Assessing circularity at farm gate

the SENSE project

SENSE

Synergies in Integrated Systems
Improving Resource Use Efficiency
While Mitigating GHG Emissions Through
Well-Informed Decisions about Circularity

"Synergies in integrated systems: Improving resource use efficiency while mitigating GHG emissions through well-informed decisions about circularity"

Elena Testani – 02 March 2023

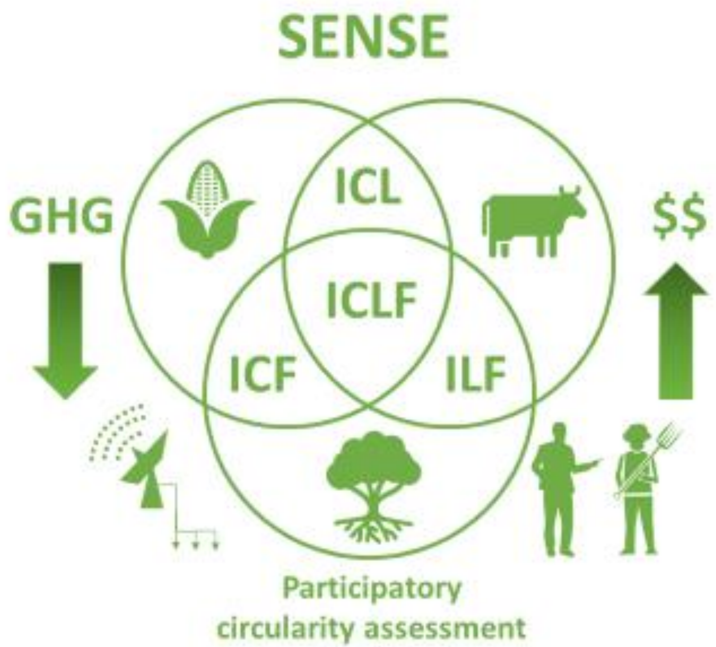
The SENSE project

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

SENSE
Synergies in Integrated Systems
Improving Resource Use Efficiency
While Mitigating GHG Emissions Through
Well-Informed Decisions about Circularity

Key words:
Integrated crop-livestock-forestry systems, Circularity, GHG mitigation, Resource use efficiency

Integrated crop-livestock-forestry systems offer multiple opportunities to reduce the environmental impact of agricultural production systems, to improve circularity in agriculture and as a key greenhouse gas (GHG) mitigation strategy.



WP 4

Evaluating at farm level, the side effects of circularity measures on other societal goals based on multidimensional sustainability assessment tools.

WP 3

Simulating (process-based Models) contrasting scenarios of C, N-P, water, biomass flows in the CSs, predicting trajectories to redesign systems towards more complete local circularity.

The aim: to obtain a clear picture of potential synergies and trade-offs coming from circularity before prioritizing solutions

WP 2

Developing a matrix of (existing) indicators for effective quantification of the status of circularity within various integrated system case studies.

SENSE is funded by the Joint Call of the Cofund ERA-Nets SusCrop, FACCE ERA-GAS, ICT-AGRI-FOOD and SusAn. Coordinated by the James Hutton Institute (Dr. Jagadeesh Jeluripati), started in March 2022 and involving 10 Institutions in 7 countries (4 in EU and 3 in SA).

Assessing circularity at farm gate

Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

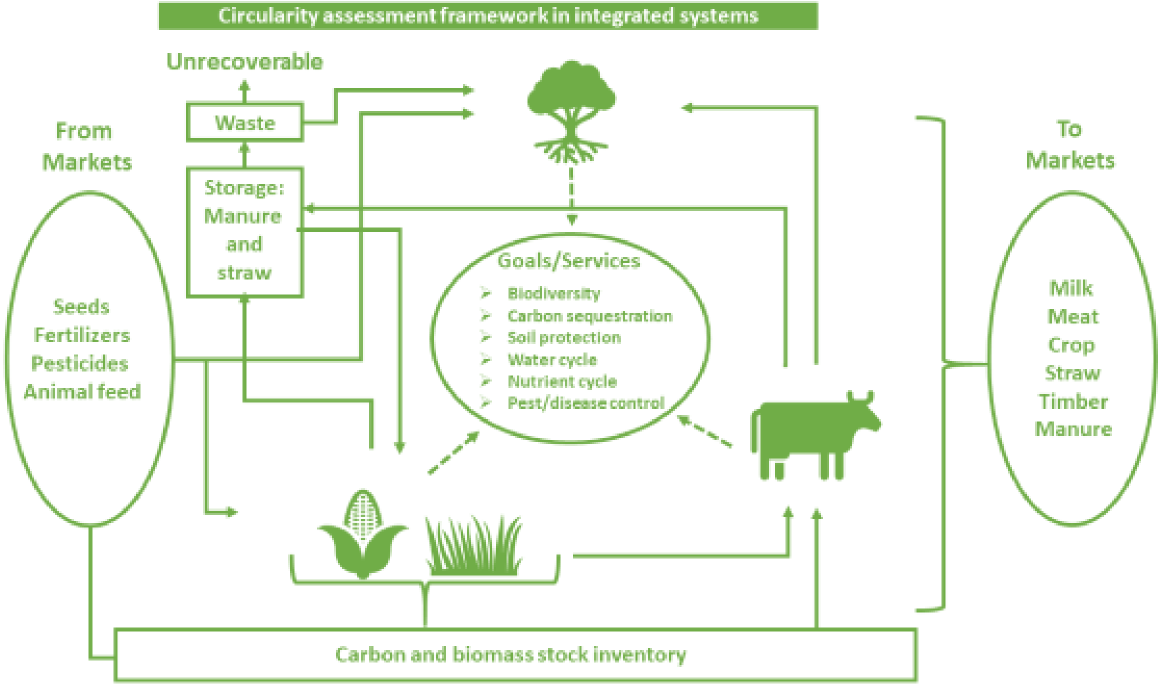
SENSE
Synergies in Integrated Systems
Improving Resource Use Efficiency
While Mitigating GHG Emissions Through
Well-Informed Decisions about Circularity

General objective: to assess the **level of circularity** of the SENSE CSs, before and after circular measures implementation

How do farmers manage the flows of biomasses, nutrients, water and resources within their own farm?

Macro-areas of investigation

- **Self-sufficiency for feed and forage**
- **Nutrient and water use efficiency**
- **Waste recycling**



What we will be able to do

- **Identify rooms of improvement of circularity in terms of land and resources management**
- **Supply a tool to farmers to assess circularity and as base for participatory discussion**
- **Assess improvements in circularity after circular measure implementation**

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

Circularity indicators

SENSE
Synergies in Integrated Systems Improving Resource Use Efficiency While Mitigating GHG Emissions Through Well-Informed Decisions about Circularity

In general:

Indicators are useful for informing about the **status of a system**, for **interpreting and summarizing complex processes**, and for **communicating effectively with stakeholders**.

Mandatory characteristics:

1. **Sensitive**. Able to detect changes timely and react to management adjustments.
2. **Intuitive**. Provide information about the process clearly without ambiguity. Easily understood by stakeholders
3. **Accepted**. Scientifically-based and transparent in terms of calculation methodology, data availability and evaluation

In SENSE:

Macro-area	Sub-area	Description	Number of Indicators
Self-sufficiency for feed and forage	Dry matter	Ratio between purchased FF and total consumption, by considering the dry content, the energy part and protein part of FF inputs (SSFF)	3
	Energy content		
	Protein content		
Resource use efficiency	Nitrogen	N-P use efficiency (NUE; PUE)	4
	Phosphorous	N-P farm-gate balance (NB; PB)	
	Water	Ratio between farm outputs (sold products in energy equivalent per hectare) and total use	2
		Ratio between use from catchments and total use (from natural supplies and catchments); Efficiency is increased by the use of natural supplies, is lowered by the use of catchments	
Waste recycling	Carbon flow	Ratio between waste exported out of the systems and total waste produced (animal waste and crop residues), by considering their C and N part	2
	Nitrogen flow		

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

Circularity indicators

SENSE
While Mitigating GHG Emissions Through Well-Informed Decisions about Circularity

Self-sufficiency for feed and forage

→ SSFF= $\frac{\sum(Fint \times C)i}{\sum(Fint \times C)i + \sum(Fext \times C)j} \times 100$

The closer the value is to 100, the higher the level of self-sufficiency of the system for animal feed and forage.

List of all the animal feeding inputs, specifying type, amount in Mg year^{-1}, if self-produced or purchased, humidity %, protein fraction%, energy content (kcal kg^{-1})

Nutrient and water use

→ NUE = $\frac{\sum(N\ output)i}{\sum(N\ ext\ Input)j} \times 100$;

→ NB = $\Sigma\ (Next\ Input)i - \Sigma(N\ output)j$

The closer the value is to 100 (N ext input tend to N output of the system), the higher the level of efficiency for nutrient use.

The same approach for P

List of all the N-P external (purchased) sources, specifying type, amount in Mg ha^{-1}, humidity %, N%, P%

List of all the N-P outputs (sold products or biomasses exported out from the farm), specifying type, amount in Mg ha^{-1}, humidity %, N%, P%

→ WUE (MJ m^{-3}) = $\frac{\sum(Energy\ output)i}{\sum(Winput)j - \sum(Wlosses)j}$

Efficiency in water use is increased by the use of precipitation, water harvesting devices and surface water supplies, is lowered by the use of groundwater.

Waste recycling

→ WR = $\frac{\sum(Rec\ W \times F)i}{\sum(W \times F)j} \times 100$

The closer the value is to 100, the higher the level of efficiency for waste recycling.

List of all the green and animal waste, specifying the type, the amount in Mg ha^{-1}, humidity %, N and C% and if recyled or exported out from the farm.

As a result, the WP is linearly related to the ratio MJ m^{-3}.

List of all the water inputs to produce farm products, specifying the amount in m^{3} ha^{-1} and the source (precipitation, water harvesting devices, surface water supplies, groundwater)

List of sold products, specifying the amount in Mg ha^{-1}, humidity %, C and N % on dry weight base

Ecological indicators

Measurements at plot scale

Synergies in Integrated Systems
Improving Resource Use Efficiency
While Mitigating GHG Emissions Through
Well-Informed Decisions about Circularity

Hypothesis: the **synergistic association of animal-crop/forestry components** in mixed systems may lead to several benefits which can be expected at field level in relation to **ecosystem services provision and functioning**

Effects on above (**pasture**) and below (**soil**) – ground diversity and functionality to supply more information on system **potential to retain nutrients and C, mitigating GHG emissions, enhancing circularity**

List of indicators

Above and belowground component	Ecological indicators	Relevance to the project scope	How
Soil	Soil C and nutrient content	C storage and GHG mitigation	soil sampling and analysis
	soil enzyme activity (N-C cycles)		
	Microbial Biomass Carbon - MBC		
	Bulk density		
	pH		
	Infiltration rate		
	Aggregate size distribution and stability		
Pasture	biomass	Circularity enhancement	biomass samplings and analysis
	Biomass N-C content		
	Fiber content		
	Digestibility		
	Diversity assessment		phytosociological surveys, diversity indices computing, trait analysis

Ecological indicators

Synergies in Integrated Systems
Improving Resource Use Efficiency
While Mitigating GHG Emissions Through
Well-Informed Decisions about Circularity

Where? In randomized treatments representing the integration of components and at least a **control** where the crop/forestry component is not present

When? During the most intensive grazing time when plant and soil activity is at maximum stage, for two monitoring consecutive years

to return a more **comprehensive evaluation of systems** and **give new arguments for stakeholders to boost innovations and leverage circularity**


crea
Consiglio per la ricerca in agricoltura
e l'analisi dell'economia agraria
Thank you

Who is CREA, who I am

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

CREA CENTERS

12 Research Centers

- **AA** Agriculture and Environment
- **GB** Genomics and Bioinformatics
- **DC** Plant protection and Certification
- **IT** Agricultural Engineering and Food Transformation
- **AN** Food and Nutrition
- **PB** Politics and Bio-economy
- **ZA** Zootechnics and Aquaculture
- **FL** Forestries and Wood
- **CI** Cereals and Industrial Crops
- **VE** Viticulture and Oenology
- **OF** Horticulture and Floricolture
- **OFA** Fruit, Citrus, and Olives Trees

CREA-AA carries out studies and research for the characterisation, sustainable management and space-time modelling of agricultural and forest ecosystems through an inter and multidisciplinary approach.

Elena Testani
Researcher at CREA-AA since 2017, permanent position since 2019
Research assistant at CREA–AA (formerly CRA-RPS) form 2011 to 2016)
elena.testani@crea.gov.it

- **Re-designing of organic systems following agroecological approach**
  - **Diversification strategies (Agroforestry also)**
  - **Conservation practices**
- **Above and below-ground diversity and functionality assessment**
- **Participatory action Research**

https://www.crea.gov.it/