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ENVIRONMENTAL IMPACT ASSESSMENT OF MILK PRODUCTION: IS A SIMPLIFIED TOOL POSSIBLE?

BACKGROUND

From studies carried out in the last 10 years, on a very large number of dairy cattle farms in Northern Italy, mostly intensive, it has been estimated that the production of a kilogram of fat and protein corrected milk results in emissions ranging from a minimum of 1.3 to a maximum of 2.7 kg of CO_2 eq, with an average value of about 2.0 kg of CO_2 eq /kg milk

ENVIRONMENTAL IMPACT ASSESSMENT

Life Cycle Assessment-LCA

SHARED EVALUATING METHOD

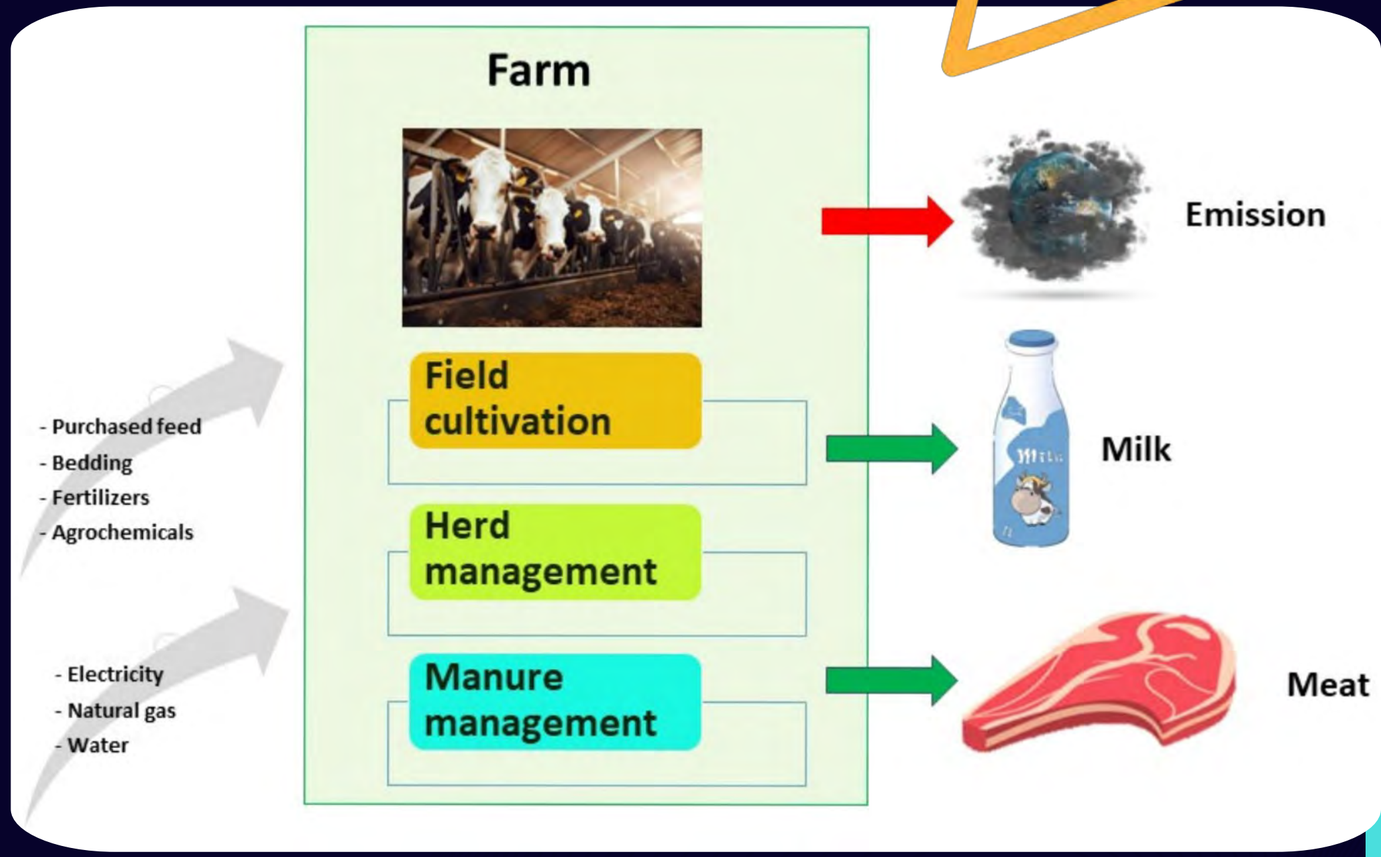
TIME CONSUMING METHOD

01 Allows to assess the overall impact of each phase of the production process, considering the entire life cycle of the product.

02 Allows the identification of critical points and emission-related issues, using a common method evaluating

03 All the inputs necessary for production are considered, e.g. raw materials and energy used in processes.

04 All that is produced by the system (all the outputs) are calculated, namely milk and meat, but also emissions.



AIM

To develop a simplified system for estimation of the carbon footprint of cow milk, which can be used by farmers:

- **as a self-assessment system**
- **to simulate what would happen if some indicators varied**

SIMPLIFIED SYSTEM FOR THE EVALUATION OF CLIMATE CHANGE OF MILK PRODUCTION

ANAFIBIJ

- Data of animal management
- Data of fertility
- Genetic Indices

DISAA

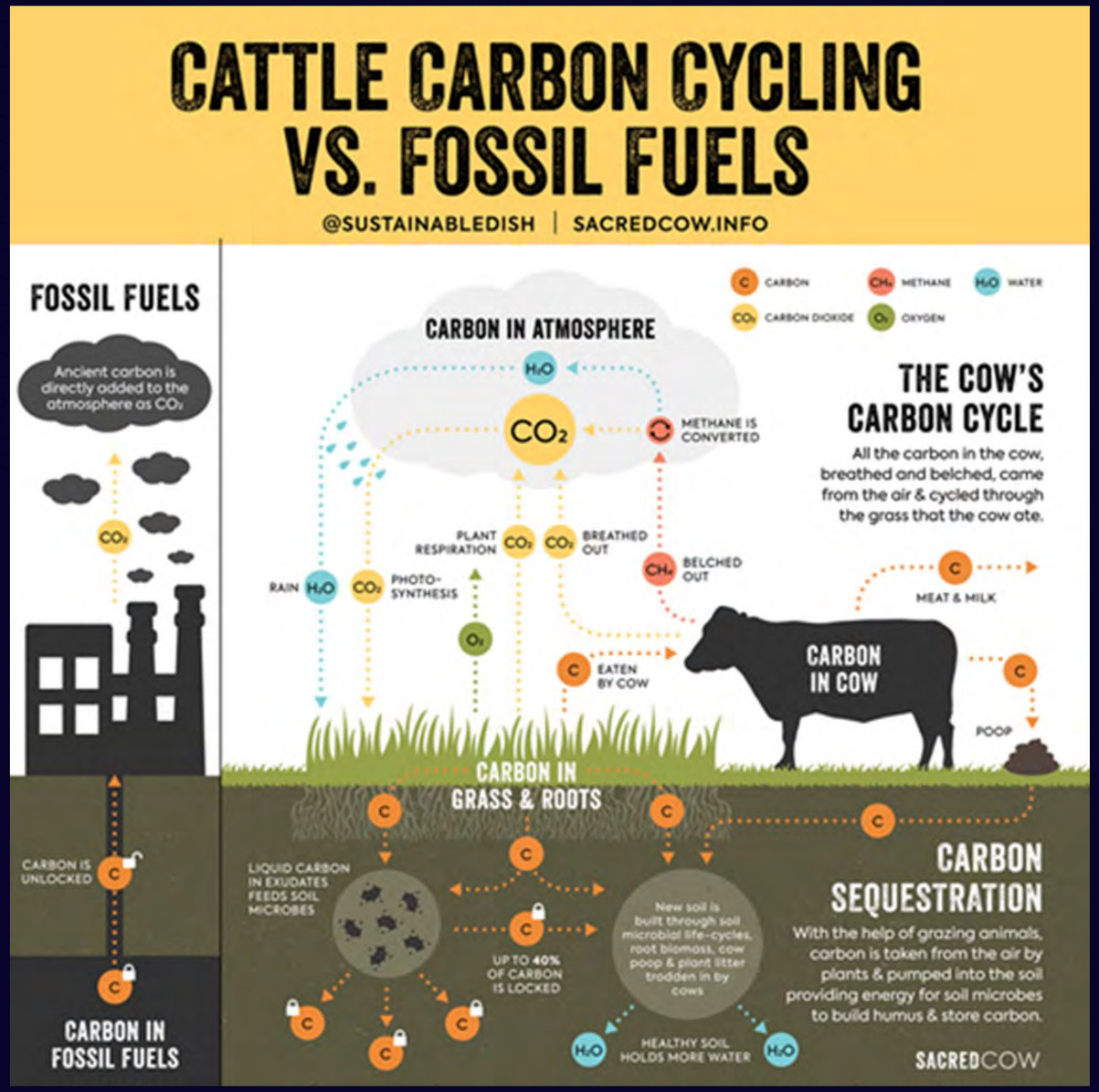
- Calculation for estimating environmental impact
- Experience in applying Life Cycle Assessment method

FARM SAMPLE

- 54 farms (Holstein Friesian cows) located in Northern Italy, in plain and hill areas
- Complete LCA analysis
- Performance data: production, management and fertility data (i.e. pregnant cows at 120 d, and milk sold per Livestock Unit, LU), and genetic indices (i.e. Health and Economic Index - IES, predicted Methane Emission Index - pCH4)

LIFE CYCLE ASSESSMENT

- Goal of this LCA: quantify the climate change of milk production
- Functional Unit: 1 kg FPCM
- Allocation milk and meat: physical method (IDF, 2015)
- System boundaries: from cradle to farm gate
- Primary data, secondary data (Ecoinvent and Agri-footprint databases) and proxy
- Emissions of greenhouse gases in air: IPCC 2019 guidelines
- Characterization: EF 3.0 method, software SimaPro V 8.3.



CLIMATE CHANGE

Carbon from enteric fermentations

The biogenic carbon is part of a cycle that is considered in equilibrium with carbon fixed and stored by plants in the form of carbohydrates, and ingested by animals

Carbon from fossil fuels

It represents new carbon transfers, from long-term geological reserves to the atmosphere, meaning a net addition of carbon in the atmosphere

STATISTICAL ANALYSIS

- **SAS and R studio Software**
- **DESCRIPTIVE STATISTICS**
- **MULTIVARIATE ANALYSIS:** performed using CC, farm characteristics and performance data.
  A Principal Component Analysis (PCA, Proc PRINCOMP) to find a multidimensional relation between variables.
- **PREVISIONAL EQUATION: linear model with stepwise selection.**
  Starting from a **collinearity test**, variables with high VIF (**Variance Inflation Factor**) were excluded from the dataset.
  Stepwise procedure (Ordinary Least Squares, OLS) to select the best parameters for CC_es.
  Validation of the equation was performed by randomly selecting 15 farms from the database 1,000 times to test the equation, and the average correlation coefficient between CC_es and CC was calculated.

RESULTS-DESCRIPTIVE STATISTICS

Table 1. Summary of descriptive statistic

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Variable	Unit	Mean	Std	Min	Max
Lactating cows	n	232	186	56.0	817
FPCM[1] per lactation	kg	9591	1357	6754	13284
Fat	%	3.83	0.23	3.28	4.23
Protein	%	3.40	0.12	3.02	3.70
Soybean meal in the ration	%	10.7	5.28	0	22.5
IES index[2]		161	159	-93.6	733
CH4 index[3]		100	1.42	97.1	105
Age at first calving	month	26.9	2.47	23.0	34.7
Pregnant cows at 120 d	%	58.3	9.25	37.0	73.0
Milk sold per LU[4]	kg	6239	827	4494	8093

[1] FPCM, Fat and Protein Corrected Milk

[2] IES index, Health and Economic Index, Expresses as the expected economic difference (€) of individual animals (or daughters of bulls) from the reference genetic basis.

[3] CH4 index, Methane Emission Index

[4] LU, Livestock Unit

RESULTS-PCA

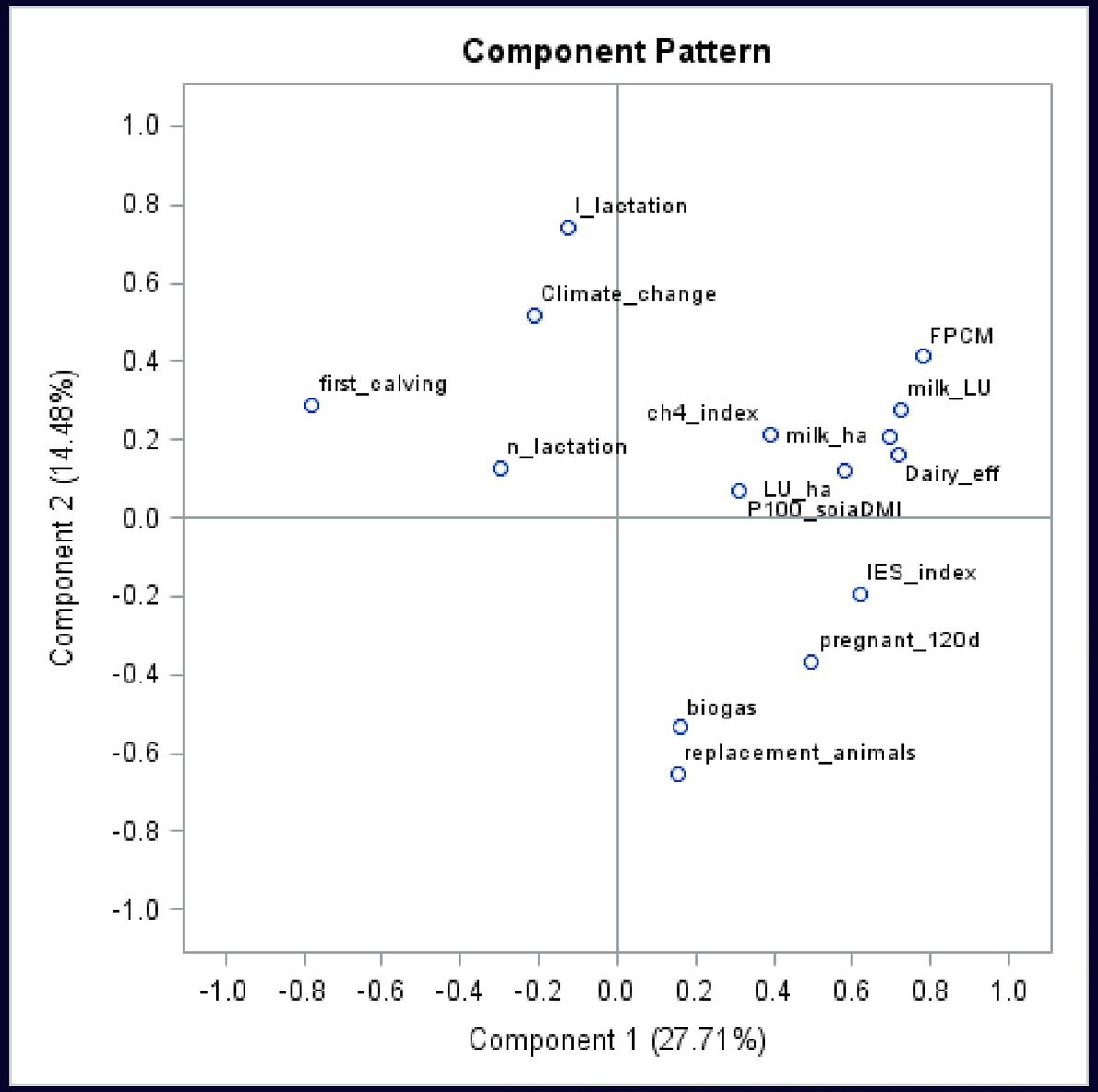


Figure 1. Results of PCA

FPCM= Fat and Protein Corrected Milk
IES index= Health and Economic Index
CH4 index= Methane Emission Index
LU= Livestock Unit

RESULTS-ESTIMATION OF CC

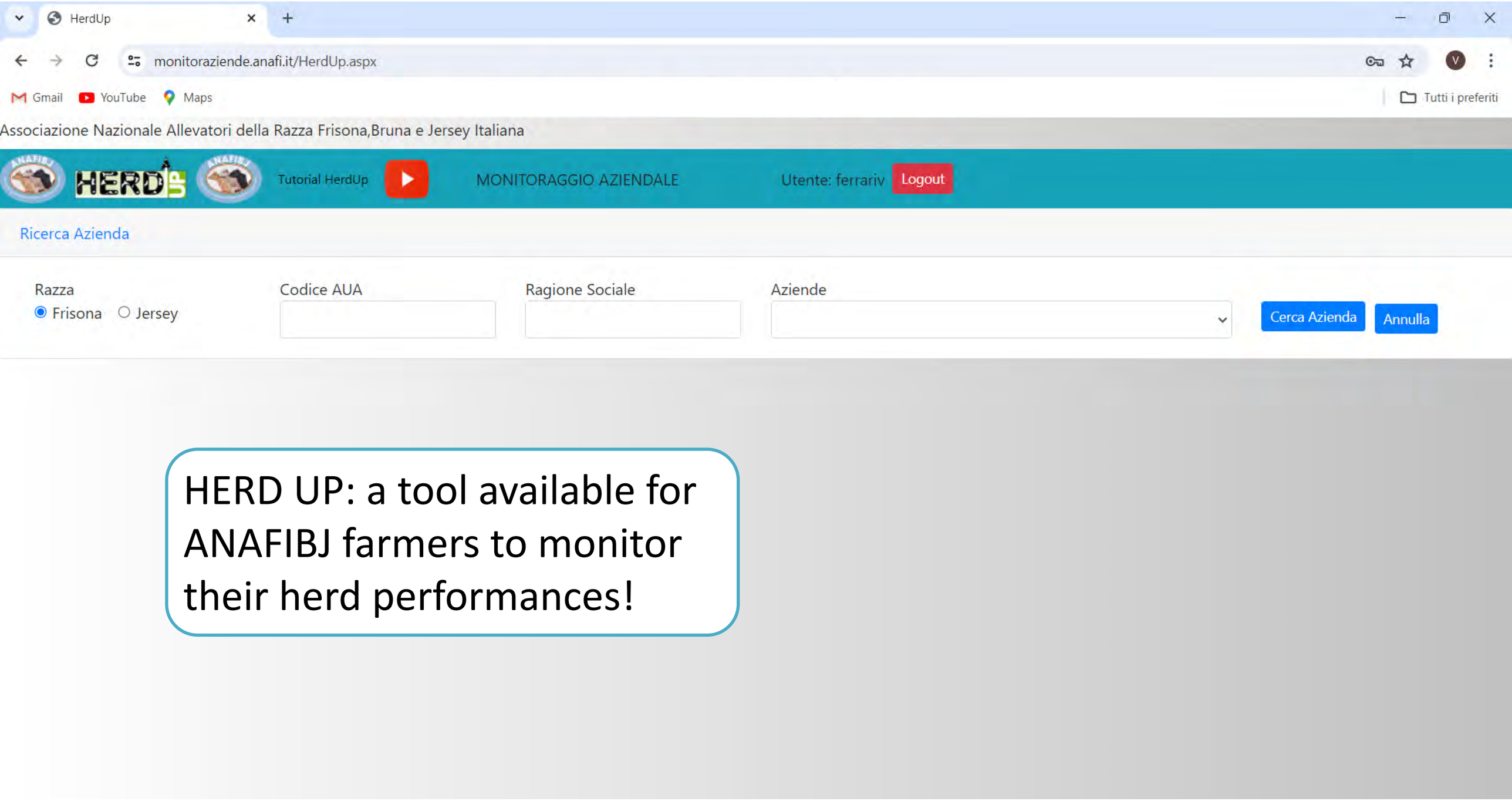
Table 2. Variables selected for the estimation of CC

Variable
Biogas
Percentage of soybean meal in the ration
IES index[1]
CH4 index[2]
Age at first calving
Pregnant cows at 120 d
Milk sold per LU[3]

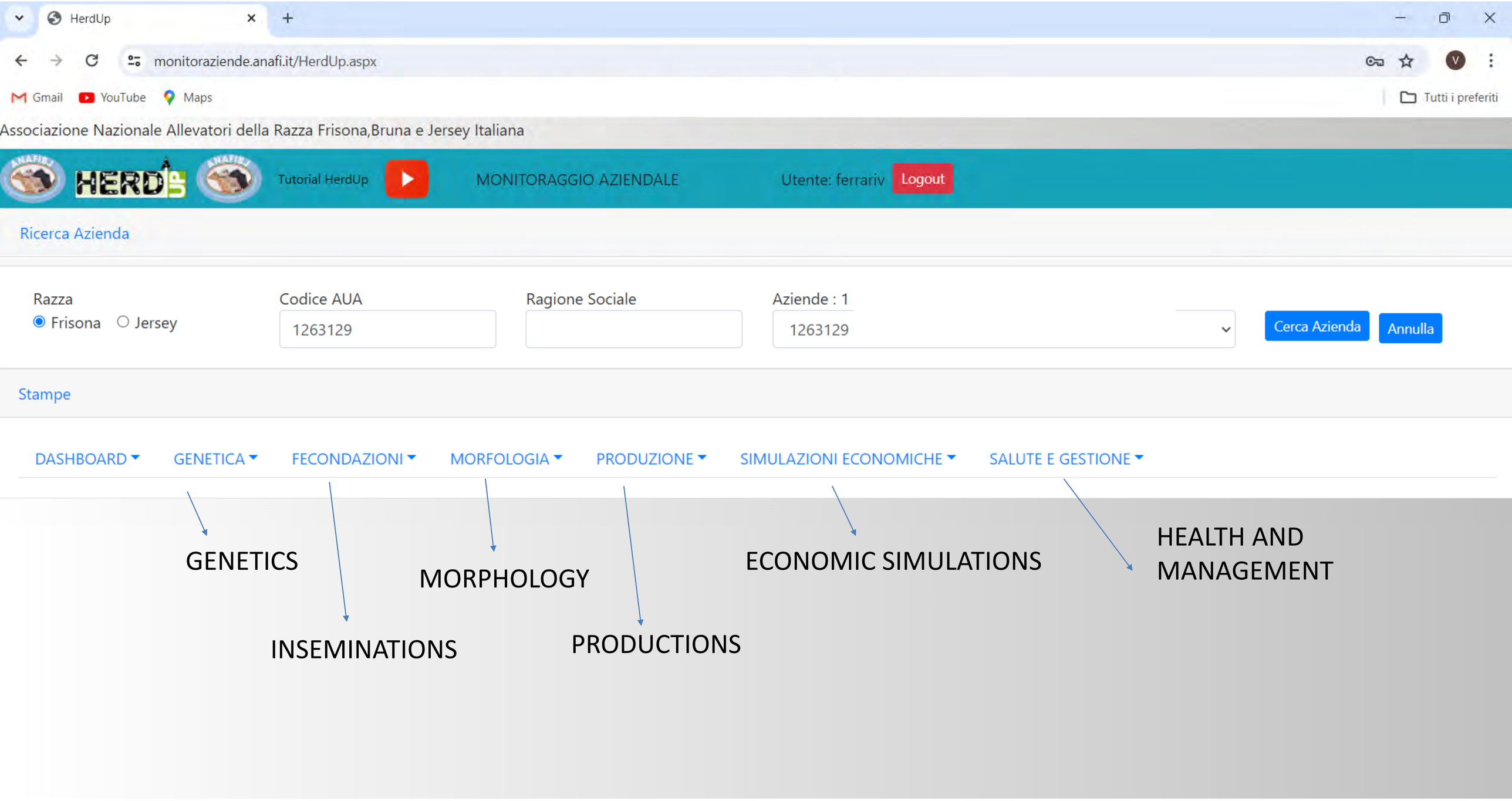
[1] IES index, Health and Economic Index
[2] CH4 index, Methane Emission Index
[3] LU, Livestock Unit

Adjusted R2 of the equation was 0.63
Average correlation coefficient between CC_es and CC was 0.77

EXAMPLES OF APPLICATION



HERD UP: a tool available for ANAFIBJ farmers to monitor their herd performances!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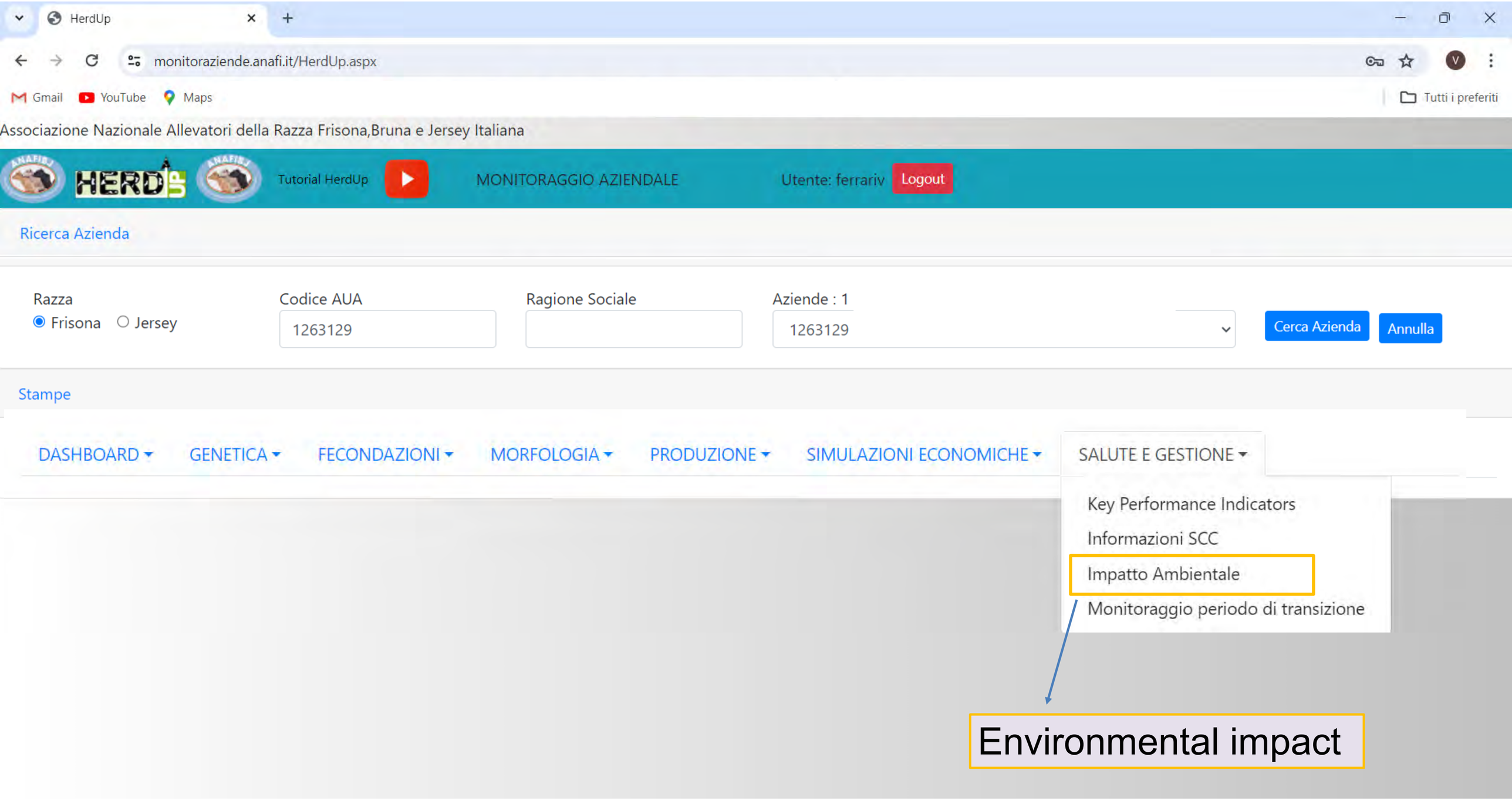
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SIMULAZIONI ECONOMICHE
SALUTE E GESTIONE
Key Performance Indicators
Informazioni SCC
Impatto Ambientale
Monitoraggio periodo di transizione
Environmental impact

Example HERD 1

Total UAA (Utilised agricultural area)	0
Biogas	◉Si ○No
Organic Farm	○Si ◉No
Amount of hay in the ration (kg/d)	12,30
Amount of soybean meal in the ration (kg/d)	1,73
Total feed quantity (kg/d)	0,00
Amount of protein concentrate in the ration (kg/d)	0,00
Total dry matter intake per day	27,50

Parametri	Default	Simulazione
Reference year	2024	
Daily milk yield of current cows (kg/d)	36,93	40,00
Estimated annual herd milk production (q/year)	43808,21	47450,00
Fat (%)	4,27	
Protein (%)	3,59	
Cows (lactation + dry) (n)	325	
Heifers > 12 mo (n)	164	
Heifers between 12 and 6 mo (n)	84	
Female calves < 6 mo (n)	85	
Age at first calving (mo)	24,27	
Average IES (Economic Sustainability Index) (Average of last 5 years)	380	
Average Predicted Methane Emission Index	101	
Herd milk yield sold/LU (livestock units)	8103,63	8777,28
Pregnant cows at 120 d (%)	66	70
Herd environmental impact (kg CO2 eq./ kg milk)	0,98	0,90

Example HERD 2

Total UAA (Utilised agricultural area)	121
Biogas	○Si ◉No
Organic Farm	○Si ◉No
Amount of hay in the ration (kg/d)	12,30
Amount of soybean meal in the ration (kg/d)	2,70
Total feed quantity (kg/d)	0,00
Amount of protein concentrate in the ration (kg/d)	0,00
Total dry matter intake per day	28,50

Parametri	Default	Simulazione
Reference year	2024	
Daily milk yield of current cows (kg/d)	39,70	40,00
Estimated annual herd milk production (q/year)	47094,13	47450,00
Fat (%)	4,22	
Protein (%)	3,73	
Cows (lactation + dry) (n)	325	
Heifers > 12 mo (n)	83	
Heifers between 12 and 6 mo (n)	43	
Female calves < 6 mo (n)	51	
Age at first calving (mo)	22,43	
Average IES (Economic Sustainability Index) (Average of last 5 years)	559	
Average Predicted Methane Emission Index	101	
Herd milk yield sold/LU (livestock units)	10761,91	10843,24
Pregnant cows at 120 d (%)	62	70
Herd environmental impact (kg CO2 eq./ kg milk)	1,23	1,16

Future perspectives

- This is a «pilot» version.
- Enroll new farms to enlarge the data sample…in progress.
- For more details about the tool, please contact valentinaferrari@anafi.it

your COW
our FUTURE

Thank you for your attention!

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www.anafibj.it

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