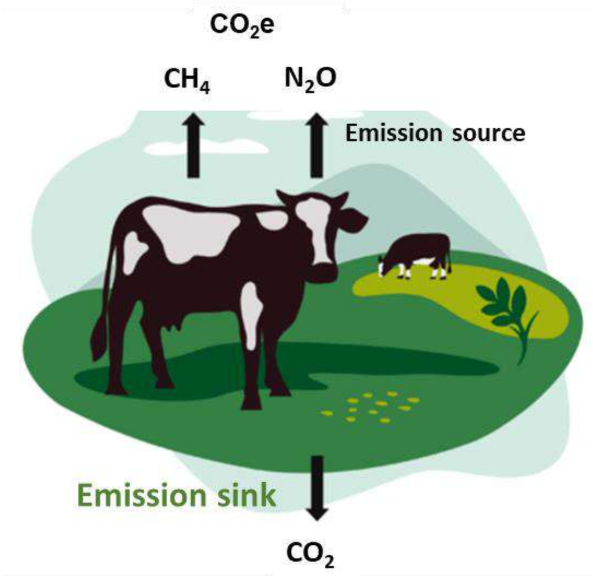
Herd Management Practices

- Reduce number of unproductive animals
- Reduce animal decease
- Improve feeding and housing technologies

GHG Emissions Reductions Strategies

At pasture level, GHG mitigation capacity of traditional livestock herding can be restored through:

- Supporting the stocking rates that are in line with pasture carrying capacity.
- Promoting seasonal pasture rotations and traditional four-season nomadic rotational grazing.
- Rehabilitating vegetation and enhancing soil carbon sequestration capacity in degraded pastures.



Optimizing grazing pressure and improving grazing livestock distribution is critical to fully benefit from the GHG mitigation capacity of natural grasslands and traditional livestock herding in Mongolia.

Environmental Services from Traditional Livestock Herding

Raising cattle on pasture is inherently more challenging than fattening them on feedlots, but the results are **worth the extra effort**.

Pasture-raised livestock

Multi-functional systems that **deliver** multiple environmental services, including mitigating GHG emissions through carbon sequestration services.

Feedlot-raised livestock

Single-function system that **impacts** multiple environmental services, including carbon sequestration and water quantity and quality services.

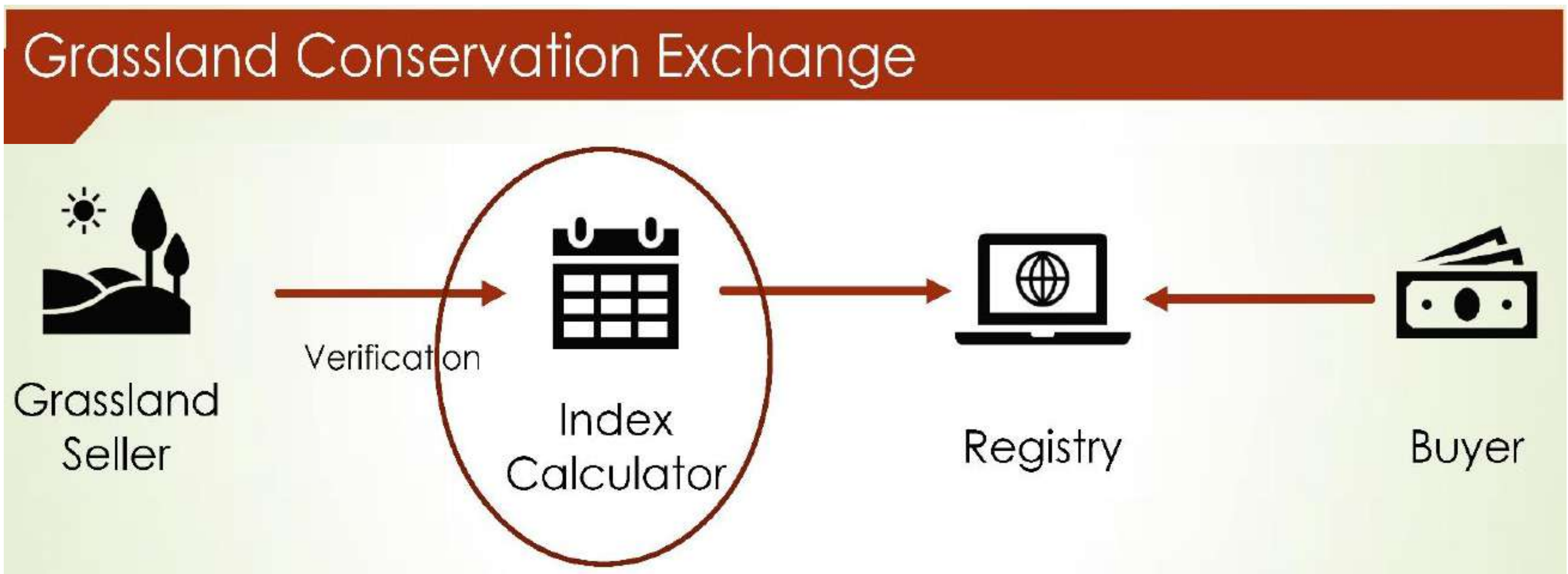
- Feedlots in mixed systems require special diet composition that can potentially increase GHG emissions from cultivated lands.
- Concentration of livestock over small areas can lead to challenges in manure management and, eventually, higher GHG emissions and water pollution issues.

Environmental Services from Herd Restructuring

Environmental services	Influence of current livestock herding	Responsiveness to climate-resilient livestock farming		Opportunity to enhance via climate-resilient livestock farming	
		Grass-finished	Feedlot-finished	Grass-finished	Feedlot-finished
Provisioning services					
Meat production	Moderate	Moderate	High	Low	High
Non-meat products	Moderate	Moderate	High	Low	High
Water supply	Large	High	Low	Moderate	Low
Regulating services					
Water quality regulation	Large	High	Low	Moderate	Low
Air quality regulation	Moderate	Moderate	Low	Low	Low
Disease regulation	Moderate	High	High	Moderate	High
Soil quality regulation	Large	High	Low	High	Low
Climate regulation	Large	Moderate	Low	High	Moderate
Cultural services					
Cultural heritage	Slight	Low	*Not relevant*	Low	*Not relevant*
Recreation and tourism	Slight	High	*Not relevant*	Moderate	*Not relevant*
Biodiversity and habitat					
Biodiversity	Large	High	Low	High	Moderate
Habitat maintenance	Large	High	Low	High	Moderate

Markets for Environmental Services from Pastoral Systems

Grassland Conservation Index: a weighted combination of environmental services that are economically, environmentally and socially relevant to grasslands.



Herders who supply grasslands services benefits to potential buyers.

The system that issues, tracks, transfers and retires grassland units in the exchange.

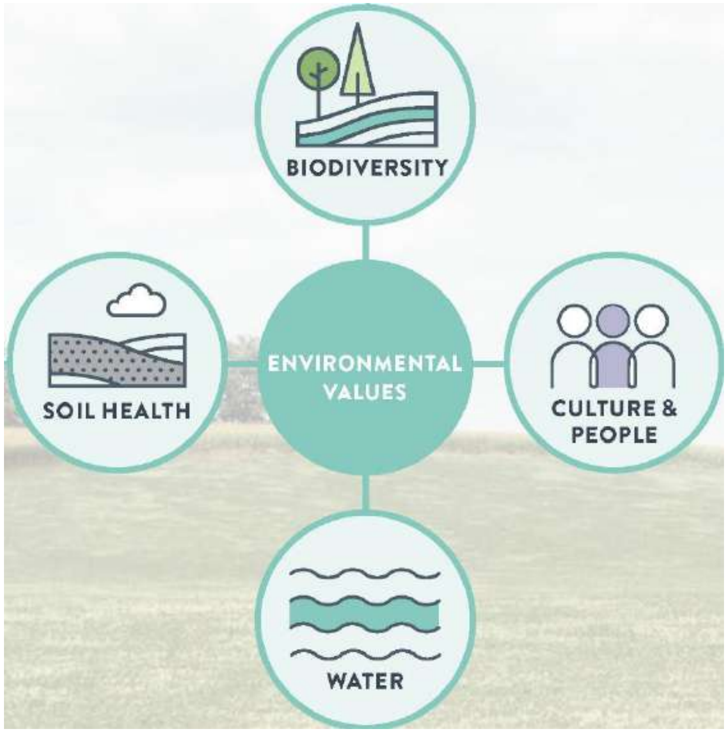
A discovery tool used to identify and calculate a weighted combination of grassland services assets in a standardized way.

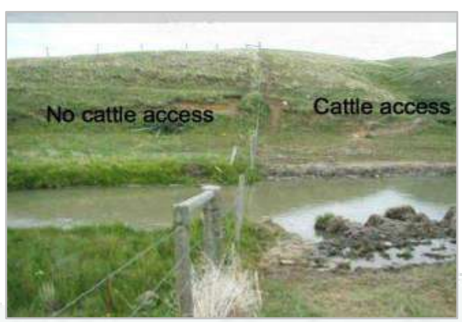
The process of authenticating the grassland services indicators and associated metrics that will be delivered to the buyer.

Investors in the grasslands conservation exchange who pay for and benefit from grasslands services.

Western Stock Growers' Association
EcoServices Network
ALBERTA INNOVATES

Markets for Environmental Services from Pastoral Systems





Markets for Environmental Services from Pastoral Systems

Grasslands Conservation Sample Index Report

Member ID: *123456*
Date of issue: *01/01/2021*
Year of measurement: *2020*
Grassland area (ha): *250*

Biodiversity

SCORE	INDICATOR	CUMULATIVE SCORE
	Biodiversity index as an indicator of species abundance and richness	150
	Landscape connectivity scores or density values	
Additional information may also be provided such as habitat for native pollinators, habitat for species at risk or species of interest for certain buyers.		

Water

SCORE	INDICATOR	CUMULATIVE SCORE
	Water quality index or estimated average nutrient loading of phosphorus, nitrogen and total suspended solids.	150
	Soil water filtration measurements	
	Estimated water storage (volume)	
Additional information may also be provided such as watershed quality, flood risk and drought.		

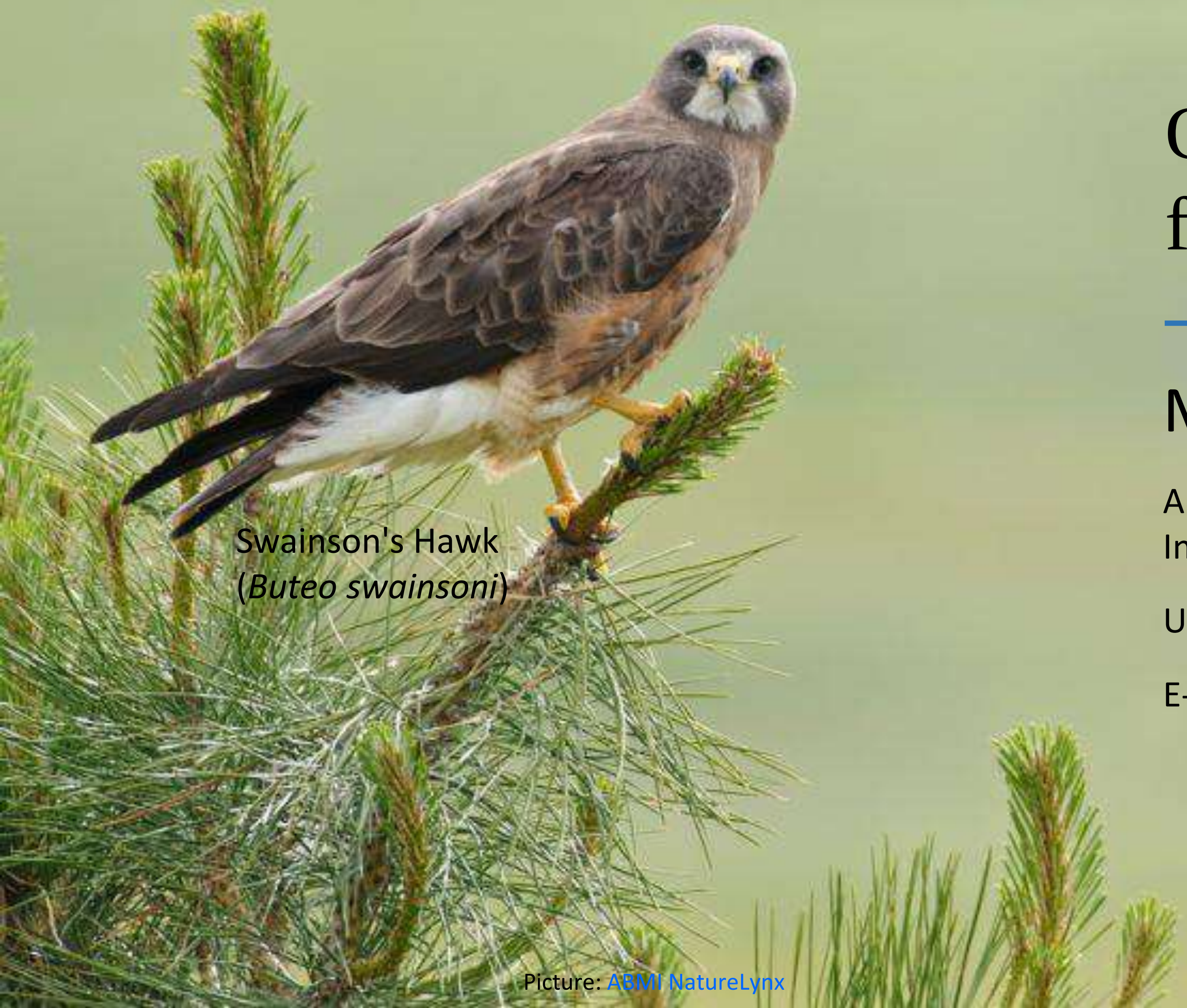
Soil

SCORE	INDICATOR	CUMULATIVE SCORE
	Soil aggregate stability	150
	Bacteria to fungi ratio	
	Soil microorganisms measurement e.g. soil mites	
	Estimated average of soil organic matter	
Additional information may also be provided such as estimates of soil carbon sequestration per year based on modeled and published research data.		

30% Biodiversity
30% Soil Health
30% Water
10% Culture and People

Implications for Policy and Programs

- Local herders must play a fundamental role in the development process of new policies, as they deeply understand the environmental good and services essential to their herding livelihood systems.
- Efforts to address livestock related GHG emission risks are likely to require systemic changes in Mongolian livestock management and marketing to sustain herders' incomes over the long term.
- Community-based rangeland monitoring and management can support local agreement on livestock mobility or seasonal pasture rotation, an adaptive strategy traditionally used by Mongolian herders to prepare for and respond to pasture and climatic conditions.
- Adaptive measures that reduce livestock mortality and increase livestock productivity are required to minimize the herders' only offset mechanism or increasing their herd size to compensate for possible livestock losses from harsh climate events.
- Reports about GHG emissions and carbon sequestration rates are particularly rare for Mongolia. More effort needs to be put into a systematic assessment of the potential GHG emissions and removal from Mongolian livestock sector.



Swainson's Hawk (*Buteo swainsoni*)

Picture: ABMI NatureLynx

Questions and feedback

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It's Our Nature *to Know*

Alberta Biodiversity Monitoring Institute

CTCN CLIMATE TECHNOLOGY CENTRE & NETWORK

БАЙГАЛЬ ОРЧИН, АЯЛАЛ ЖУУЛЧЛАЛЫН ЯАМ

UN environment

GHG Emissions Assessment of Climate-Resilient Livestock Farming

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alinea

ABMI

Dec 8, 2022; UB, Mongolia

Presentation Outline

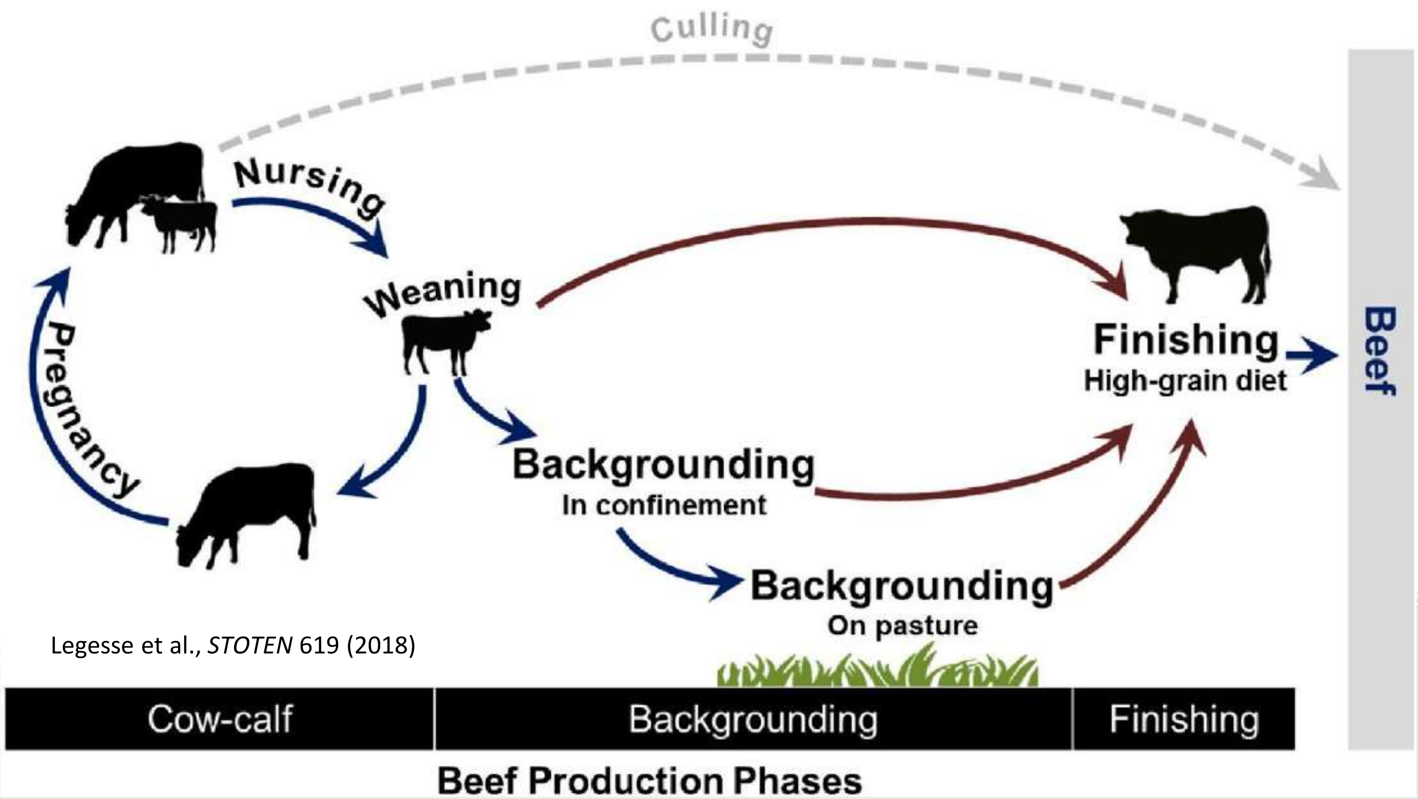
- Livestock Life Cycle Impact Assessment
- Existing Methodologies and Data and Information Needs
- GHG Assessment in Bayantumen Soum
- Open Discussion

Livestock Life Cycle Impact Assessment

All sources of emissions along the livestock supply chain

Total emissions for a given farming system or emissions per unit of a single product or combinations of different commodities/farming systems/locations at different spatial scales.

Livestock farming: All processes up to the farmgate where the animals or products leave the farm.



Legesse et al., *STOTEN* 619 (2018)

Livestock Life Cycle Impact Assessment

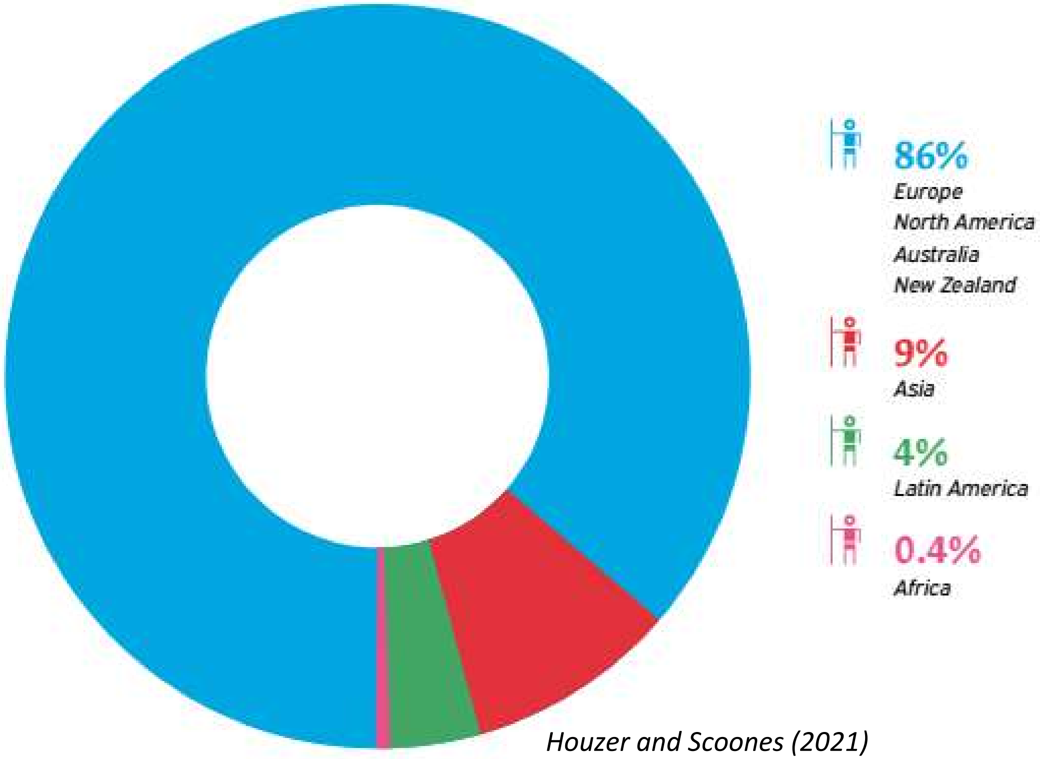
LCAs draw on data from high-income countries, where agricultural systems are more industrialized.

The perspectives of nutritionally vulnerable, poor populations are often missing or underrepresented in scientific analyses.

Assumptions embedded in many Life Cycle Analyses lead to an overestimation of emissions from extensive livestock settings.

An assumption of many LCA assessments is that the abandonment of livestock extensive systems would result in beneficial, 'land-sparing' rewilding/ regeneration of the land, allowing more effective carbon sequestration.

Regions covered by 164 life cycle analysis



Houzer and Scoones (2021)

GHG Emissions Assessment Approaches

The IPCC presents a 3-tiered classification of methodological approaches to GHG emissions quantification

Approach	Method	Data Requirements	Aggregation Level/ Uncertainty	Notes
Tier 1 Empirical Model	IPCC Tier 1 default equations and factors (FAO-LEAP Level 1 model)	Limited land use and management activity data, little soil delineation and vegetation types; no requirement for model calibration and validation; least data input/output complexity	Typically, large spatial units; National scale; annual resolution	Suitable for rough overviews and where only limited data is available)
Tier 2 Model	Similar to Tier 1 approach with regionally specific empirical factors or with factors derived from validated process models	Intermediate spatial/temporal scale input data; land use and activity data stratified; intermediate requirement for model development and validation; modest data input/output complexity	Finer spatial and temporal resolution than Tier 1; can achieve reasonable uncertainty when good amount and quality of empirical data are used for model development.	Suitable for roll-ups to regional to national scale; can be suitable for project-based, farm-specific accounting.
Tier 3 Measurement	Amount and change by periodic measurement only	Spatial data on soils, land use, land management, vegetation, climate for stratification in carbon estimation areas, annual land management, data from periodic soil sampling; high data complexity	Spatial scale depends on sampling plan, can be coarse or very fine; capable of lowest uncertainty possible for quantification	Most costly to implement

Viresco Solutions Inc. (2020)

GHG Emissions Assessment Tools and Data Requirements

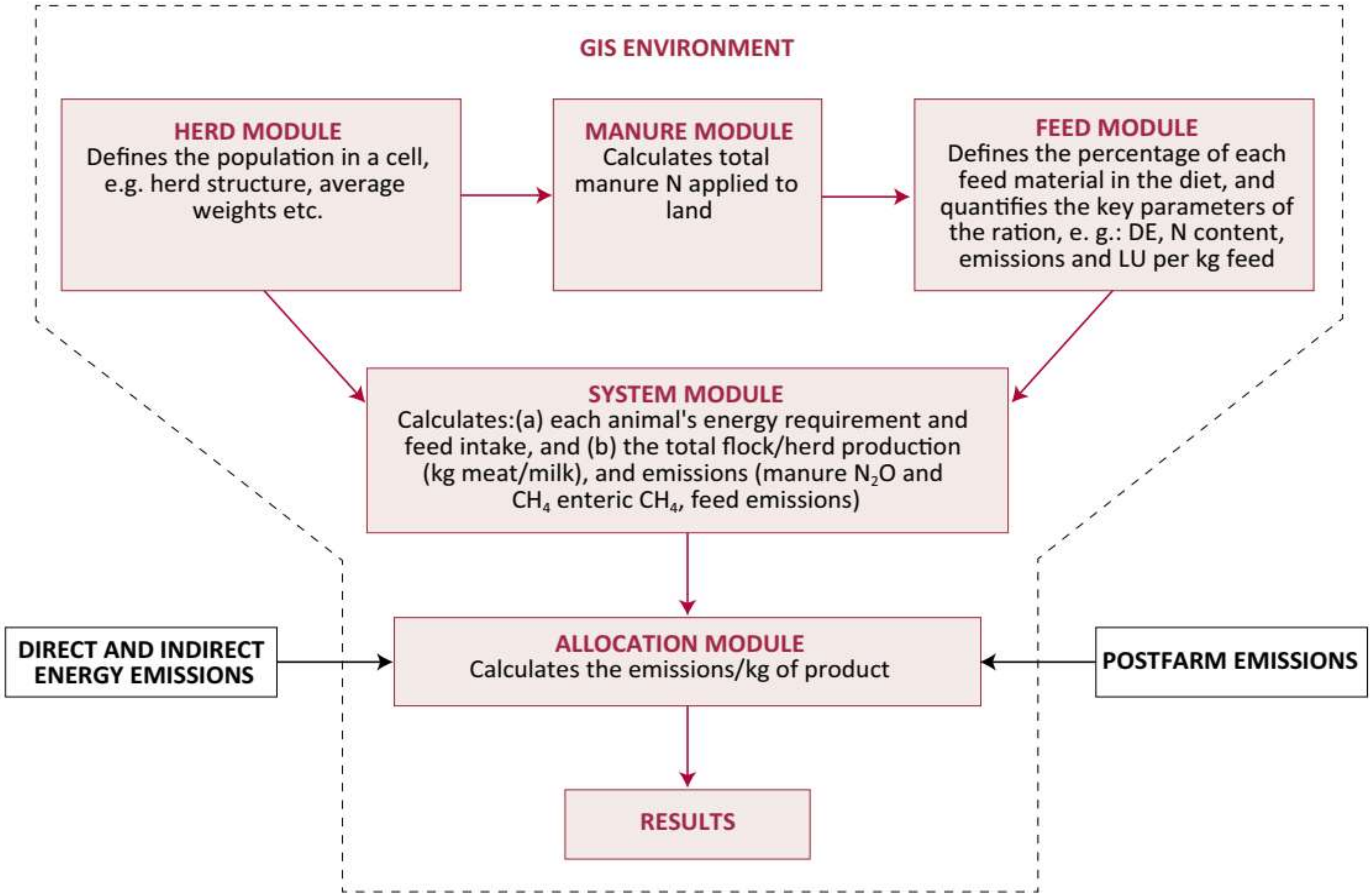
Name of Calculator/tool	Linkage between SOC and other sources and sinks	Transparency	Focus
APSIM	Modular format allows linkage with other models. Crop Livestock Enterprise Model (CLEM) is a module for modeling grassland and livestock productivity and resource use using the APSIM platform.	Detailed reports for each crop type, module, and underlying data for defaults. Available publicly.	Cropping systems in temperate and tropical regions – grains, fibers. CLEM focus is farm resource management rather than a SOC model. Focus on farm managers, agronomists, and researchers.
Cool Farm Tool	SOC available for perennial grass and forage crops in the crop module. Crop footprints can be linked with the livestock module.	Detailed methods documents are available to members. Methods follow IPCC. The origin of some default factors is more difficult to obtain.	Whole farm assessment, ease- of-use for the farmer, but increasingly used as a supply chain GHG calculator at scale. Includes SOC stock estimates from Open Land map datasets but does not integrate this data with calculations yet. Includes Land Use Change.
Holos	The whole farm approach integrates livestock emissions with SOC.	A good set of references available publicly. Transparency of methods and underlying data and assumptions likely available to Canadian users.	Specifically designed for whole-farm assessments in Canada. More widely used by researchers and agrologists than farmers.
Canada National Inventory Report	Comprehensive for Canada is divided into subregions and then into categories and subcategories of emissions.	Methods are well documented and comparable with that of other countries	National estimates

SOC: Soil Organic Carbon

Viresco Solutions Inc. (2020)

GHG Emissions Assessment Tools and Data Requirements

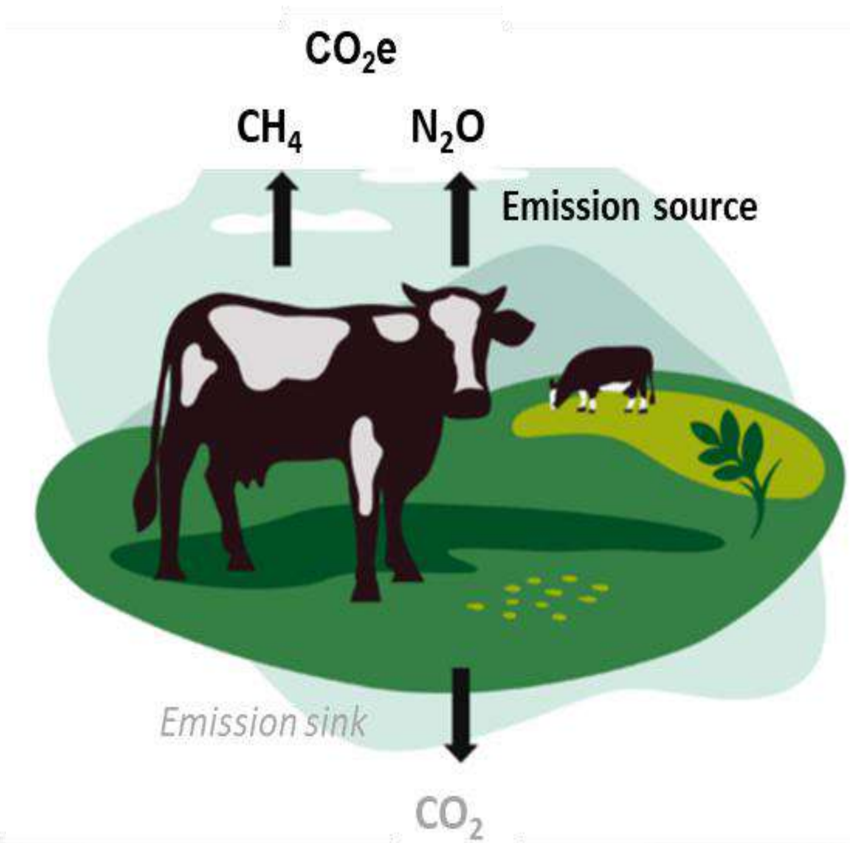
Global Livestock Environmental Assessment Model (GLEAM)



Opio et al., 2013, FAO

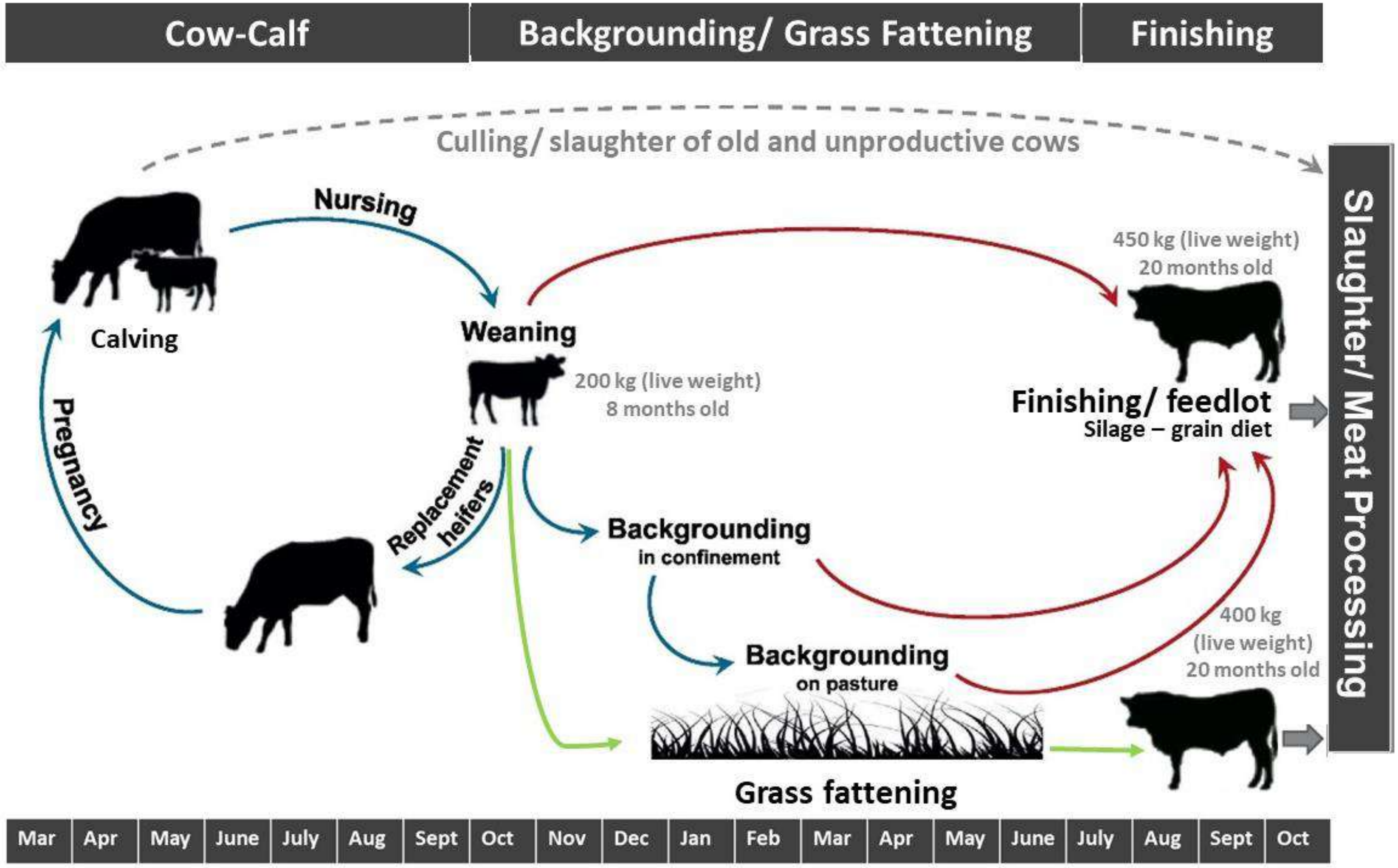
GHG Emissions from Improved Local Livestock Farming

- GHG emissions from enteric fermentation and livestock waste.
- Assuming no grazing and haymaking-induced CO_2e emission and loss from pasture and cultivated soils.
- Assuming an average climate and livestock-marketing year
- Based on the best available data from open-access studies and datasets



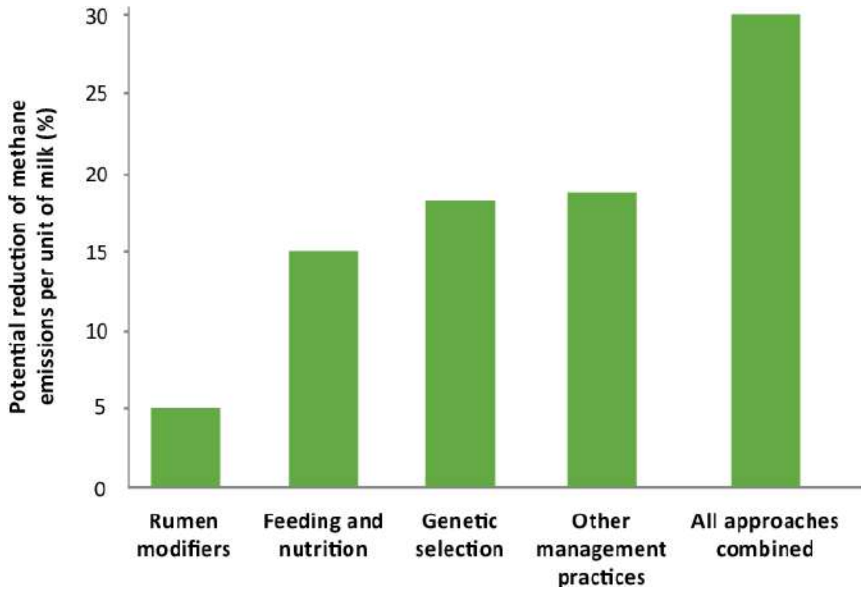
GHG Emissions from Improved Local Livestock Farming

Effects of cattle herd and sheep flock restructuring scenarios for average herder households.

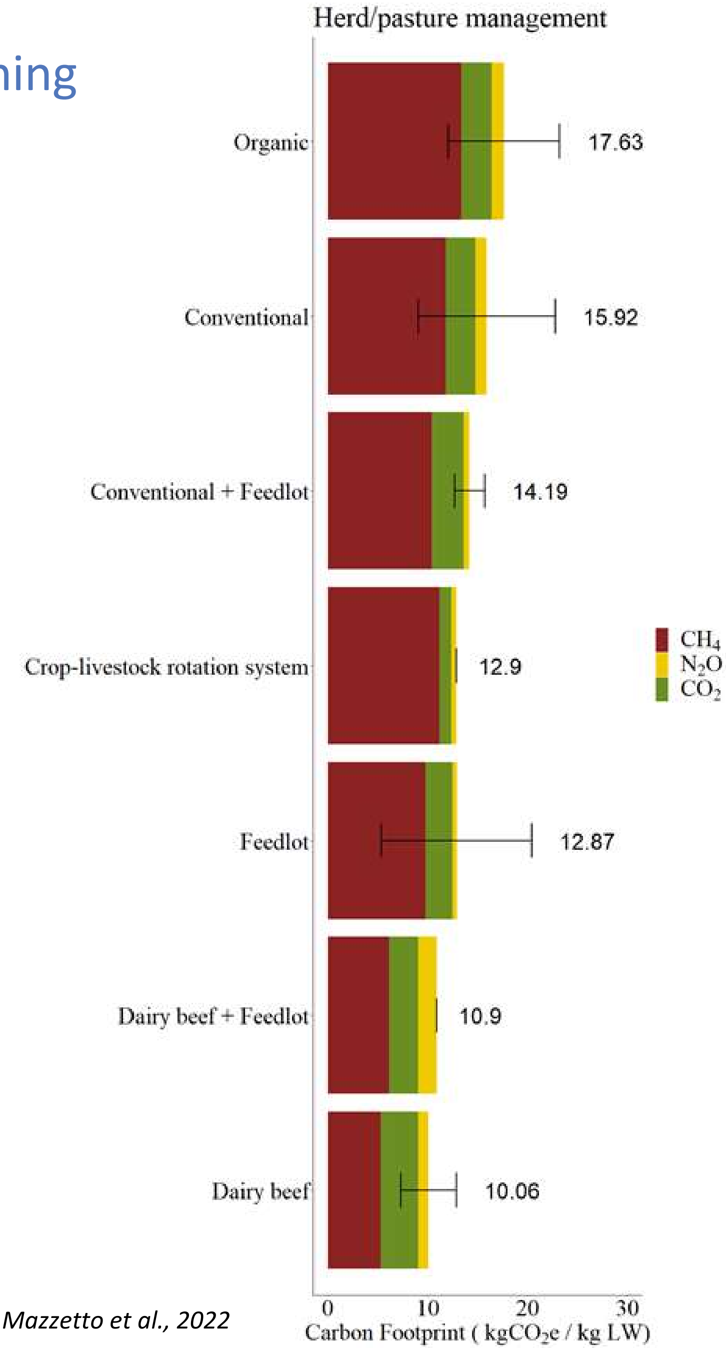


GHG Emissions from Improved Local Livestock Farming

GHG emission reduction effects from improved grazing, pasture, and livestock productivity.



Aguirre-Villegas et al., 2017. Sustainabledairy.org



Mazzetto et al., 2022

1) Conventional: mostly grass-based management (included extensive/intensive management with/without the use of supplementary feeds)
2) Feedlot: animals are on a feedlot after weaning
3) Organic: organic production systems
4) Dairy-beef: beef derived from dairy animals
5) Crop-livestock rotation system: land is rotated between different crops and pasture over time.

GHG Emissions from Improved Local Livestock Farming

Realistic ranges (min and max) of GHG emission intensity or kg of CO_2e per head of adult livestock per year from relevant studies and tools (e.g., GLEAM and LEAP).

Cattle types	Current - 20 Adult Cows							GHG Emission					
	Total Aug	CUs Aug^	Total Sold (Dec)	Average Live weight (kg)	Total Live weight (kg)	Price (MNT/ kg)	Total Value (1000 MNT)	Intensity (kg CO2e/head/yr)		Total (kg CO2e/yr)		kg CO2e/kg live weight	
								Min	Max	Min	Max	Min	Max
Adult cows (42 months and older)	20	20	2	450	900	3000	2700	1731	2398	34620	47960		
Calves (born in spring)	19	6	0				0	1731	2398	10963	15187.33 333		
Yearlings (16-18 months old)	18	9	0				0	1731	2398	15579	21582		
Steers (30 months old)	8	8	0				0	1731	2398	13848	19184		
Replacement heifers (30 months old)	8	8	0				0	1731	2398	13848	19184		
Non-pregnant replacement heifers (34 months old)	0	0	0				0	1731	2398	0	0		
Steers (42 months old)	8	8	0				0	1731	2398	13848	19184		
Steers (54 months old)	7	7	7	450	3150	3000	9450	1731	2398	12117	16786		
Bull for breeding	1	1	0				0	1731	2398	1731	2398		
Open cows (48 months and older)	3	3	1	450	450	3000	1350	1731	2398	5193	7194		
Total	92	70	10		4500		13500	1731	2398	121747	168659	27.1	37.5
^ 3 calves considered as one adult cow and 2 yearlings considered as one adult cow. The rest of the herd considered as 1 adult cow.													

GHG Emissions from Improved Local Livestock Farming

Overall GHG emissions for cattle and sheep meat production in grass-finished and mixed operation (a combination of pastures and creep feeding or feedlots).

Cattle types	With Project - 40 Adult Cows (calves sold at weaning)							Feedlot-finished-only herd restructuring					
	Total Aug	CUs Aug^	Total Sold (Dec)	Average Live weight (kg)	Total Live weight (kg)	Price (MNT/kg)	Total Value (1000 MNT)	Intensity (kg CO_2e/head/yr)		Total ((kg CO_2e)	Total ((kg CO_2e)	kg CO_2e/kg live weight	
								Min	Max	Min	Max	Min	Max
Adult beef cows (42 months and older)	35	35	4	450	1800	3000	5400	1731	2398	60585	83930		
Adult milk cows (42 months and older)	5	5	0				0	1731	2398	8655	11990		
Calves (born in spring)	40	40	35	450	15750	3000	47250	1731	2398	69240	95920		
Replacement heifers (18 months old)	5	5	0				0	1731	2398	8655	11990		
Replacement heifers (30 months old)	5	5	0				0	1731	2398	8655	11990		
Non-pregnant replacement heifers (34 months old)	1	1	1	350	350	3000	1050	1731	2398	1731	2398		
Bull for breeding	2	2	0				0	1731	2398	3462	4796		
Total	93	93	40		17900		53700			160983	223014	9.0	12.5

GHG Emissions from Improved Local Livestock Farming

GHG emission reduction effects from improved grazing, pasture, and livestock productivity.

Grass finished Herd restructuring & Pasture/grazing improvement								Grass finished Herd restructuring & livestock improvement							
Pasture improvement Factor (-)		Adjusted Intensity (kg CO2e/head/yr)		Total (kg CO2e)		kg CO2e/kg live weight		Livestock improvement Factor (-)		Adjusted Intensity (kg CO2e/head/yr)		Total ((kg CO2e)		kg CO2e/kg live weight	
Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
30.1	8.3	1210	2199	42349	76964			14.0	9.2	1489	2177	52103	76208		
30.1	8.3	1210	2199	6050	10995			14.0	9.2	1489	2177	7443	10887		
30.1	8.3	1210	2199	48399	87959			14.0	9.2	1489	2177	59546	87095		
30.1	8.3	1210	2199	6050	10995			14.0	9.2	1489	2177	7443	10887		
30.1	8.3	1210	2199	6050	10995			14.0	9.2	1489	2177	7443	10887		
30.1	8.3	1210	2199	1210	2199			14.0	9.2	1489	2177	1489	2177		
30.1	8.3	1210	2199	2420	4398			14.0	9.2	1489	2177	2977	4355		
				112527	204504	8.9	16.2					138445	202497	10.9	16.0

GHG Emission from Herd Restructuring

- A herder can raise 40 cows, sells steers when weaned and maintain fewer cattle over the winter.
- A herder can earn 27.4 million MNT by selling weaned calves compared to only earning 13.5 million MNT under traditional management.
- A herder can drop the annual rate of GHG emission by up to 23 % by moving to a cow-calf operator or calf supplier.
- A herder can drop the GHG emission rate per unit live weight of cattle remarkably, in particular when pasture and livestock productivity improved.

Cattle Herd management	Operation	GHG Emission							
		Total (tCO_2e/yr)		Rate ($kgCO_2e/kg$ live weight)		Change in Total (tCO_2e/yr)		Change in Rate ($kgCO_2e/kg$ live weight)	
		Min	Max	Min	Max	Min	Max	Min	Max
Current (20 adult cows)	Traditional	122	169	27	38	-	-	-	-
Restructured (40 adult cows)	Cow-calf	109	151	12	17	-13	-18	-15	-21
	Grass-finished	161	223	13	18	39	54	-14	-20
	Feedlot-finished	145	201	8	11	23	32	-19	-26
Restructured & grazing/pasture improved	Cow-calf	76	139	8	15	-46	-30	-19	-22
	Grass-finished	113	205	9	16	-9	36	-18	-21
	Feedlot-finished	101	184	6	11	-21	15	-21	-26
Restructured & livestock productivity improved	Cow-calf	94	137	10	15	-28	-32	-17	-23
	Grass-finished	139	203	11	16	17	34	-16	-22
	Feedlot-finished	101	176	6	10	-21	7	-22	-28

GHG Emission from Herd Restructuring

- A herder can raise 100 sheep, sell lambs in the fall when they are 8-9 months of age and maintain fewer sheep over the winter.
- A herder can earn 10.2 million MNT by selling weaned calves compared to earning 9 million MNT under traditional management.
- A herder can drop the annual rate of GHG emission by up to 43 % by moving to a ewe-lamb operator or lamb supplier.
- A herder can drop the GHG emission rate per unit live weight of sheep remarkably, in particular when pasture and livestock productivity improved.

Sheep Flock Management	Operation	GHG Emission							
		Total (tCO_2e/yr)		Rate ($kgCO_2e/kg$ live weight)		Change in Total (tCO_2e/yr)		Change in Rate($kgCO_2e/kg$ live weight)	
		Min	Max	Min	Max	Min	Max	Min	Max
Current (100 ewes)	Traditional	118	168	17	25	-	-	-	-
Restructured (100 ewes)	Grass-finished	81	115	11	15	-37	-53	-7	-10
	Feedlot-finished	73	104	9	12	-45	-64	-9	-13
Restructured & grazing/pasture improved	Grass-finished	56	106	7	14	-61	-62	-10	-11
	Feedlot-finished	51	98	6	11	-67	-70	-12	-14
Restructured & livestock productivity improved	Grass-finished	63	108	8	14	-55	-60	-9	-11
	Feedlot-finished	51	91	6	11	-67	-77	-12	-14

GHG Mitigation Capacity of Local Livestock Farming

If no adaptive measures are taken to prevent and remove additional livestock from the landscape and rehabilitate soil and vegetation of degraded pastures in the soum, then in the year 2025 alone, an estimated total GHG emission removal opportunity of 479 to 1010 thousand tons of CO_2e from the soum's livestock sector will be missed. This would roughly equal annual carbon removal by 23.9 to 50.5 thousand trees (20 kg CO_2e/yr removal by a single young tree).

Description	Scenario	Year	Livestock Types					
			Horse	Cattle	Camel	Sheep	Goat	Total
Livestock Population (10^3 heads)	Historic	2017	25.1	17.6	0.7	70.1	45.6	159.0
		2021	38.4	30.9	0.9	109.8	69.5	249.6
	Change (%)	2017-2021	53.2	76.1	36.8	56.7	52.4	57.0
	Projected	2025	58.8	54.4	1.3	172.1	106.0	392.6
	Optimized*	2025	38.4	24.7	0.9	76.9	69.5	210.5
GHG intensity (tCO_2e/head/yr)!			0.91	2.06	1.61	0.26	0.23	-
GHG emission (10^3tCO_2e/yr)	Historic	2017	22.7	36.2	1.1	17.9	10.4	88.3
		2021	34.8	63.8	1.5	28.0	15.9	143.9
	Projected	2025	53.3	112.4	2.1	43.9	24.2	235.7
	Optimized	2025	34.8	51.1	1.5	19.6	15.9	122.8
GHG emission change (10^3tCO_2e/yr)	Historic	2017-2021	**12.1**	**27.6**	**0.4**	**10.1**	**5.5**	**55.6**
	Projected	2021-2025	**18.5**	**48.6**	**0.6**	**15.9**	**8.3**	**91.8**
	Historic - Optimized	2021-2025	**0.0**	**-12.8**	**0.0**	**-8.4**	**0.0**	**-21.2**
	Projected - Optimized	2025-2025	**-18.5**	**-61.3**	**-0.6**	**-24.3**	**-8.3**	**-113.0**

! Values are based on Shi et al., 2022 (Front. Public Health, 11).

Conclusions and Limitations

- This preliminary assessment demonstrates the potential GHG emission and removal from the traditional livestock sector in the Bayantumen Soum.
- It demonstrates how restructuring the existing livestock herds and improvement in grazing and livestock management can potentially increase the GHG emission efficiency of livestock products while increasing the total production of livestock live weight for an average herder household.
- While great care has been taken to ensure that the input data and the results were of the highest quality possible, there remain several limitations in the underlying datasets and therefore projected changes.
- These results provide a basis for identifying adaptation pasture and livestock management measures that target the mitigation of GHG emissions from the livestock sector.
- However, they also suggest that more effort needs to be put into a systematic assessment of the sector's potential GHG emissions and removal.
- This includes considering the IPCC Guidelines Tier 3 methods that require locally appropriate emission factors for different livestock types and practices that can be obtained though direct measurement of GHG emissions from different aspects and stages of the livestock life cycle.

Swainson's Hawk
(*Buteo swainsoni*)

Picture: ABMI NatureLynx

Questions and feedback

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It’s Our Nature *to Know*

Alberta Biodiversity Monitoring Institute

Carbon Sequestration Assessment of Climate-Resilient Livestock Farming

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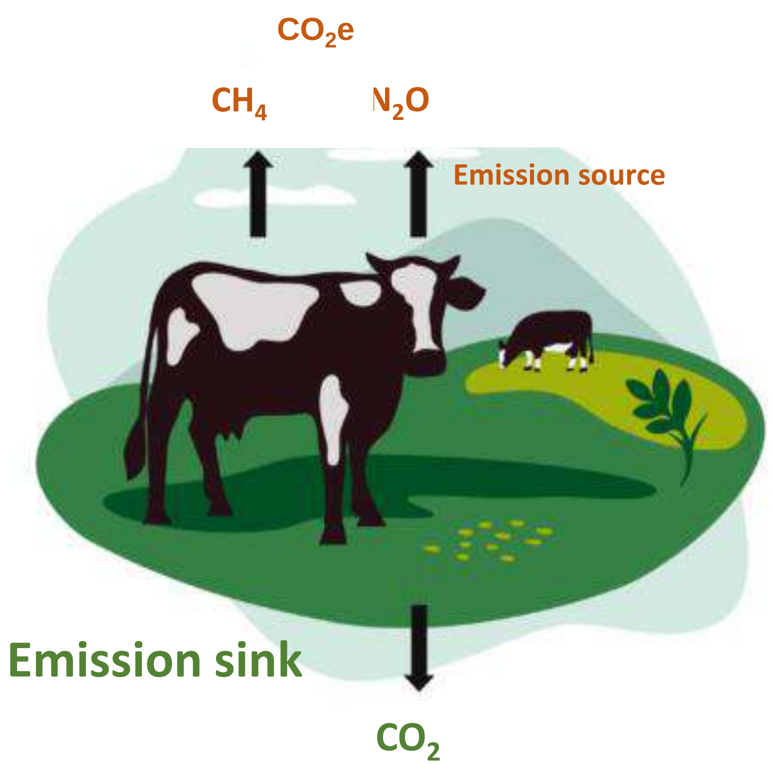
Dec 8, 2022; UB, Mongolia

Presentation Outline

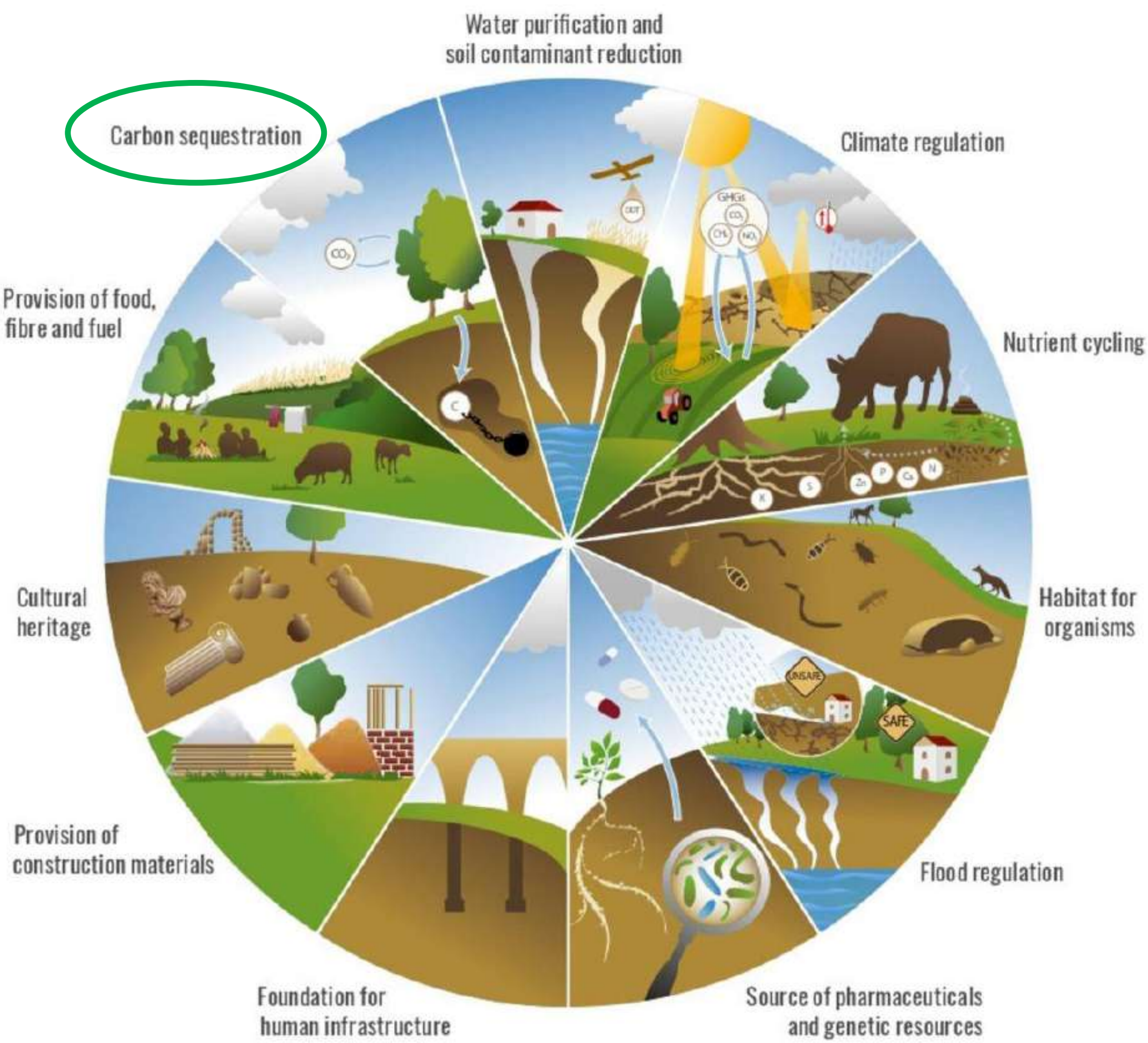
- Introduction
- Carbon Sequestration, Carbon Stock and Carbon Stock Changes
- Existing Methodologies and Data and Information Needs
- Carbon Sequestration Assessment in Bayantumen Soum
- Open Discussion

Emission Sink and Emission Source

- A **carbon sink** is anything that absorbs more carbon from the atmosphere than it releases.
- A **carbon source** is anything that releases more carbon into the atmosphere than it absorbs.



Carbon Sequestration



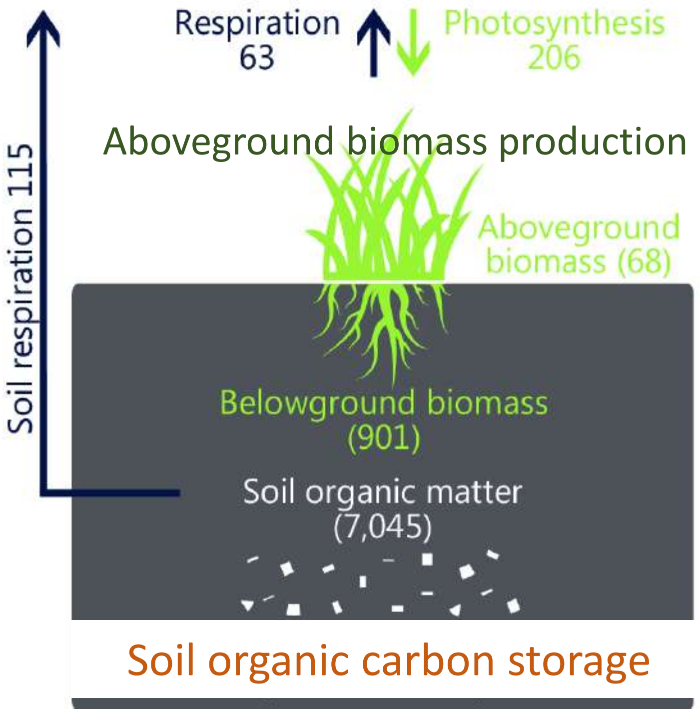
Soil carbon sequestration is a process whereby CO_2 is removed from the atmosphere by vegetation, and stored in the soil's pool of organic carbon

Carbon sequestration results from the interactions of several ecosystem processes, of which photosynthesis, respiration, and decomposition are key.

Source: adapted from FAO. 2015. *Soils deliver ecosystem services that enable life on Earth – Infographics.* https://www.fao.org/publications/card/en/c/0815e457-c6a4-47e9-ab6c-f23224279834

Carbon Sequestration and Organic Carbon Stocks

Grassland Organic Carbon Stocks



Carbon storage (in parentheses): g/m^2
Carbon fluxes (arrows): $g/m^2/day$

Janowiak et al. 2017; Burke et al. 2008

Soil organic matter is a heterogeneous mixture of soil microbes including bacteria and fungi, decaying material from once-living organisms such as plant and animal tissues, fecal material, and products formed from their decomposition (fresh plant residues to highly decomposed material or humus).

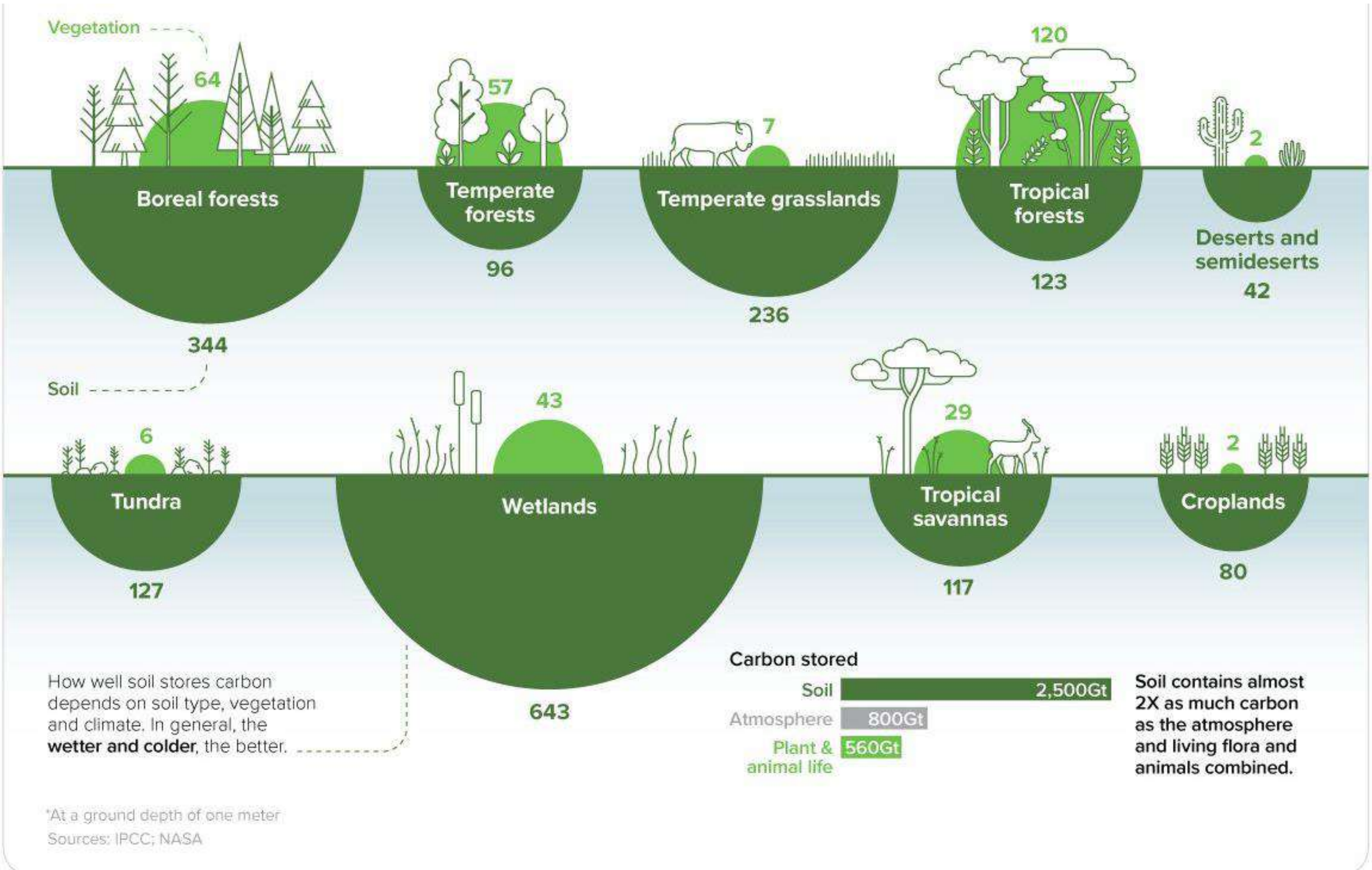
Soil organic carbon (SOC) is directly related to the amount of organic matter contained in soil and SOC is often how organic matter is measured in soils.

Organic matter (%) = Total organic carbon (%) x 1.72 or 1/0.58

Organic Carbon Stocks are total organic carbon stored in a grassland system.

It is much easier to estimate carbon stocks to a given relative accuracy than carbon stock changes to that same accuracy.

Organic Carbon Stocks in Different Landscapes



Organic Carbon Stock Types

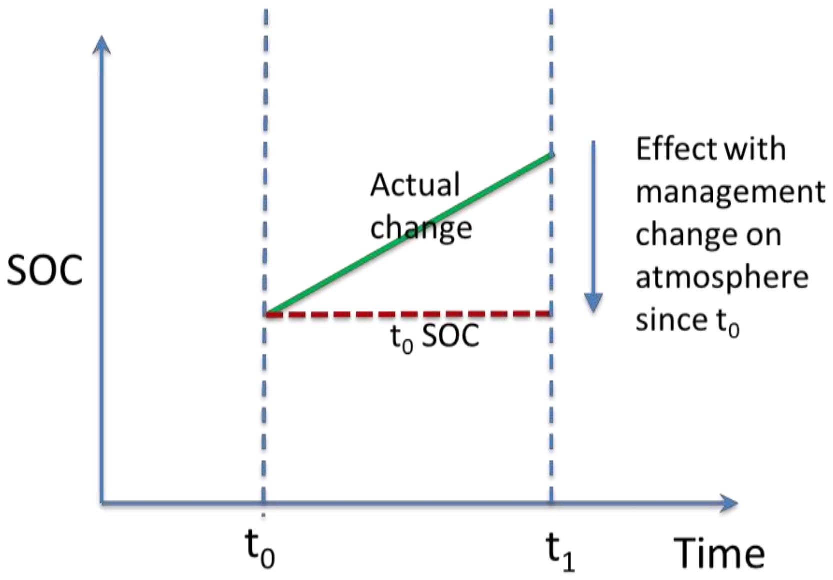
Computed stocks of carbon within various components of grazed and non-grazed grasslands

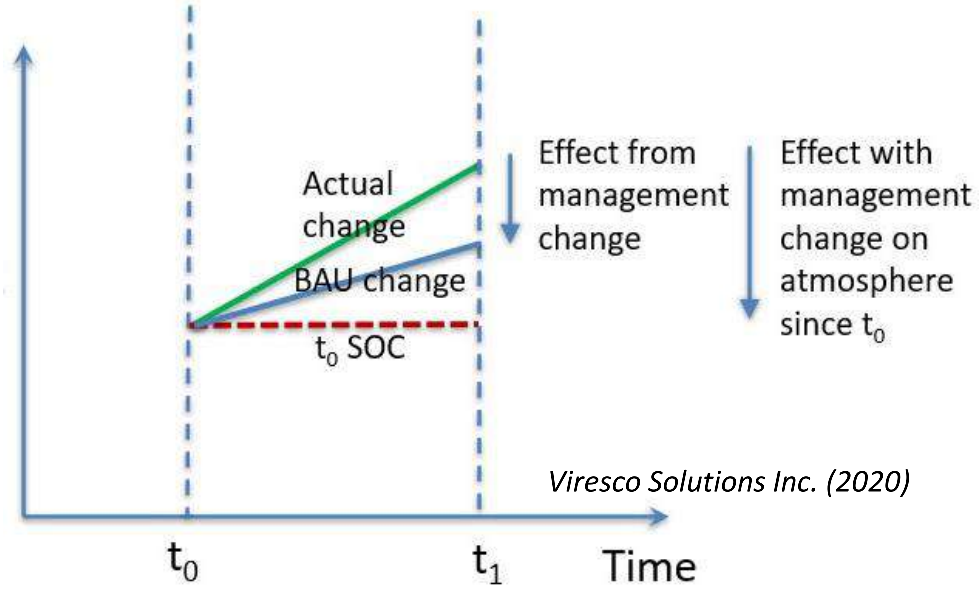
		Total C Stock (Mt)		**Δ C Stock Under Grazing**	**Grazing-Induced Value Add**
Ecosystem Pool	Contributing Components	Grazed	Non-Grazed	(Mt C)	($B - Cdn.)
Live Vegetation	Live Shoots + Roots	11.0	0.4	+ 1.7	0.312
Dead Vegetation	Litter + LFH	46.8	2.4	- 2.1	-0.385
Surface Soil Carbon	Mineral SOC (0 - 15 cm)	165.8	6.9	+ 11.2	2.053
Total Soil Carbon	Mineral SOC (0 - 30 cm)	257.8	11.6	+ 6.4	1.173
Aboveground	Live Veg, Litter and LFH	49.9	2.5	- 2.2	-0.403
Belowground	Roots and SOC (0 - 30 cm)	295.7	12.5	+ 14.7	2.695
Total Ecosystem C	ALL components	347.6	14.8	+ 17.1	3.135

Bork et al., 2022

Carbon Stock Change Assessment

It's important to consider what SOC change is to be measured!





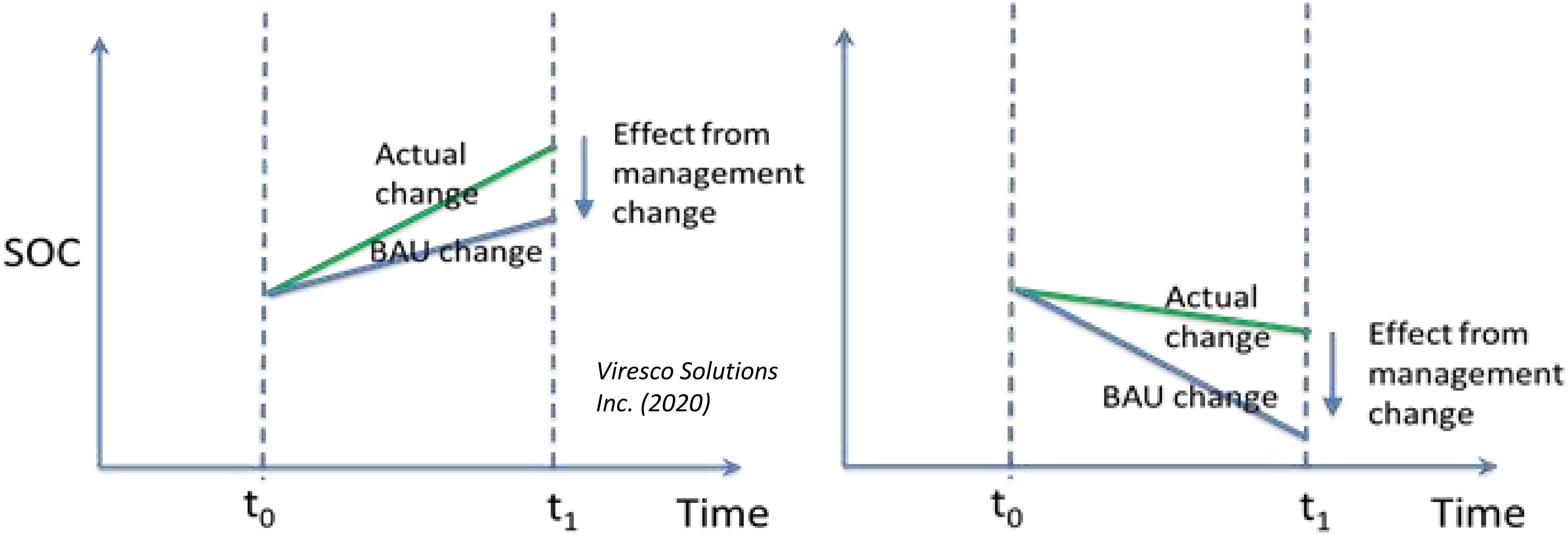
Overall SOC change and effect on atmosphere since t0 – this considers the SOC change from a fixed SOC stock at a point in time at which the management change is implemented. This case does not include changes that would have occurred over time without the management change.

SOC change is limited to the effect of a management change only – this considers a business-as- usual (BAU) baseline where an assumed background rate of SOC change is included in the quantification so that the SOC change is only due to the management change.

Most carbon markets require comparison to a business-as-usual baseline to develop offset credits specifically from the implementation of a management change.

Carbon Stock Change Assessment

It's important to consider what SOC change is to be measured!



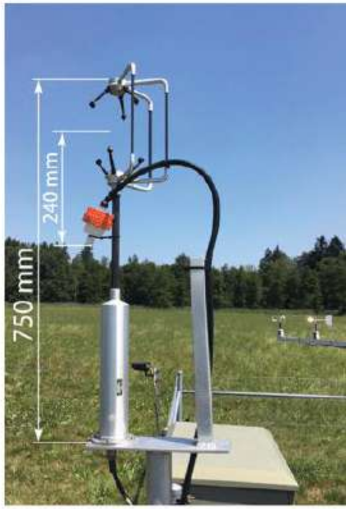
With a BAU baseline, it is possible to have a C credit even if SOC decreases due to changing weather patterns, providing the BAU decreases more. This is called avoided loss (i.e. credit) compared to the loss that would have occurred under the business as usual scenario (i.e. the 'with project' management change loses less than the BAU).

Modeling the BAU SOC allows for project developers to manage this weather-induced risk, which is typically not economically feasible to do with a fixed SOC stock.

Carbon Stocks Assessment Approaches

Main approaches

- Empirical factors
- Measurement only
- Hybrid of modeling and with-project measurement
- Modeling supported by monitoring (measurements)



Measurement approaches

- Direct measurement
- Flux measurements of emissions by flux towers and eddy covariance

Modeling approaches

Extrapolation of empirical models across a larger area

Process soil models: biogeochemical models that exclude simulations of plant growth

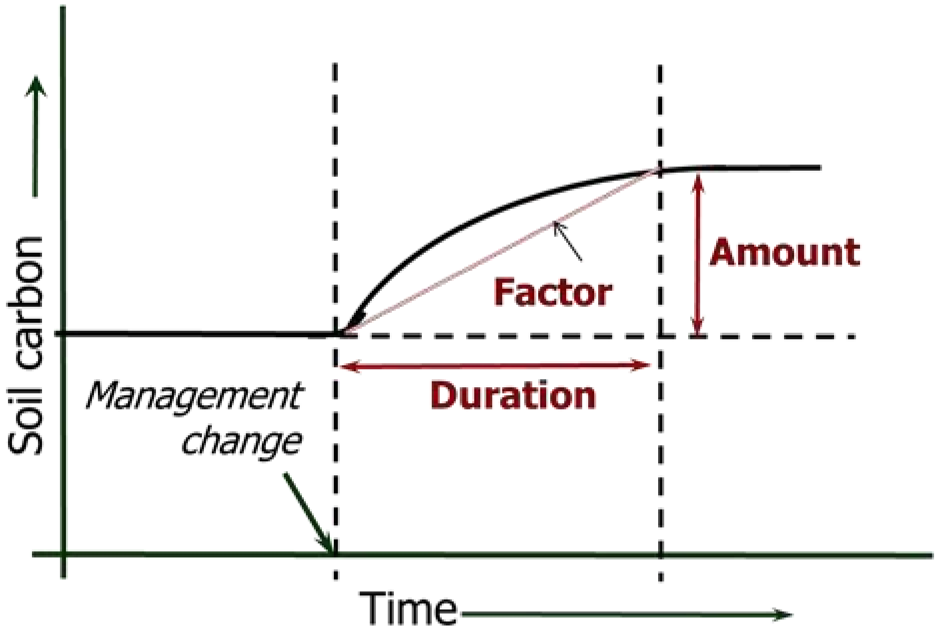
Ecosystem models: biogeochemical models that include simulations of plant growth.

These approaches can be employed independently or in some combination.

It is important to understand the relevance of each quantification approach to the desired use.

Carbon Stocks Assessment Approaches

Empirical Factors



Viresco Solutions Inc. (2020)

Empirical factors are simplified representations or models which can be applied to an appropriate time and area to estimate SOC stock change.

Factors are derived from observations or validated process models for various management practices and locations, depending on the level of detail and rigor required.

Empirical factors are also simple to implement and understand.

There is often a lack of suitable data from which to derive factors and management changes can be difficult to define given the large variability in land management across diverse landscapes.

Carbon Stocks Assessment Approaches

Measurement only

- Direct measurement of SOC stocks from soil samples to determine SOC change.
- The accuracy and usefulness of empirical measurements is a function of the statistical and scientific design of the sampling approach.
- Rangelands will require expensive sampling due to inherent variability.
- There is no backup when relying solely on direct measurement.
- There is a risk that the SOC change will not be detectable or significant, within a desired commercial timeframe.
- There is no capability to project SOC changes over time when using direct measurement.

Carbon Stocks Assessment Approaches

Hybrid of ‘with-project’ measurement and modeling

- Considers project direct measurement and modeling.
- Rely on project developers to conduct the intensive sampling that is required to generate high quality datasets to validate and true up models
- The BAU SOC change is modeled through well validated models and carbon credits are issued based on modeled estimates of ‘with project’ SOC change.
- Periodic soil carbon measurements (every 5 years) are used to “true-up” modelled results.
- New observations are used to improve the model to better estimate SOC for the with-project scenario and the BAU SOC.
- It’s entirely possible and highly likely that the ‘true-up’ measurements may have so much inherent uncertainty that the true up becomes suspect as well.

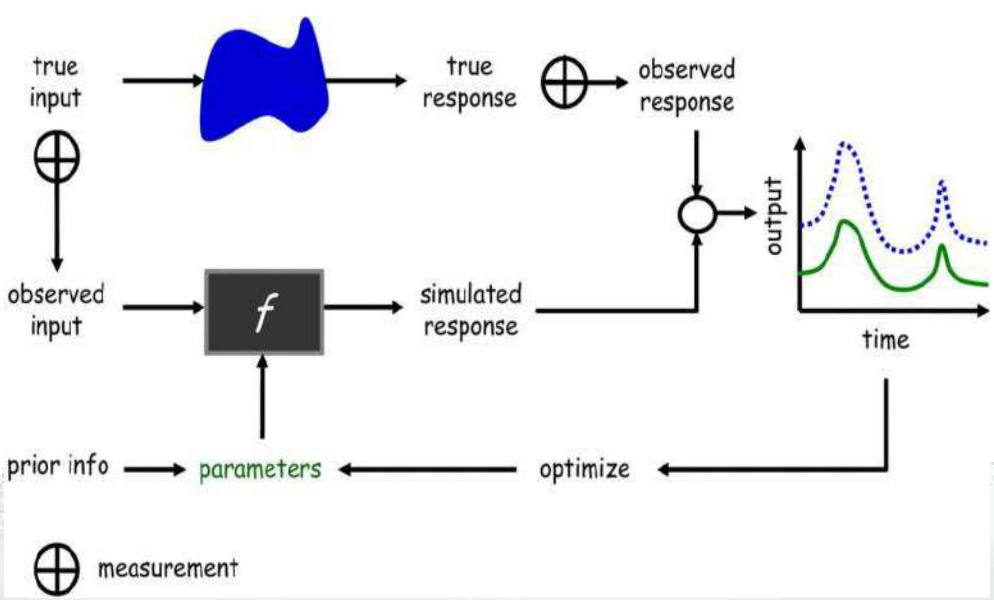




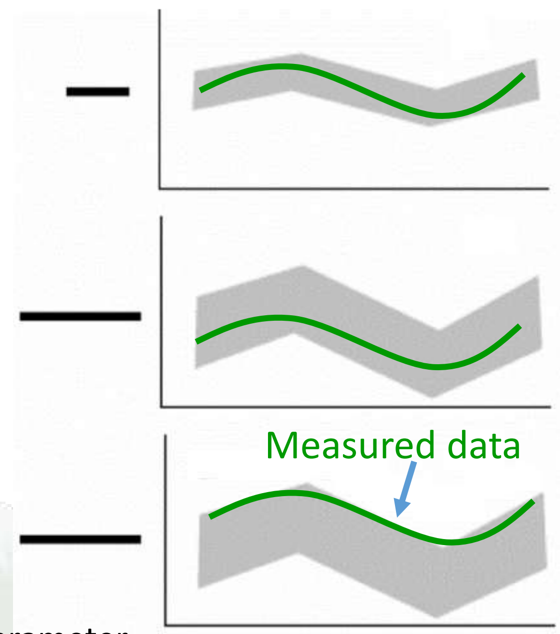
Carbon Stocks Assessment Approaches

Modeling only with measurement support

- Relies on modeling to quantify the SOC change but uses measurement support by way of a well- established network of monitoring sites.
- Proposes establishing a set of key ‘sentinel sites’ across the project domain, generating high-quality validation data from a wide range of combinations of practices, land types, and weather/soil/topographic conditions for which the model will be applied.
- Require some on-going measurements to ensure that the model remains validated.
- The overall cost of this approach will be low, and this will be a versatile approach.
- Carbon credits can be issued annually based on model estimates supported by measurements.



Vrugt *et al.* 2008, Vadose Zone Journal



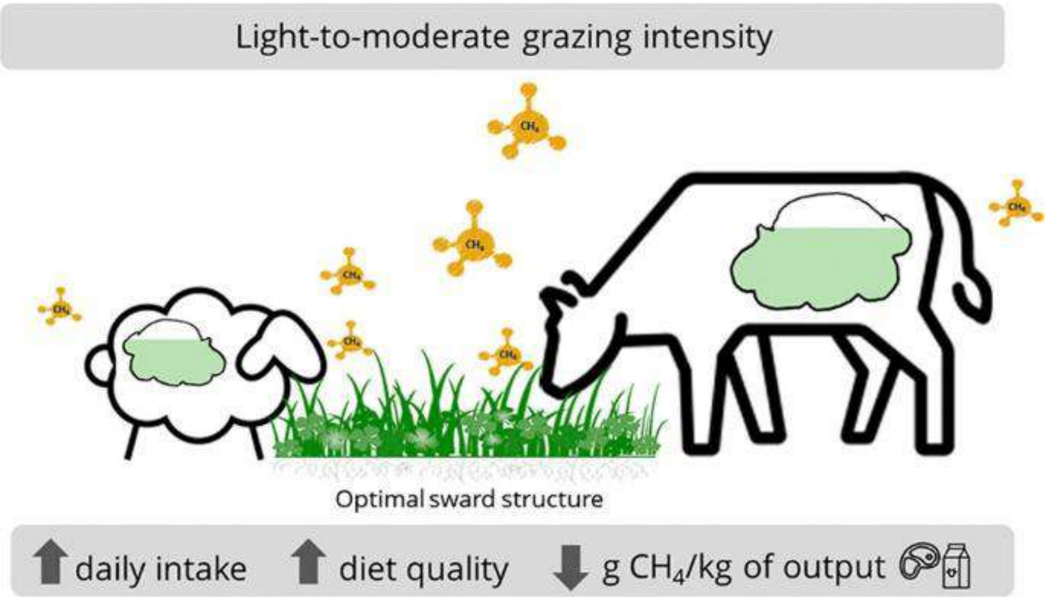
Parameter range

Model outputs

Carbon Sequestration Assessment of Improved Livestock Farming

High grazing intensity shifts pasture vegetation composition towards less desirable plant communities.

Overgrazing limits potential carbon sequestration in pastures and accelerates carbon loss from soil by increasing erosion and deterioration of soil structure.



Sánchez Zubieta et al., 2021, STOTEN 754 (142029)

Optimizing grazing pressure and improving grazing livestock distribution is critical to fully benefit from the carbon sequestration capacity of natural grasslands and traditional livestock herding practices.

Improved grazing management through herd restructuring (more intensive to less intensive grazing pressure) and promoting seasonal pasture rotations can potentially rehabilitate vegetation and soil in degraded pastures in the short-term.

Carbon Sequestration from Herd Restructuring

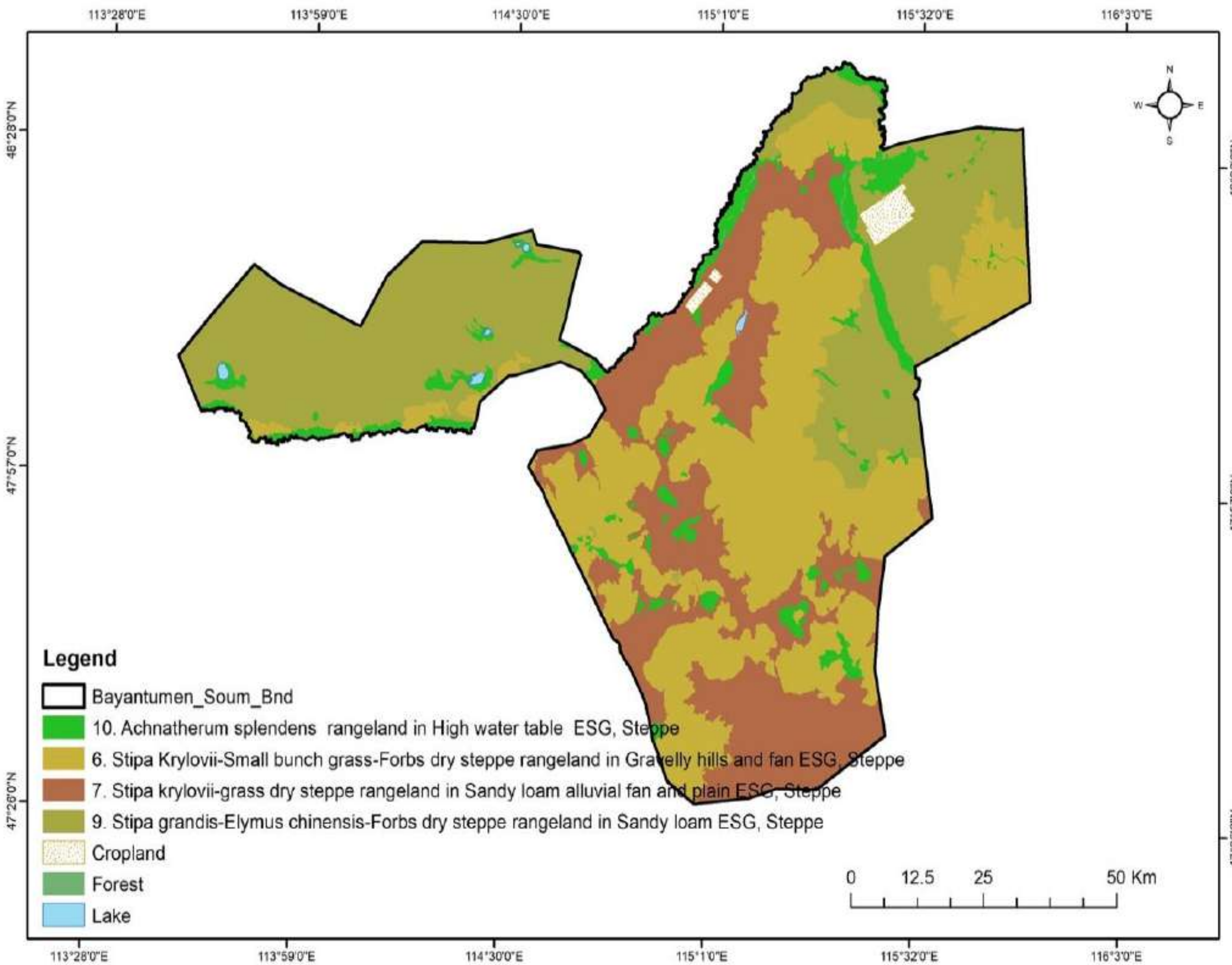
Assuming an average climate and livestock-marketing year , herd restructuring can potentially drop the number of grazing cattle by 20% (333 to 267 SUs) and sheep by 30% (381 to 264 SUs) in the short term (3-5 years).

Cattle types	Current - 20 Adult Cows			
	Total Aug	**Total Dec**	**SUs Aug^**	**SUs Dec^**
Adult cows (42 months and older)	20	17*!	120	102
Calves (born in spring)	19	18*	38	36
Yearlings (16-18 months old)	18	17*	54	51
Steers (30 months old)	8	7*	48	42
Replacement heifers (30 months old)	8	5ā	48	30
Non-pregnant replacement heifers (34 months old)	0	3!	0	21
Steers (42 months old)	8	7*	48	42
Steers (54 months old)	7	0!	42	0
Bull for breeding	1	1	6	6
Open cows (48 months and older)	3	2!	18	12
Total	**92**	**77**	**422**	**333**

Cattle types	With Project - 40 Adult Cows			
	Total Aug	**Total Dec**	**SUs Aug^**	**SUs Dec^**
Adult beef cows (42 months and older)	35	30*!	210	180
Adult milk cows (42 months and older)	5	5	30	30
Calves (born in spring)	40	5£!	80	10
Replacement heifers (18 months old)£	5	5ā	15	15
Replacement heifers (30 months old)ā	5	4*	30	24
Non-pregnant replacement heifers (34 months old)	1	0!	6	0
Bull for breeding	2	2	12	12
Total	**93**	**51**	**383**	**267**

Carbon Sequestration from Herd Restructuring

Map of Ecological Site Groups of Rangelands in Bayantumen Soum.



Mongolian rangelands are divided into around 22 ecological site groups, based on their productivity and capacity to endure different intensities of use, and to recover and regrow after being used.

Based on the vegetation plot data and state and transition models, the majority of vegetation communities within the *soum* area have the potential to recover in the short-term through optimized grazing and pasture management.

Vegetation Carbon Sequestration from Herd Restructuring

Forage yield for different states (health) of key ecological site groups (ESGs) in Bayantumen Soum.

Steppe Zone			
***Stipa krylovii* – grass dry steppe rangeland in sandy loam alluvial fan and plan ESG**			
Reference state	Grass-thinned state	*Artemisia frigida* or *Kochia prostata* dominate	Degraded state
890-1000 kg/ha	550-620 kg/ha	370-425 kg/ha	370-425 kg/ha
30-34 SU/100 ha	30-34 SU/100 ha	18-21 SU/100 ha	18-21 SU/100 ha
Stipa grandis – Elymus chinensis – forbs dry steppe rangeland in sandy loam alluvial plan and fan ESG			
Reference state	Forb decreased state	Stipa grandis decreased	Degraded state
1300-1470 kg/ha	760-800 kg/ha	670-710 kg/ha	350-370 kg/ha
78-86 SU/100 ha	41-44 SU/100 ha	34-36 SU/100 ha	17-18 SUs/100 ha
***Achnatherum splendens* rangeland in high water table ESG**			
Reference state	Grass decreased state		Degraded state
380 - 400 kg/ha	150 - 290 kg/ha		80 -130 kg/ha
22-24 SU/100 ha	8-16 SU/100 ha		4 -7 SU/100 ha
***Stipa krylovii*-small bunch grass forbs dry steppe rangeland in gravelly hills and fan ESG**			
Reference state	Grass-thinned state		Degraded state
970-1030 kg/ha	900-940 kg/ha		362-679 kg/ha
57-62 SU/100 ha	45-52 SU/100 ha		18-34 SU/100 ha

Considering coarse estimates of the current state of vegetation, and rough estimates of the distribution and area proportion of seasonal pastures.

Soil Carbon Sequestration from Herd Restructuring

- Realistic ranges (i.e., min and max) of carbon sequestration rates (tC/ha/yr) from relevant studies for both pasture vegetation and soil, including sequestration rates for different levels of degradation (heavily vs. moderately degraded), grazing pressures (high vs. moderate) and grazing system practices (continues vs. rotational).
- Carbon sequestration ranges for Ecological Site Groups (ESGs) by considering coarse estimates of the current state of vegetation and soil, and rough estimates of the distribution and area proportion of seasonal pastures.

Ecological Site	Area (ha)	C sequestration (t /ha/yr)		C sequestration (t CO2e/ha/yr)		C sequestration (t /yr)		C sequestration (t CO2e/yr)	
		Min	Max	Min	Max	Min	Max	Min	Max
6. Stipa Krylovii-Small bunch grass-Forbs dry steppe rangeland in Gravelly hills and fan ESG, Steppe	301,950	0.15	0.34	0.55	1.47	45,293	102,663	166,073	442,860
9. Stipa grandis-Elymus chinensis-Forbs dry steppe rangeland in Sandy loam ESG, Steppe	275,727	0.05	0.15	0.18	0.55	13,786	41,359	50,550	151,650
7. Stipa krylovii-grass dry steppe rangeland in Sandy loam alluvial fan and plain ESG, Steppe	192,157	0.1	0.25	0.37	0.92	19,216	48,039	70,458	176,144
10. Achnatherum splendens rangeland in High water table ESG, Steppe	55,779	0.15	0.3	0.55	1.25	8,367	16,734	30,678	69,538
Total	**835,680**					**86,661**	**208,795**	**317,758**	**840,192**

Carbon Sequestration from Herd Restructuring

- Annual sequestration estimate of 99.8 to 224.3 thousand tons of carbon or 366.1 to 897.1 thousand tons of CO_2e from pasture vegetation and soil (86.8% to 93% in the soil).
- Annual sequestration rate of 0.12 to 0.27 tons carbon per hectare per year or 0.44 to 1.07 tons CO_2e per hectare per year.
- Equal to removal of direct GHG emission from 202 to 495 thousand cattle heads or 1,570 to 3800 thousand sheep heads annually.
- Equal to CO_2e removal by 18.3 to 44.8 thousand typical young trees annually (based on a conservative annual carbon removal of 20 kg).

Ecological Site (ESGs)	Area (10^3 ha)	Vegetation C Sequestration				Soil C Sequestration			
		Total C (10^3t/yr)**		Total CO_2e (10^3t/yr)!		Total C (10^3t/yr)		Total CO_2e (10^3t/yr)	
		Min	Max	Min	Max	Min	Max	Min	Max
6. *Stipa Krylovii*-Small bunch grass-Forbs dry steppe rangeland	302.0	5.7	6.8	20.9	24.8	45.3	102.7	166.1	442.9
9. *Stipa grandis-Elymus chinensis*-Forbs dry steppe rangeland	275.7	4.3	5.1	15.9	18.8	13.8	41.4	50.5	151.6
7. *Stipa krylovii*-grass dry steppe rangeland	192.2	2.8	3.3	10.3	11.9	19.2	48.0	70.5	176.1
10. *Achnatherum splendens* rangeland	55.8	0.3	0.4	1.2	1.4	8.4	16.7	30.7	69.5
Total	835.7	13.2	15.5	48.3	56.9	86.7	208.8	317.8	840.2

** Carbon sequestration rates across ESGs ranged from 0.006 to 0.022 and 0.05 to 0.34 tC/ha/yr for vegetation and soil, respectively.
! A conversion factor of 44/12 or 3.67 was used to calculate the CO2e of the carbon sequestration estimates.

Preferred Carbon Stocks Assessment Approach for Mongolia

- SOC stocks can be measured directly, but it can take many years to detect a discernable change in SOC stocks due to significant variability in measurements, management, and weather.
- As an alternative, SOC stocks and their changes can be estimated with process models of SOC – but it is essential that those models are validated with high-quality empirical data.
- The preferred approach is to utilize process models supported by measurements from a monitoring network of sites across the country collecting high-quality data, a Grassland Carbon Observation Network.
- The establishment of this network is the critical and fundamental initial goal on the roadmap towards better, more practical quantification of SOC stocks and their changes.
- The network will collect, manage, and share datasets of observed SOC change paired with information on management practices, soils, climates, and grasslands across the nation to validate and calibrate models.
- The network will leverage all the value possible from relevant past studies of grasslands but, importantly, it will also include new ongoing observations to provide the data to evaluate models for current grassland management and conditions.

Swainson's Hawk (*Buteo swainsoni*)

Picture: ABMI NatureLynx

Questions and feedback

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