

Evaluating the Sustainability of Agroforestry systems in five different countries of Europe using Emergy evaluation



Adrian Gliga¹, Mignon Sandor^{1*}, Jo Smith², Bhim Bahadur Ghaley⁴, Andrea Pisanelli⁵, Angela Augusti⁵, Rafal Wawer⁶, Robert Borek⁶, Laurence Smith^{2,3}

¹ University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Department of Environment and Plant protection, 400372, Romania;

² The Organic Research Centre, Hamstead Marshall, Newbury, Berkshire RG20 0HR, UK;

³ The Royal Agricultural University, Cirencester, Gloucestershire GL7 6JS, UK;

⁴ University of Copenhagen, Department of Plant and Environmental Sciences, 2630 Taastrup, Denmark;

⁵ National Research Council, Research Institute on Terrestrial Ecosystems, 05018, Porano, Italy;

⁶ Institute of Soil Science and Plant Cultivation –State Research Institute, Department of Soil Science Erosion Control and Land Protection, ul. Czartoryskich 8, 24-100 Puławy, Poland

* Author to whom correspondence should be addressed; E-Mail: sandor.mignon@usamvcluj.ro

CONTEXT

Traditionally, agricultural research focussed on increasing crop yields and enhancing the economic efficiency of different production systems, which helped in boosting the production and bringing down the price of food.

However, the ecological costs are not sufficiently been taken into account, which have a significant bearing on the long-term sustainability of agriculture. Hence, there is a need for more integrated accounting procedures to account for both economic and ecological costs in evaluating production systems, to provide a balanced view on the comparative resource use.

STUDY CASE SYSTEMS AND METHOD

Resource use and environmental impacts of five different agroforestry systems from five European countries were assessed using emergy evaluation. Five integrated food and non-food production systems, representative for diverse pedo-climatic contexts and socio-economic settings in Europe were chosen for this study:

Table 1. Studied farms, location and size

No.	Agroforestry farm	Study location	Size
1	Livestock silvopastoral system with wooded semi-natural grasslands	Petrova Municipality Romania	94 ha
2	Organic farm with willow and hazel alley cropping system, mixed species timber and apple system, hedgerows	Wakelyns Farm, Suffolk, UK	22 ha
3	Experimental Combined Food and Energy system, integrating food and fodder crops with mixed stands of willow, alder and hazelnut.	Taastrup, Denmark	11 ha
4	Organic farm comprised of olive orchard with natural grassland between the tree rows	Orvieto Municipality, Italy	38.36 ha
5	Livestock farm with wooded grasslands, hedgerows and forest	Beskid Mountains, Poland	200 ha

Emergy is a widely used method for the assessment of energy efficiency and sustainability within agroforestry systems that expresses and accounts for different forms of energy on a common physical basis.

Emergy is the sum total of energy used up in the creation of a certain service or product and is sometimes referred as 'energy memory' of a product and hence the emergy value of a product is the energy used up in the creation of the product. Production in ecosystems and economic systems requires inputs of different types like sunlight, fuel, machinery, human labour and economic services, etc. and all the inputs can be converted into a common unit of solar emjoules or solar equivalent joules (sej).

RESULTS

Table 2. Comparative emergy inputs and outputs of the systems during one year

Emergy inputs	IT	UK	DK	RO	PL	unit
Total local renewable	7.32E+15	9.48E+14	3.81E+14	3.76E+16	7.57E+16	J/ha/yr
Total local non-renewable	1.85E+21	5.60E+19	3.04E+14	3.75E+19	1.20E+19	J/ha/yr
Total purchased	4.61E+15	2.99E+17	1.55E+16	4.78E+21	9.97E+21	J/ha/yr
Total emergy use (U)	1.85E+21	5.63E+19	1.62E+16	4.82E+21	9.98E+21	J/ha/yr
Total output	8.22E+10	4.60E+15	2.76E+11	2.67E+11	3.06E+10	J/ha/yr

Table 3. Comparative emergy indices for the studied systems

Emergy indices	Parameters	IT	UK	DK	RO	PL
Output (J/ha/yr)	Y	8.22E+10	4.60E+15	2.76E+11	2.67E+11	3.06E+10
Solar transformity (sej/j)	U/Y	2.25E+10	1.22E+04	5.87E+04	1.81E+10	3.26E+11
Emergy yield ratio (EYR)	U/F	4.01E+05	1.88E+02	1.05E+00	1.01E+00	1.00E+00
Environmental loading ratio (ELR)	(F+N)/R	2.53E+05	5.94E+04	4.15E+01	1.28E+05	1.32E+05
Emergy sustainability index (ESI)	EYR/ELR	1.59E+00	3.17E-03	2.52E-02	7.86E-06	7.59E-06

