Synergies in Integrated Systems

Improving Resource Use Efficiency While Mitigating GHG Emissions

Through Well Informed Decisions about Circularity

D1.2 Technical Briefs – Germany

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Project Partners:

Funders:
The author(s)/editor(s) acknowledge the financial support through the partners of the Joint Call of the Cofund ERA-Nets SusCrop (Grant N° 771134), FACCE ERA-GAS (Grant N° 696356), ICT-AGRI-FOOD (Grant N° 862665) and SusAn (Grant N° 696231).

Project summary

Acronym	SENSE
Title	Synergies in integrated systems: Improving resource use efficiency while mitigating GHG emissions through well-informed decisions about circularity
Call	2021 Joint Call ERA-NET Cofund ICT-AGRI-FOOD, FACCE ERA-GAS, SusCrop and SusAn: Circularity in mixed crops and livestock farming systems with emphasis on climate change mitigation and adaptation
Duration	36 months
Website	https://sense-eranet.hutton.ac.uk/
Coordinator	The James Hutton Institute (JHI)
Partners	Centre for Ecology and Hydrology (CEH) University of Bristol (UOB) Stichting Wageningen Research (WUR) University of Hohenheim (UHOH) Demeter e.V. (Demeter) Consiglio per la ricerca in agricoltura e l'analisi dell'economia agrarian (CREA-AA) Brazilian Agricultural Research Corporation (Embrapa) National Institute of Agropecuarian Technology (INTA) Instituto Nacional de Investigación Agropecuaria (INIA)

Deliverable summary

Work package	WP1: Standardized data collection : SENSE centralized database
Task	Task 1.2: Preparing the Technical Briefs
Deliverable	D1.2: Technical Briefs
Responsible partner	WUR

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1 Introduction

Specialization, intensification and spatial separation of crop, livestock and forestry production systems have contributed to climate change and biodiversity loss. Circularity in integrated crop-livestock-forestry production systems may reduce the environmental impact of agricultural production systems by increasing resource-use efficiency while simultaneously mitigating greenhouse gases (GHG) emissions. The SENSE project (2021 Joint Call on Circularity) operates in various case studies involved in integrated crop-livestock-forestry systems in four European countries (Italy, Germany, the Netherlands, and the United Kingdom) and three South American countries (Argentina, Brazil and Uruguay).

The case studies conducted by SENSE can be classified into two categories, namely benchmark and participatory, depending on the availability of historical data and the data generated during the project. These case studies may take place on either an experimental station of a project partner or a commercial farm. In benchmark case studies, sensors will be deployed to enable near real-time monitoring of soil and climate properties (i.e. soil temperature and moisture, air temperature, rainfall, etc), to model GHG emissions and carbon and nutrient cycling (WP3). Circularity and ecological indicators will be assessed (WP2) and short-term circularity measures will be implemented and tested (WP2 and WP3). Case studies will be further co-assessed with farmers/farm managers with a multidimensional sustainability assessment tool (WP4). This will allow us to assess understanding of the current circularity status of these systems. The data we collect will drive models to determine alternate scenarios for improving resource use-efficiency while simultaneously mitigating GHG emissions (WP3), thus identifying best measures that will improve circularity within these integrated systems. To test the viability of GHG mitigation, options will be co-assessed with commercial farmers and their trade-offs with other ecosystem services and their effects on economic and environmental resilience will be further explored with a multidimensional sustainability assessment tool (WP4).

SENSE case studies in Europe and South America cover different climatic and pedological zones and exhibit different levels of integration in crop-livestock-forestry systems and a diverse range of establishment dates and species integration. A particular strength of the SENSE project is the longstanding experience (> 20 years) that South American partners have with the implementation of these integrated systems.

The aim of this Technical Brief is to present the characterization of the case studies in the SENSE project. This report showcases the case studies in Germany, which are coordinated by our partner UHOH.

2 Task description

In the first year of the project, a data template table has been developed and shared with all case study coordinators to compile the required data for site characterization. Compiled data includes: case study categories (i.e. benchmark, participatory, experimental station, commercial farm); type of integrated system (i.e. Integrated Crop-Livestock (ICL), Integrated Crop-Forestry (ICF), Integrated Livestock-Forestry (ILF), Integrated Crop-Livestock-Forestry (ICFL)); time under integration; area; climate and soil classification; as well as a brief description of the crop, livestock and forestry components. The results are presented in this document.

3 Case studies in Germany

There is one benchmark case study in Germany (DE1) and several participatory case studies. Table 1 exhibits the general characterization of the case studies in Germany.

Table 1. General characterization of the case studies in Germany.

Case study	Location	Institution	Experimental Station (ES) or Commercial Farm (CF)	Type of Integrated systems	Year of implementation or start of the integration study	Total area (ha)	Crop (others) area (ha)	Livestock (grass) area (ha)	Forestry (tree) area (ha)	Climate classification (Köppen)	Mean Precipitation (mm)	Mean Temperature (˚C)	Soil classification (WRB)
DE1	Baden-Württemberg state	UHOH/Demeter	CF	ILF; ICLF	2022; 2020	68.5	27.5	34.5	6.5	Cfb	1700	7.3	Cambisol
DE2	Baden-Württemberg state	UHOH/Demeter	CF				20			Cfb	824#	8,5#	Stagnosol
DE3	Lower Saxony state	UHOH/Demeter	CF							Cfb	721#	10,4#	Plaggic Anthrosols, Histosols, Podsols
DE4	Lower Saxony state	UHOH/Demeter	CF							Cfb	576#	10,6#	Stagnosol, Cambisol
DE5	Schleswig-Hosltein state	UHOH/Demeter	CF							Cfb	732#	10,2#	Luvisol

*1992-2022, #2013-2022

3.1 DE1

The case study DE1 is a commercial farm, which is located in the state of Baden-Württemberg (Fig. 1a). The local climate is classified as Cfb, which is characterized by cool summers and mild winters and frequent precipitation (Fig. 1b).

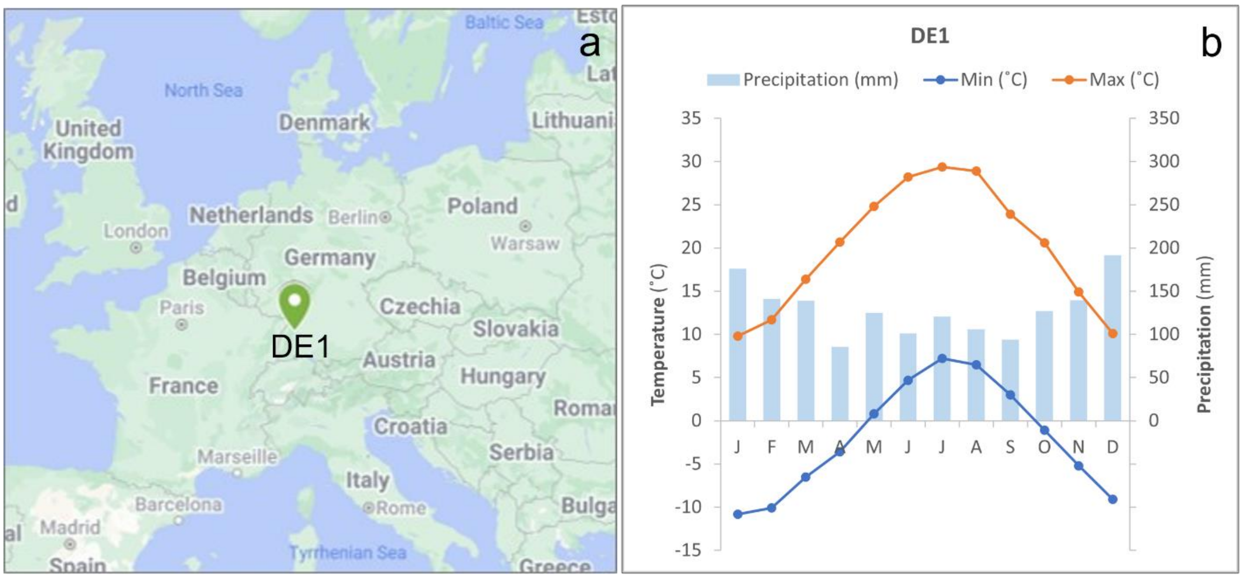

Fig. 1. Location of the case study DE1 (Google Maps© image) (a) and the monthly climatic data for the area (b). Climatic data is derived from a 30-year observed data series (1992-2022). Source: opendata.dwd.de

The farm is a 70-hectare farm located in the Black Forest at an elevation of 680-770 m ASL. Despite the high amount of precipitation in the area (1700 mm per year), the region is also characterised by an average of 1700 hours of sunshine per year, which is about the same amount as in many other regions in Germany. The farm is located on hilltop with largely south-east exposure and is near to a dam, which has a positive effect on the microclimate insofar as the water from the dam serves as a buffer against extreme temperatures in summer as well as winter. The soil is classified as Cambisol. Soil types are predominantly loamy sand and partly sandy loam. The pH value of the arable soils is mostly in the weakly acidic range (Table 2). The general region is dominated by spruce forests, which also can be found at some of the farm edges. The forest ecosystem includes fauna such as roe deer, fallow deer, and also occasionally red deer, plus wild boar and hare.

Table 2. Mean soil chemical properties for different soil depths under integrated crop-livestock system.

Soil depth	pH ($CaCl_2$)	P mg/100g	K mg/100g	Mg mg/100g	Corg %	C %	N %
0-10	5.8	13.0	21.2	12.9	2,63	2,67	0,27
10-30	5.1	6.0	7.3	6.8	1,34	1,39	0,15
30-60	5.1	2.3	3.9	3.5	0,56	0,60	0,07
60-90	5.0	1.0	2.9	1.6	0,17	0,17	0,04

Sampling was done in June 2021.

The farm has different operating branches, all of which aim to enhance the circularity of the farm. The various branches are described below.

Multifunctional agroforestry systems

Part of the farm includes the development and testing of multifunctional, successional agroforestry systems. The way the successional agroforestry systems are developed on the farm is inspired by the successional stage of natural forest edges, where the highest productivity and diversity is found. The complex agroforestry systems of the farm, which can be managed mechanically, consist of rows of nutritious wild fruit bushes, fruit and nut trees, valuable wood, and woody pioneer plants. The woody pioneer plants are fast growing and are intended to improve the conditions for the successful growth of neighbouring plant groups which are slower-growing, e.g., by stimulating soil life. Fodder trees are planted for cattle, and nut trees with nutritious crops for human consumption are integrated into the grassland. In total, about 10,000 woody plants on about 16 ha of agroforestry area – spread out over different areas of the 70-hectare farm – have been planted so far. Another 3ha are planned for 2023.

Cattle husbandry

In order to combine cattle husbandry with milk production, climate and soil protection, and animal welfare, the farm engages in practices such as mother-bonded calf rearing, mobile parlours for milking in the pasture, and holistic pasture management. They strive to use preventative health measures, such as feeding based on the Obsalim method, line breeding, alternative medical care and on-farm slaughtering. The hay milk is processed into cheese directly at the farm´s own dairy.

Chicken rearing: free range with mobile chicken coops

The farm works with a dual-purpose chicken breed (for both eggs and meat) called *Coffee & Cream*. They use a free-range system that is a less intensive form of production and allows outdoor access. When the birds are not in the field, they are kept in appropriately sized mobile coops. Only 90 birds are kept together per mobile house so that the chickens can develop a stable social coexistence. They are always fed fresh grass and hay, and the farm tries to produce the feed components themselves as much as possible.

Regenerative arable farming

The farm is revitalizing crop fields through minimum tillage and by using techniques such as surface-level rototilling in which green manure is mixed as shallowly as possible and as deeply as necessary into the soil layers as an effective way of incorporating organic material into the soil. The farm also uses compost tea as fertilizer and develops the subsoil through a method which does not require turning the soil but nevertheless deeply loosens it (*nichtwendende Tiefenlockerung* in German) and by applying charcoal (Terra Preta) produced on the farm. They rely not only on diverse crop rotations, but also on mixed cropping, under sowing and catch crops. When selecting cultivars, they pay particular attention to nutritional value, and appropriate qualities for successful site adaptation.

Vegetable production in the market garden

The vegetable garden currently provides about 100 people with a variety of different crops all year round. The vegetables are mostly consumed locally, by an intentional community that lives on and around the farm. From a circularity perspective, this is noteworthy because it means that there is minimal or no packaging and fuel used to transport the vegetables compared with a scenario where the vegetables would be sent further out into the supply chain, with therefore less GHG emissions in the process. Other vegetables and farm products are sold at a small on-site farm shop, and the farm organizes a CSA. The farm also keeps bees as pollinators for the garden and produces its own honey.

For the seedling cultivation, peat-free soil and only open pollinated varieties are used. A large proportion of the vegetables are grown on permanent beds that promote humus build-up, and are lovingly cultivated by hand according to the principles of market gardening. Hardly any machines powered by petroleum are used. The beds are divided by permanent crop strips with perennial vegetable shrubs and bushes as beneficial insect habitats (the inter-planted bushes can also be considered another aspect of the farm´s agroforestry systems). Almost all crops are mulched (all mulching material comes from the farm), and are interplanted with numerous flowers and flowering strips, green manure and medicinal herbs. For winter storage of crops, low-energy methods like earth mounds and earth cellars are used. The farm also uses non-heated greenhouses to produce some vegetables in winter, cultivates winter-hardy vegetables, and processes vegetables and fruits into non-perishable goods like soup, jam, and so on.

Fig. 2. Aerial view (a) and ground view (b) of the case study DE1.

Circularity in DE1 involves a close interconnection of all the branches of the farm to minimize the amount of external input e.g., fodder for animals or fertilizer. Many efforts (see described above) were made to close the nutrient loops and to enhance the water use efficiency as well as to reduce waste and GHG emissions.

3.2 Participatory case studies

There are several participatory case studies in Germany spread all over the country from far North to the very South.

DE2 is located on a plateau between the Black Forest and the Swabian Alb in south-west Germany. Situated in the rain shadow of the Black Forest, the climate is continental with large temperature fluctuations throughout the day and year. Frost is not uncommon, even in summer. The landscape is characterised by many rivers, several peat bogs and forests.

DE3 belongs to the North German Plain geographical region. The surface relief varies from flat to hilly and has been shaped by repeated successions of cold and warm periods with varying positions of the Scandinavian inland ice. Due to its proximity to the North Sea, the climate is strongly Atlantic with moderately warm summers and relatively mild winters.

DE4 belongs to the geographical region of the North German Plain, shaped by the Ice Age, and lies at the boundary between different types of landscape: very fertile areas characterized by loess, sandy areas that are not very suitable for agriculture because they are not very fertile and peatlands. DE4 is further south than DE3 but is also classified as having a maritime climate.

DE5 belongs to the North German Plain geographical region. However, in contrast to DE3 and DE4, the relief was formed by the last major inland glaciation and is therefore much more varied, with low hills alternating with numerous lakes. Soils are much less weathered. The climate of DE5 is influenced by the proximity of the Baltic Sea, precipitation is evenly distributed throughout the year.

4 Outlook

The general characterization of the case studies presented here will be used in other WPs for biophysical contextualization of the case studies in the SENSE project. Results from WP2 (circularity and ecological indicators), WP3 (near real-time monitoring of GHG emissions and carbon and nutrient cycling) and WP4 (multidimensional sustainability assessments) can further enrich the information currently presented here. The Technical Briefs will be uploaded to the project’s website for dissemination and communication purposes.