Synergies in Integrated Systems

Improving Resource Use Efficiency While Mitigating GHG Emissions

Through Well Informed Decisions about Circularity

D1.2 Technical Briefs – the United Kingdom

Authors: Carlos Francisco Brazão Vieira Alho[1] (carlos.brazaovieiraalho@wur.nl); Priscila Matos[2]; Matt Aitkenhead[2] and Jagadeesh Yeluripati[2]

Affiliations: [1]Stichting Wageningen Research (WUR), the Netherlands and [2]The James Hutton Institute (JHI), the United Kingdom

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

Contents

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 study in the United Kingdom, which is coordinated by the project coordinator JHI.

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 the United Kingdom

There is one benchmark case study in the United Kingdom (UK1). **Error! Reference source not found.** exhibits the general characterization of the case study in the United Kingdom.

Table 1. General characterization of the case study in the United Kingdom.

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)	Agroforestry area (ha)	Livestock (grass) area (ha)	Forestry (tree) area (ha)	Climate classification (Köppen)	Mean Precipitation (mm)	Mean Temperature (˚C)	Soil classification (WRB)
UK1	Aberdeenshire council area	JHI	ES	ICLF	2002	1100	10	67	66	Cfb/Cfc	1209	7.5	Cambisol, Podzol, Histosol

3.1 UK1

Glensaugh farm is a 1100 ha research station owned by the James Hutton Institute ca. 56 km (about 34.8 mi) southwest of Aberdeen (56°53' N 002°32' W), lying within an altitudinal range of 120 and 450 meters above sea level, with an average annual rainfall of 1,209 mm (±286mm) (Fig.1). Glensaugh climate is relatively mild, with average temperature of 7.4°C, and minimum and maximum temperatures of -0.16°C and 17.1° C, respectively. This farm covers around one thousand hectares, mostly (almost 65 percent) dominated by semi-natural plant communities (grassland/moorland/heather), with 132 ha of heather moorland and heather/grass-dominated bogs, 45 ha of predominantly rotational grassland, 67 ha of permanent pastures, 10 ha covered by agroforestry plots and 66 ha of woodlands (Table 1).

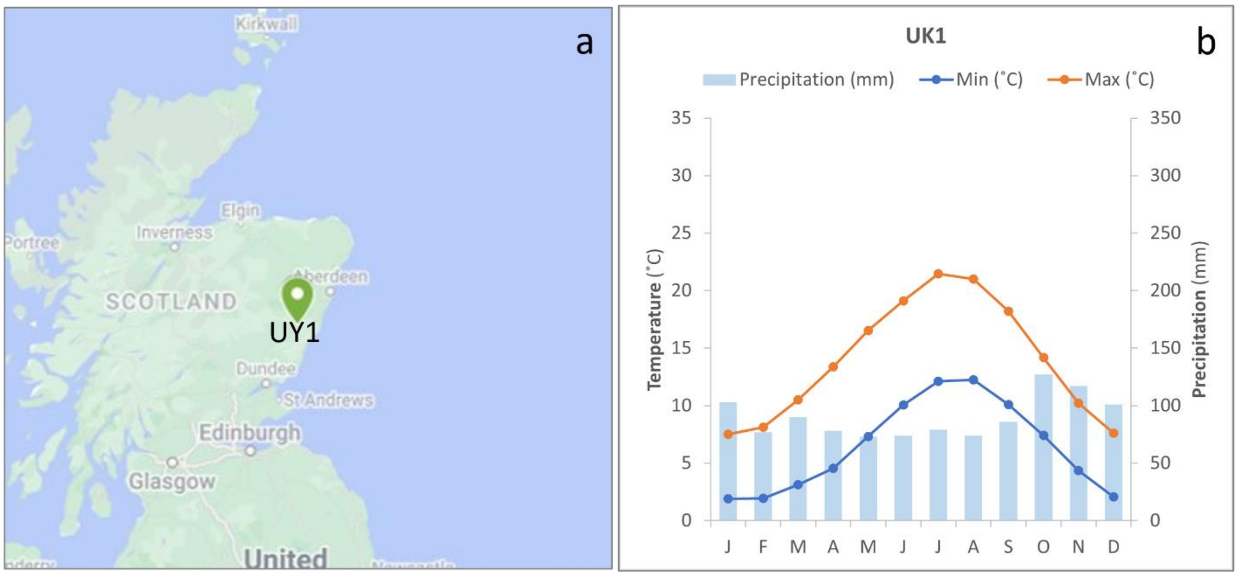

Fig. 1. Location of the case study UK1 (Google Maps© image) (a) and the monthly climatic data for the area (b). Climatic data is derived from a 30-year observed data series (1990-2020). Source: metoffice.gov.uk.

The silvopasture experiment was established on permanent improved pasture in spring 1988 mainly to investigate the impacts of silvopasture on sheep and wood output (Fig. 2) (Sibbald et al. 2001). The site contains three tree species, namely Scots Pine (Pinus sylvestris), Hybrid Larch (Larix eurolepis) and Sycamore (Acer pseudoplantanus) at densities of 100, 200 and 400 trees ha^{-1}. Agroforestry research plots were planted at Glensaugh in 1988. Three tree species were selected and planted at different densities to compare their performance.

- Scots Pine (*Pinus sylvestris*) planted at a density of 400 trees per hectare.
- Hybrid Larch (*Larix eurolepis*) planted at a density of 100, 200 and 400 trees per hectare (lower densities have now been felled).
- Sycamore (*Acer pseudoplatanus)* planted at density of 100 and 400 trees per hectare. -Control plots planted at conventional forestry densities of 2,500 trees per hectare.
- Commercial ewes, with lambs at foot in spring and early summer, are grazed in and around the trees between April and November.

- There was no measurable reduction in sheep output, although production of grass in closed canopy plots of larch and sycamore has subsequently declined. In addition, a new timber source had been created and a positive impact made on the landscape, and its biodiversity value.
- Suckler cows were introduced to the Scots Pine plot in 2008 to determine what benefits tree pasture will bring for the cattle and to identify any disadvantages to the trees.

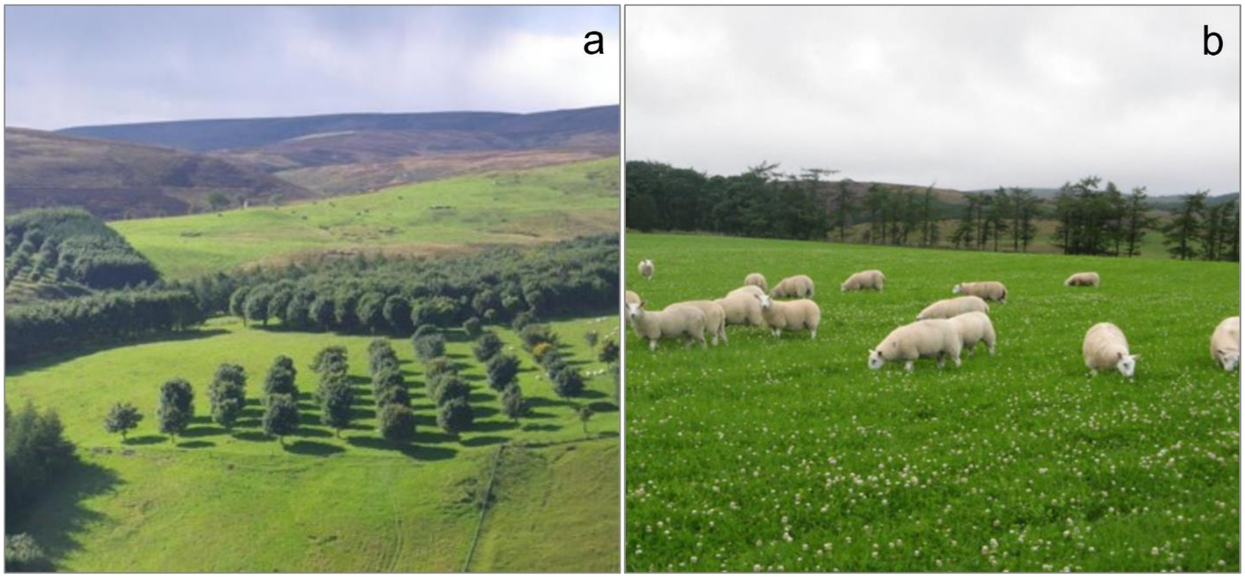

Fig. 2. Aerial view (a) and ground view (b) of the case study UK1.

The farmland is varied in terms of its capability for agricultural production, with around 9% Land Capability for Agriculture (LCA) class 3.2 (capable of average production through yield of barley, oats and grass), 14% of LCAs 4.1 and 4.2 (capable of producing a narrow range of crops primarily grassland with short arable breaks for forage crops), 35% LCAs 5.2 and 5.3 (capable of use as improved grassland), and the remaining 22% of LCAs 6.1 and 6.2 (capable of use as rough grazing with moderate quality of plants). According to the Land Capability for Forestry map, about 14% of Glensaugh has a moderate capacity for trees, and 43% a limited capacity for trees. The native woodland potential model (Towers et al., (2004) suggests a higher potential to grow trees, with 71% of Glensaugh land having the potential to grow native woodland, mainly upland Oak-Birch communities (37%), but also mixed and pure Scots pine woodlands (29%) (Fig. 3).

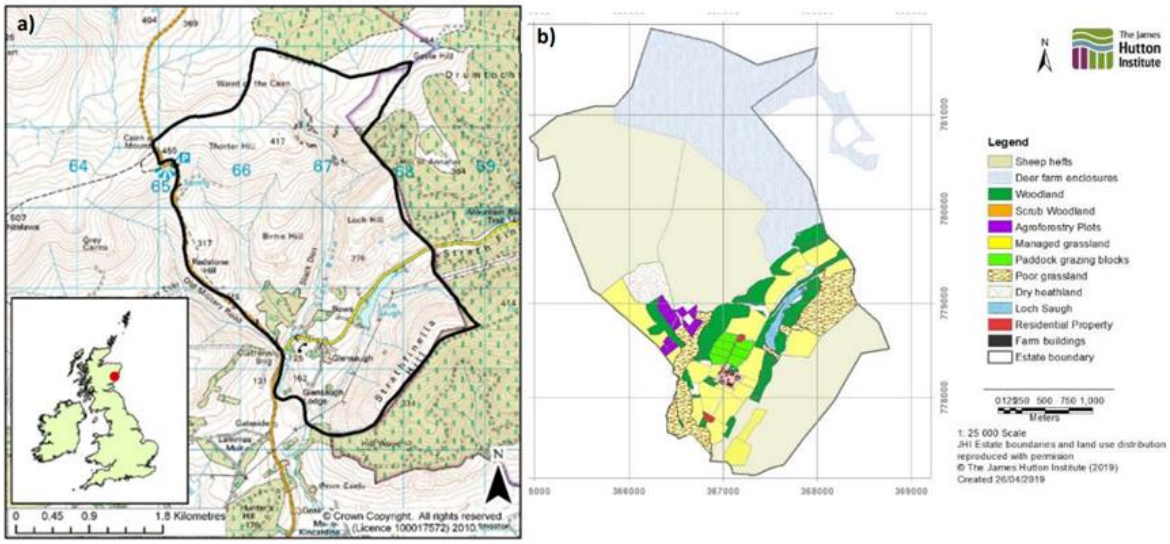

Fig. 3. Glensaugh (a) farm location and (b) land use distribution.

The Highland Boundary Fault divides Glensaugh into two distinct geological zones. North of the fault the soils are of the Strichen Association developed on drifts derived from schistose rock: the brown forest soils and podzols of the lower slopes give way to peaty podzols and, on the highest ground, to peat. To the south of the fault the soils are developed on drifts derived from Old Red Sandstone: humus-iron podzols dominate the lower slopes and peaty podzols occur at higher elevations (Stutter et al., 2012). The two main water curses in Glensaugh are Cairn Burn and Birnie Burn, both affluent of the Devilly burn which is a river, in the River North Esk catchment of the Scotland river basin district. Part of Glensaugh lies inside the Nitrate Vulnerable Zone Strathmore and Fife (including Finavon). Likewise, part of Glensaugh (the west slope of Strathfinella Hill lies inside the Laurencekirk Potentially Vulnerable Area 07/01, whereas the main flooding sources in the Luther Water. Glensaugh is a typical upland livestock farming system with beef-cattle, sheep, and deer. The farm operates two distinctive livestock farming systems: (i) suckler cow herd, low ground sheep flock, and deer calves, which are systems that rely on conserved winter feed, and (ii) hill sheep flock and deer breeding stocks that rely on extensive grazing through the year. The overall system is based on the management of semi-natural grassland, rotational grassland, moorland, and permanent pastures that provide swards, haylage and silage to support livestock production. This management system also includes small scale rotational heather burning to maintain younger, more nutritious heather as part of the extensive grazing system. The predominantly rotational grassland is reseeded with perennial ryegrass and white clover mixtures every 7-10 years. This provides grazing for the crossbred ewe low-ground flock, swards for experimental work, silage for winter feeding and aftermath grazing for finishing lambs. Glensaugh carries about 420 Scottish Blackface (pure breed) and a similar number of crossbred ewes (mated with Texel and hybrid rams). In addition, the farm carries 50 Blue-Grey suckler cows (mated with Charolais and Limousine bulls), and 80 red deer breeding hinds. There is housing for 80 cows and calves, 500 ewes and 100 red deer calves, as set out in Table 2.

Table 2. Summary of land-based farm business and their characteristics in Glensaugh.

Enterprise	Description
Beef-cattle	Blue-grey 50 suckler cows, grazing in the lowlands, and housed in winter, with a high dependency on own produced haylage and silage.
Sheep	420 Blackface ewes and gimmers, grazing in hill sheep heft (467 ha), with supplementary feed offered at times of severe stress; 430 cross breed sheep, grazing low ground areas, and dependant on haylage and silage for winter feeding. Replacement and finishing stock are silage and haylage fed in low-ground areas. There is housing for 500 ewes.
Deer	80 red deer hinds grazing in a deer farm fenced area close to 231 ha, mainly covering semi-natural grasslands, heather moorland, and blanket-bog. About 100 deer calves are temporarily housed and silage and haylage fed.
Winter feed (silage and haylage)	Temporary and permanent improved grasslands (112 ha) that are in part harvested to produce conserved winter feed in the form of silage and haylage. Those grasslands are also foraged by beef-cattle and low-ground sheep flocks during the summer. The ground is not ploughed, or ploughing is infrequent (e.g., for growing annual forage crops).
Grassland management	
Agroforestry	Experimental parcels covering 10 ha planted with Scots pine, sycamore, and hybrid larch in 1988, used for sheep and beef-cattle grazing, and biomass provision for heating
Forestry	66 hectares of conifer, broadleaf and mixed forest, 50 ha of which have been planted in the last 10 years.
Renewable energy production	50 kW wind turbine commissioned in 2010, to provide electricity to the farm and the grid. 70 kW biomass boiler commissioned in 2011 (burns wood logs to heat Glensaugh Lodge and adjoining buildings in a mini district heating scheme), and 50kW solar panel array installed in 2014.
Recreation (fishing/shooting)	Fishing of brown trout in loch Saugh by a local angling association (who rent the fishing rights). Small-game shooting (grouse, partridge, pheasant, duck, and woodcock) by a hunter that rents the shooting rights. Occasionally wild red deer Stag are shot, to avoid breeding with the farm red deer herd.
Recreation (hostel, amenity)	One holiday cottage with a 50% occupancy rate over the year
Research/training/ demonstration	Visits of group of students from SRUC and University of Aberdeen and St. Andrews, 3 to 4 times a year, and about 2 demonstration activities a year

Forestry is an expanding activity in Glensaugh with about 50 ha of new woodlands being planted over the last 10 years. Agroforestry plots were planted in Glensaugh in 1988, using Scots pine, hybrid larch and sycamore. Those plots are a source of biomass and are also grazed by ewes between April and November, with lambs at their feet in spring and early summer. A 50kW turbine for renewable energy production was commissioned in 2010 to meet part of Glensaugh' s electricity requirement. A 70kW biomass boiler was commissioned in 2011, displacing liquid petroleum gas (LPG) as a source of heating fuel, and a 50kW solar panel array was installed in 2014. Activities carried out by third parties on the farm include sporting (small game shooting, and fishing carried out by sporting tenants/licensees). Residential accommodation is available for recreational visitors or researchers engaged in longer-term research projects. The farm is available as a platform for the JHI staff to conduct outdoor experiments from plot to field right up to landscape scale. As a research farm, it has an exceptional baseline of biophysical and economic data and monitoring stations. Glensaugh is one of the national terrestrial and freshwater monitoring sites of the UK Environmental Change Network (ECN), with a freshwater sampling point in Birnie Burn. The ECN involves routine monitoring for several indicators, such as vertebrate and invertebrate species abundance and presence, vegetation survey, meteorological data, and soil and data chemistry indicators since 1992 (Sier and Monteith, 2016). It is also a monitoring site for the Cosmic-ray soil moisture monitoring network (COSMOS-UK). In addition to previous data sets, the farm manager keeps a large and detailed set of physical and monetary records that have proven to be useful for evaluating the economic and environmental performance of livestock, crop, and renewable energy enterprises, and assessing their impacts and dependencies on natural capital.

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.

5 References

Sibbald AR (2006) Silvopastural agroforestry: a land use for the future. Scott For 60(1):4–7.

Towers, W., Hall, J., Hester, A., Malcolm, A., Stone, D., 2004. The potential for native woodland in Scotland: the native woodland model. Nat. Herit. Manag.

Stutter, M.I., Dunn, S.M., Lumsdon, D.G., 2012. Dissolved organic carbon dynamics in a UK podzolic moorland catchment : linking storm hydrochemistry , flow path analysis and sorption experiments 2159–2175.

Sier, A., Monteith, D., 2016. The UK Environmental Change Network after twenty years of integrated ecosystem assessment: Key findings and future perspectives. Ecol. Indic. 68, 1–12.