Olaf Bastian, Michael Lütz

PLANNING SUSTAINABLE AGRICULTURAL LANDSCAPES - A NEW EUROPEAN APPROACH

Introduction

In the 25 million EU member states, 197 million hectares are covered by agricultural land, which is equivalent to 46 % of the total area. Thus, agricultural landscapes are representing the dominating landscape type in Central and Western Europe. There is also the fact that agricultural landscapes are seriously suffering from environmental problems, and the demands of the human society on agricultural landscapes in Europe are increasingly directed towards non-production aspects such as biodiversity, landscape aesthetics, and recreational values.

Sustainable agriculture is characterized by the following aspects (e.g. Büchs 2003): It

- conserves the resources on which it depends;
- restricts itself to a minimum input of production means from outside the same farming system;
- controls pests and diseases by internal regulation processes as far as possible;
- guarantees food quality and animal welfare;
- ensures the diversity and multifunctionality of agricultural landscape, incl. its ecological, economic and social values and functions.

The need to overcome unsustainable agricultural practices in Europe becomes more and more evident for several reasons, e.g. the rapid decrease of biodiversity in many rural areas, threats to abiotic resources (soil, waters), and the loss of the natural and cultural-historical identity of landscapes. As one aspect of landscape planning in rural areas, agri-environmental programmes can help to improve the ecological situation, and to implement the principles of sustainable land use. "Agri-environmental programmes are schemes where farmers agree to comply with certain environmental rules or practice a specified form of environmentally friendly agriculture, and are compensated for the loss of income such methods bring with them" (IEEP, 1998).

The orientation towards more sustainability is a main goal of the present Common Agricultural Policy (CAP) of the EU. The EU wants to counteract lasting environmental problems in rural areas, e.g. the loss of biodiversity. Especially in view of the EU enlargement, it is impossible to maintain the actual system of high subsidies for farmers, which costs the European taxpayers billions of Euros. Also the WTO requests a further progressive and substantial reduction in support and protection in agricultural world markets. These two seemingly conflicting tasks - to raise the efforts in the area of environmental protection, and at the same time to relieve the financial budget of the European Community - shall be reconciled. For it, effective and economical approaches are necessary. However, EU countries still lack a coherent framework to fully integrate environmental concerns in agricultural and rural policies.

That's why the EU-Commission entrusted the IUCN (The World Conservation Union) and their partners in seven European countries (Estonia, Hungary, Italy, Sweden, The Netherlands, Switzerland, and Germany) with the project "Definition of a common European analytical framework for the development of local agri-environmental programmes for biodiversity and landscape conservation" (AEMBAC, term: 2001-2004).

AEMBAC: Aim and methodology

The principal aim of the AEMBAC methodology is not to find uniform solutions to achieve sustainability in agriculture throughout the whole European territory, but to identify and to suggest a common tool for the identification, development and evaluation of appropriate agri-environmental targets and measures which are tailored for the local (!) level (for a farm, a community, or a small region).

The agri-environmental measures (AEM) shall be scientifically based, locally targeted, economically sound, and contributing to biodiversity and landscape conservation. AEMBAC is creating and using synergies between conserving biodiversity (and landscape) and reforming the CAP through (EU, STAR Working Document VI/3872/97, in Simoncini 2002):

- Identification of general and specific agri-environmental targets;
- Collection of baseline data and establishment of systems to monitor impacts;
- Identification of elements to be monitored and evaluated: environmental, agricultural, socio-economic;
- Selection of suitable indicators;
- Assessment of relation to other policies, including competition with other land use schemes.

The connection with environmental or landscape functions is an additional distinctive feature of AEMBAC. The general AEMBAC methodology was developed by R. Simoncini (2002, see also Simoncini et al. 2004), and tested by the partners in the study areas (2-3 in each of the seven countries). In the following chapters the main working steps of AEMBAC will be outlined and illustrated on examples from the German study areas in Saxony.

The AEMBAC methodology (Fig. 1) is starting from a strong landscape-ecological approach: state and pressure indicators (ecological and selected socio-economic data), as well as various environmental or landscape functions are chosen and analysed. The local agricultural systems (environmental and socio-economic attributes), their positive/negative environmental impacts (pressure indicators describing impacts exerted by agriculture on the performance of landscape functions identified), and the driving forces have to be assessed. The definition of Environmental Minimum Requirements (EMR), the evaluation of land use sustainability in the farms, the proposal of realistic policy targets, and the development of specific agri-environmental measures are further steps.

Altogether, AEMBAC has developed a process of nine sequential steps that start with ecological and socio-economic analyses of the (local) agricultural area and ending with the implementation of AEM:

Section 1. Identifying agriculture's environmental impacts and related pressures

(1) Identify agricultural areas and important environmental (resp. landscape) functions
(2) Identify environmental state indicators
(3) Identify agricultural pressure indicators
(4) Relate pressure indicators to state indicators

Section 2. Creating agri-environmental measures (AEM)

(5) Identify ways to change agricultural pressures and their environmental consequences
(6) Conduct socio-economic analyses and economic evaluations
(7) Identify policy targets and instruments
(8) Involve stakeholders and produce accounting and reporting systems
(9) Produce contracts and implement agri-environmental measures (AEM)

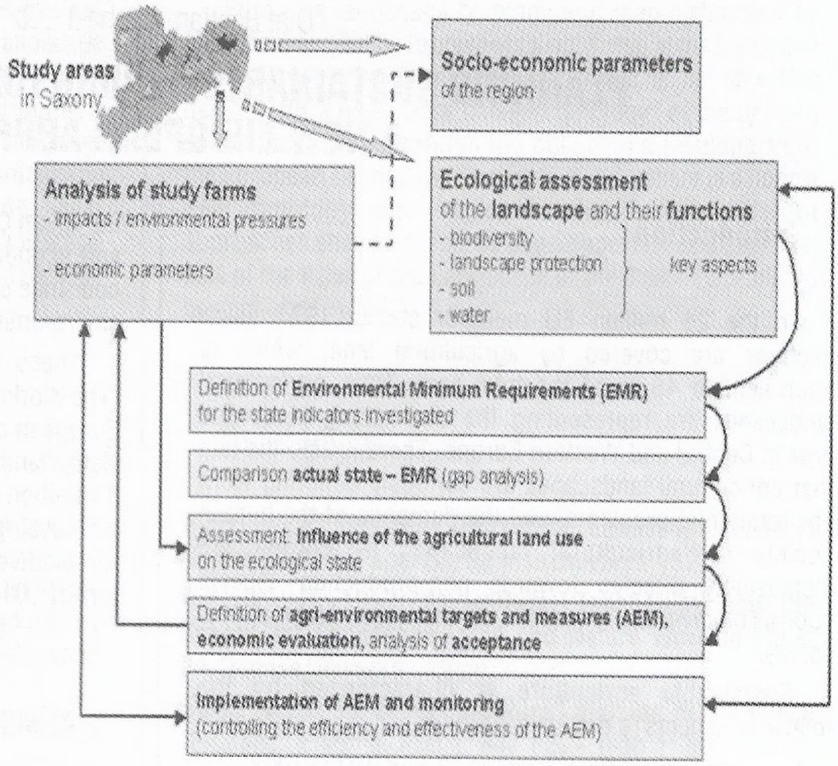

Fig. 1.
Diagram of the AEMBAC methodology

Functions	Characteristics, performances
Biodiversity	
• Habitat function	• Landscape's capacity to supply favourable living conditions for a rich flora and fauna (with its biocoenoses and biotopes) in a landscape which is presently impoverished by strong agricultural activities in many parts of the study areas
Landscape conservation	
• Aesthetic values	• Enjoying the scenery in an intensively used agricultural landscape
• Recreational value	• The landscape's capacity to enable human recreation (relaxation, health, and enjoyment of the landscape in order to elevate fitness, joy and life-span)
• Cultural and historic information	• Landscape elements as monuments of the historical development
• Maintenance / dynamics of land use	• Land use as an expression of natural and economic (+ societal / political) conditions
Soil	
• Production function	• Capacity to produce biomass
• Regulation of matter and water fluxes:	
- (Resistance to) soil erosion	• Ability to withstand soil losses by water caused by human activities
- Complex soil structures and performances	• Maintenance of the structure and functionality of the soil cover
- Water runoff regulation	• Ability of the landscape to contribute to balanced water runoff situations and to retain water by the reduction of fast runoff components (surface runoff, interflow)
- Groundwater recharge	• Flow of percolating water into the groundwater
- Soil and groundwater protection against N, P, pesticides	• The different ability of a landscape to protect soils and groundwater against contaminants, to waken their effects, or to delay their penetration
Waters	
• Maintenance of essential ecological processes and functions of running waters	• Water supply, self-purification ability, and habitat and aesthetical performances
• Regulation of the groundwater table	• Situation and changes of the groundwater table influencing matter cycles and habitat quality

Table 1.
Environmental functions (characteristics, performances) investigated in the Saxon study areas

Identifying agriculture's environmental impacts and related pressures

The heart of the AEMBAC methodology lies in the identification and analysis of two sets of indicators and their relationships. These indicators describe

- the state of the agro-ecosystems and its capacity to perform environmental (resp. landscape) functions;
- the pressures local agricultural systems exert on the environment; and
- the causal relationships between environmental states and the pressures that impact upon these environmental states.

Indicators are derived from the collection and collation of environmental, agricultural, social, economic, cultural and scientific data. Among other things, they are used to assess landscape functions (Tables 1+2). Every landscape has many functions (benefits, or goods and services - cp. Mannsfeld 1979, Marks et al. 1992, de Groot 1992) for man and society. In order to enhance the ecological, economic, societal and cultural sustainability, and to maintain or develop the multifunctionality of agricultural landscapes, we have to know the functions they are providing. According to Haase (1991), the assessment of landscape functions is a pre-condition of linking the ecological conditions of a landscape with economic and societal categories.

The landscape functions can be impaired by agricultural (and other human) activities. These impacts can be measured with the help of pressure indicators (Table 3).

There is a great variety of environmental consequences agricultural measures are entailing (Table 4).

Indicator	Sc	Av	Si
Biodiversity			
Biotope types	S	+	++
Naturalness / hemeroby of biotopes / vegetation	S	++	++
Rare / threatened / protected biotopes	S	++	+++
Biotope value	S	++	++
Habitat for selected plant / animal species	S	+++	+++
Small biotopes in the agricultural landscape	S	+++	+++
Vegetation and flora			
Diversity of plant communities	S	+++	+++
Potential natural vegetation	S	++	+
Ecotones	S	+++	++
Flora	S	++	++
Rare, threatened, protected, flagship (target) plant species	S	+	++
Number of cultivated plant species (crops)	F	+	++
Fauna			
Avifauna	S	+	++
Rare, threatened, protected animal species (selected taxon. groups)	S	+++	+++
Number of rare / cultivated cattle species	S	+	++
Landscape conservation			
Landscape diversity	S	+	+
Linear landscape structures	S	+	+++
Share / pattern of forests and non-forest areas	S	+	+
Protected areas	S	+	+
Archaeological sites	S	+	+
Cultural-historical elements (relics) of the agricultural landscape	S	+++	++
Soils			
Yield potential/ Soil fertility	S	++	++
Soil erosion	S	++	+++
Diffuse transfer of nutrients / decomposition und transfer of pesticides	S	+++	++
Groundwater recharge and discharge	S	++	+
Waters			
Water quality	S	+++	++
Water body morphology	S	++	+++

Sc – Scale: Study area = S, Farm level = F
Av – Data availability (low: +, medium: ++, high: +++)
Si – Significance, importance (low: +, medium: ++, high: +++)

Table 2.

State indicators used to assess landscape functions in the study areas in Saxony, and remarks on their scale, availability, and significance

Indicator	Parameter/ methodology	Av	Si
Median field size	Average size of parcels	++	+++
Proportion plant / animal production	Proportion of market crops	+	++
Crop species diversity	Shannon-Weaver-Index	+	++
Cereals, rape, root crops, maize for silage, legumes, and grass mixture	Influencing factors for the recirculation of organic matter, humus and nutrient balance	+	+
Integrated plant protection (pesticide application)	Calculation of costs; comparison of the actual pesticide application intensity (amounts) with official recommendations	++	++
Arable land without cultivated plants	Fallow land during winter time, permanent fallow land (supporting programmes, cyclical fallows)	+	+++
Livestock	In animal units / ha (AU/ha), differentiated in cattle, dairy cows and pigs	+	++
Forms of housing	Proportion of semi-liquid manure / manure / grazing	+	+++
Grassland management	Proportion of different types and intensities of grassland use (pasture, pasture for cutting, meadow, participation on agri-environmental programmes – date of the first cut, amount of fertilizer application)	++	+++
Nitrogen balance	Difference between all N-inputs (e.g. fertilizer, feedstuffs, N-fixation by legumes) and N-outputs (sold farm products, inevitable NH_3 losses from livestock); farm gate balance	++	+++
Humus balance	Difference between the losses of organic matter due to soil cultivation and the organic matter inputs from crop roots, plant residues and farm manure in ROS ('replacement-effective organic matter')	++	+++

Av – Availability: costs and complexity of data research and assessment (low: +, medium: ++, high: +++)
Si – Significance, importance (low: +, medium: ++, high: +++)

Table 3.

Pressure indicators for assessing potential risks for ecosystems caused by agriculture on the example of study areas in Saxony (at farm level)

Pressure	Consequences (examples)	Environmental impact	C
Increase in size of parcels (rationalization of management)	Increasing risks of soil compaction caused by heavy machines	↑ Soil erosion	+
	Loss of small landscape elements within farmland (woods, field tracks, etc.)	↓ Species, habitats	++
		↑ Homogenisation of landscape	++
	Reduction in work processes (distances to be covered	↓ Utilization of energy (fuel)	+++
		↓ Emissions	+++
Farming on less suitable sites: transformation of grassland to arable land	Removal of grassland species (missing habitats for birds breeding in meadows)	↓ Species, habitats	+++
	Farming in flood plains, leaching of matters	↑ Eutrophication of waters	+
	Increased surface runoff; longer periods with bare soils	↑ Soil erosion	++
Modern mowing techniques	Altered times and techniques of grassland cutting, too high stock density	↓ Species, habitats (change in grassland vegetation)	++
		↑ Eutrophication of waters	+
		↓ Emissions	+
Changes in crop rotation	Increased share of maize cultivation	↓ Species (segetal flora, adapted fauna)	++
	Increased PPP application in poor crop rotations	↑ Water pollution	+
		↓ Species (segetal flora, adapted fauna)	+
Unsuitable application of pesticides, fertilizers, dung	Nutrient surplus exposed to leaching, risks of drifting, erosion and leaching from soils; losses in natural soil fertility and necessity of additional mineral fertilization	↑ Water pollution	+
		↓ Species (segetal and grassland flora, adapted fauna)	+
Drainage	Changes in the natural soil moisture regime, shortened retention periods, impacts on natural water structures	↑ Eutrophication of waters	+
		Changes in species spectrum and site conditions	+

C – Causality of pressure and impact (low: +, medium: ++, high: +++); ↑ - increase; ↓ - decrease

Table 4. **Environmental consequences of agricultural measures, and possibilities of interpretation**

Indicator	Study area: Jahna (244.4 km²)		Große Röder (partial study area Moritzburg – 47.3 km²)		Biosphere reserve 'Upper Lusatian Heath and Pond Landscape' (301.0 km²)	
	EMR	Actual state	EMR	Actual state	EMR	Actual state
Biodiversity (habitat function)						
Valuable biotopes	5 %	2.2 %	10 %	5 %	20 %	17.9 %
Plant species	842[1] incl. 136 segetal- (s.), 87 grassland species (g.)	772 (123 s., 80 g.)	789[1] (139 s., 58 g.)	749 (137 s., 57 g.)	1046[1] (101 s., 140 g.)	978 (94 s., 134 g.)
Breeding birds	22[2]	22	24[2]	22	21[2]	20
Landscape conservation (recreation function, aesthetic value, cultural heritage)						
Landscape diversity (Shannon-Index)	1.32[3]	0.86	1.32[3]	1.32	1.32[3]	1.94
Share of forests	3.0 %	1.8 %	7.5 %[2]	7.5 %	48.8 %	48.8 %
Soil (production function, regulation function)						
Soil loss by erosion	Water erosion: 0.6 –1.5 t/ha*a	50 % of the area exceed EMR	Water erosion, mineral soils: 10 t/ha*a; loess soils: > 80 cm - 5 t/ha*a, < 80 cm - 1 t	30-40 % of the area exceed EMR	Wind erosion: up to a 'medium' level on arable fields	Partial study area 'Kreba': almost 100 % of the arable fields exceed EMR
Water						
Morphology: Edges at running waters and ponds	5-10 m broad, at all waters (100 %)	70 %	5-10 m broad, at all waters (100 %)	32 %	10 m broad, at all waters (100 %)	40 %

[1]) assumption: all plant species existing in the study area now and until 1989 should survive in viable populations; data base: Atlas of the flora of Saxony
[2]) assumption: all key species of the agricultural landscape existing in the study area now and until 1982 should survive in stable populations; data base: Atals of the avifauna of Saxony
[3]) equivalent to the actual state in the partial study area Moritzburg, known and appreciated as a 'harmonious (agri)cultural landscape'

Table 5. **Gap analysis: Comparison of EMR values with the actual state of some state indicators in the Saxon study areas**

Once state indicators have been identified and their actual values measured, AEMBAC defines so-called Environmental Minimum Requirements (EMR) for each state indicator. An EMR is a single value (a threshold) or a set of values (a range) for a state indicator that provides a baseline against which to measure whether ecological processes are expected to be contributing positively, negatively or neutrally to the provision of environmental (or landscape) functions. For the definition of EMR specifically for the particular study area, data from the scientific literature and expert judgements was used, and the specific landscape character is taken into consideration.

If the actual value of a state indicator is the same as the EMR, then no impact (either positive or negative) on the performance of the environmental function relating to the state indicator is detected. If the state indicator values does not reach the EMR or exceeds it, then a gap analysis (Table 5) must be carried out. The 'gap' between an environmental state indicator's value and the EMR identifies the positive or negative impact of agricultural or other practices on environmental functions. A positive gap indicates the actual value of the state indicator is already satisfying its EMR whereas a negative 'gap' indicates the environmental changes that need to occur for the state indicator to achieve its EMR and adequately supply environmental goods and services.

For example, in the study area 'Jahna' at present only 2.2 % of the total area is occupied by valuable biotopes. An optimal situation (EMR) for this intensively used agricultural priority area would be 5 %. On contrary, for the biosphere reserve already presently rich in valuable biotopes (17.9 %) a slight increase (to 20 %) would be sufficient.

By relating pressure indicators to state indicators 'tiers of sustainability' can be identified. The question is: How much each agricultural pressure affects the performance of a particular environmental (landscape) function? To simplify the identification of the most important pressure, a qualitative ranking is made of each pressure to generate such tiers of sustainability. This ranking is based on the best scientific knowledge available and can be used as an effective policy tool to identify where AEM are most required.

The qualitative ranking system for expressing the sustainability of agricultural pressures can be scaled as follows (cp. Table 6):

Indicator	Study area: Jahna (244.4 km²)		Große Röder (partial study area Moritzburg – 47.3 km²)		Biosphere reserve 'Upper Lusatian Heath and Pond Landscape' (301.0 km²)	
	EMR	Actual state	EMR	Actual state	EMR	Actual state
Biodiversity (habitat function)						
Valuable biotopes	5 %	2.2 %	10 %	5 %	20 %	17.9 %
Plant species	842[1] incl. 136 segetal- (s.), 87 grassland species (g.)	772 (123 s., 80 g.)	789[1] (139 s., 58 g.)	749 (137 s., 57 g.)	1046[1] (101 s., 140 g.)	978 (94 s., 134 g.)
Breeding birds	22[2]	22	24[2]	22	21[2]	20
Landscape conservation (recreation function, aesthetic value, cultural heritage)						
Landscape diversity (Shannon-Index)	1.32[3]	0.86	1.32[3]	1.32	1.32[3]	1.94
Share of forests	3.0 %	1.8 %	7.5 %[2]	7.5 %	48.8 %	48.8 %
Soil (production function, regulation function)						
Soil loss by erosion	Water erosion: 0.6 – 1.5 t/ha*a	50 % of the area exceed EMR	Water erosion, mineral soils: 10 t/ha*a; loess soils: > 80 cm - 5 t/ha*a, < 80 cm - 1 t	30-40 % of the area exceed EMR	Wind erosion: up to a 'medium' level on arable fields	Partial study area 'Kreba': almost 100 % of the arable fields exceed EMR
Water						
Morphology: Edges at running waters and ponds	5-10 m broad, at all waters (100 %)	70 %	5-10 m broad, at all waters (100 %)	32 %	10 m broad, at all waters (100 %)	40 %

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Table 5. **Gap analysis: Comparison of EMR values with the actual state of some state indicators in the Saxon study areas**

Farm structure			
Median field size	Tier -2 -1 0 +1 +2	 larger than 20 ha (= **actual value**[1]) 15 – 20 ha 10 – 15 ha 5 – 10 ha less than 5 ha	Together with the existence of edge structures (margin grass stripes, hedges, etc.)
Plant production			
Plant protection	Tier -2 -1 0 +1 +2	 Higher rates of pesticide application in accordance with the BPJ (Best Professional Judgement) Application of pesticides in accordance with the BPJ, e.g. consideration of the damage threshold (= **actual state**) Application of pesticides only on partial areas of the field plots; use of preventive pest control measures (e.g. wide crop rotations) Very low intensity of pesticide application and only on partial areas of the field plots; use of preventive pest control measures (e.g. wide crop rotations); avoiding pesticides in river basins Avoiding pesticides; use of mechanical measures	
Livestock			
Cattle / ha	Tier -2 -1 0 +1 +2	 lower than 0.4 AU (animal unit) / ha and no use of fodder produced in the farm (field fodder and grass) as the base for feeding (roughage) lower than 0.5 AU / ha and use of grassland to produce roughage as the base for feeding c. 0.5 AU / ha and use of field fodder and grass as the base for roughage feeding (= **actual state**) 0.6 – 0.8 AU / ha and use of field fodder and grass as the base for roughage feeding[2]) 0.6 – 0.8 AU / ha and use of field fodder (not maize) and grass as the base for roughage feeding, high proportion of pasturing (extensive management, e.g. permanent grazing)[2])	

[1]) in more structured areas of the partial study area Moritzburg, the EMR-value is reached
[2]) The higher values for AU are desirable in this study area for landscape management purposes (extensive pasturing, humus balance)

Table 6. **Analysis of relations between the tiers of sustainability and the intensity of pressures regarding the habitat function (biodiversity) on examples from local agricultural systems in the study area 'Große Röder'**

+2 Presence of high and only positive impacts;

+1 Presence of only medium and positive impacts, i.e. landscape functions (environmental goods and services) are supplied at this tier and above;

+/- 0 No influence or low positive/negative impacts, i.e. ecological sustainability is kept;

- 1 Presence of medium and negative impacts, which are impeding the landscape functions (environmental goods and services);

- 2 Presence of high negative impacts.

Creating agri-environmental measures

Basing on the gap analysis for ways must be sought to alter each pressure (either by adjusting or eliminating agricultural practices) in order to lessen agriculture's negative environmental impacts and enhance its positive impacts. Possible actions are analysed to explain what activities would be necessary in order to move the pressure to a new 'tier of sustainability'. These recommendations are then tested for their feasibility, e.g. for their effects on productivity or the ability of farmers to undertake them. To master these steps, a thorough understanding of the local socio-economic environment within which farmers and their families live and work must be gained through studying the local social, cultural, economic and institutional conditions (Table 7). This is necessary because:

- Socio-economic factors may be driving forces for agricultural pressures including
  - o local driving forces originating at the local socio-economic level such as specific traditional knowledge or specific local economic forces
  - o foreign driving forces originating at the regional, national, international or global level such as national policy, the CAP or WTO agreements
- It is important to consider the possible socio-economic effects of AEM aside from agricultural ones, e.g. effects on income distribution, per capita income and employment.
- Socio-economic aspects such as social values, consciousness and existing institutions may play a role in implementing AEM.

Indicator	Methodology	Av	Si
Natural driving forces	Soil conditions (fertility, moisture, depth)	+++	+++
	Climate (precipitation, duration of sunshine, number of frost days) → crop rotation	++	++
	Geomorphology (influencing the use of machines and soil erosion)	+++	+
	Hydrology (e.g. depth of groundwater table, floodplains)	++	+
	Heterogeneity of land use; cultivation forms; occurrence of species and biotopes (e.g. grassland biotopes, small structures areas with extensive farming)	+++	++
Economic driving forces	Labour costs (e.g. animal and plant production)	+	+
	Investment and modernization (livestock husbandry)	+	+
	Market structure (prices, sales potential, deficits)	++	+++
	EU-policy of subsidies and promotion (market regulations, development of rural regions)	+	+++
	Historical development (collectivisation, mechanization, development of properties during socialist times in East Germany)	++	+++
Social driving forces	Individual farmers' awareness and experiences of an environmentally friendly production; number of employed labourers (in conflict with economic interests)	+++	++

Av – Availability: costs and complexity of data research and assessment (low: +, medium: ++, high: +++)
Si – Significance, importance (low: +, medium: ++, high: +++)

Table 7. **Assessment of driving forces in the study areas in Saxony**

	Pressure indicator	State indicator	Recommendations
Farm structure	Median field size	Vegetation and flora	- Creation of a small-patterned landscape - Creation of edge structures - Cultivation of different crops
Farm structure	Median field size	Fauna	- Partition of fields (creation of edges, lanes, field borders, buffer stripes, or different crops) - Protection and maintenance of landscape structures: low and canny application rates of nutrients and pesticides, cutting of groves, etc.
Farm structure	Proportion plant / animal production	Biotope value	- Increase in proportion of grassland - Grassland: extensive pasturing, late mowing dates - Establishment and maintenance of fruit orchards
Plant production	Crop species diversity	Vegetation and flora	- Diversification of crop rotation
Plant production	Crop species diversity	Fauna	- Due to the dense crop stands, rape is not a favourable (breeding and food) habitat (for birds) - Decrease in rape cultivation could be connected with a reduction in fertilizer and pesticide application
Plant production	Root crops in crop rotation	Vegetation and flora	- The cultivation of root crops would enrich the crop rotation - Reduction in cultivation intensity (less nutrients and pesticides necessary)
Plant production	Root crops in crop rotation	Fauna	- No decrease in root crops, areas with high erosion risks should be managed with soil protection practices
Plant production	Maize for silage	Vegetation and flora	- Lower proportion of maize in crop rotation - Less pesticide and fertilizer application (mainly liquid manure)
Plant production	Maize for silage	Fauna	- Lower proportion of maize in crop rotation - Less pesticide and fertilizer application (mainly liquid manure) - Some maize fields shouldn't be ploughed in autumn to provide fodder places for resting geese
Plant protection	Legumes and grass mixture	Vegetation and flora + fauna	- Increase in pea and alfalfa
Plant protection	Plant protection	Vegetation and flora	- Reduction in pesticide application can be achieved by other measures (wider crop rotation, less rape, etc.) - No treatment of edges and buffer stripes - Application of alternative methods of plant protection (e.g. mechanical treatment)
Live-stock	Cattle / ha	Biotope value	- Increase in proportion of grassland (extensive pasture)
Energy and nutrient balance		Vegetation and flora	- Establishment of buffer stripes (grassland) between arable land and valuable biotopes (e.g. woods and moist biotopes) - Well-balanced pasturing of grassland (near and far from the livestock stables) - Coordination of the application practice (timing and weather, etc.)

Table 8. **Selected recommendations on how to lessen the negative impacts identified and enhancing positive ones on the example of habitat function in the study area 'Große Röder'**

Basing on the gap analysis (comparison actual state / EMR) possible ways (recommendations) can be identified to lessen negative impacts and to enhance positive ones (Table 8).

To decide whether certain agricultural practices and other measures are realistic to be adopted to reduce negative and enhance positive impacts of agricultural pressures, also the socio-economic aspects must be taken into consideration. Economic valuation is used in AEMBAC to calculate the costs and, possibly also, the benefits of achieving different tiers of sustainability (Tables 9+10).

Costs of implementing AEM include:

- Compensation costs for reduced yields, other income foregone, undertaking costs, land use conversion, etc.;
- Costs of incentives to encourage uptake of the AEM;
- Indirect and induced costs specific to the local situation; and
- Administrative and transaction costs.

Benefits in terms of agri-environmental goods and services provided (i.e. above tier 0) include:

- Benefits of environmental goods and services produced;
- Benefits of negative agri-environmental impacts avoided by implementing the AEM
- Benefits of reduced production costs;
- Benefits in terms of diversification of the rural economies;
- Benefits of enhanced scientific research and ecological knowledge; and
- Other indirect or induced benefits according to the local situation.

The tiers of sustainability defined in step (5), along with the economic analysis of costs and benefits undertaken in step (6), now serve as a starting point for defining realistic and effective policy targets (environmental goals) to be achieved through AEM.

Once agri-environmental policy targets have been defined, it is possible to develop AEM to achieve them. Three types of policy instruments could be used to reach the agri-environmental targets:

1. Command and control (laws and standards);
2. Quasi-market (direct payments through contracts between farmers and administrators);
3. Market (e.g. consumers paying higher prices for products produced by environmentally friendly agricultural methods).

Study area			Changes	Costs (□ / ha)		
Jahna	Röder	ULHPL		Jahna	Röder	ULHPL[1)]
Landscape conservation						
-2 ⇨ -1/0	-2 ⇨ -1/0		Reduction in field sizes	59	59	-
Habitat function						
		-2 ⇨ 0	Valuable wet meadows	-	-	200
-2 ⇨ 0	-2 ⇨ 0		Maintenance of new biotopes	156	156	-
		-1 ⇨ 0	Maintenance of fishponds	-	-	626
Soil function						
-1 ⇨ 0			Increase in cropping diversity	0	-	-
-2 ⇨ 0	-1 ⇨ 0		Soil conservation tillage	83	83	-
(0 ⇨ +1)	0 ⇨ +1		Raising livestock density	-	17	-
Water function						
-1/0 ⇨ +1	-1 ⇨ 0	-1 ⇨ 0	Lowering agri-chemical use	114	114	80
-2 ⇨ 0	-2/-1 ⇨	-2 ⇨ 0	Establishment of buffer stripes	92	56	36

[1)] Biosphere reserve 'Upper Lusatian Heath and Pond Landscape'
(Source: K. Knickel, University of Frankfurt/M., subcontractor in the AEMBAC project)

Table 9. **Changes in agri-environmental management practices and the related costs in the three study areas in Saxony**

When using quasi-market methods to implement AEM, the following decisions need to be made:

- Zonal (in a defined area) or horizontal schemes (applied over wider areas);
- Time period of the AEM;
- Minimum number of farmers that must participate;
- Eligibility criteria for farmers;
- Payments to farmers.

Cost item	Lowering agri-chemical use	Establishment of buffer stripes	Establishment + maintenance of hedges
AEM design	Monitoring data on agri-chemical use and the need for buffer stripes are fairly well available; problem areas are known ⇨ little additional costs		Will only be carried out in a more comprehensive landscape analysis and planning context
Application to EU for approval	No data	No data	No data
Consultation with farmers, environmental, consumers associations, etc. in programme development	1.000-1.500 € per study area (1-2 consultations per study area; only direct costs)		
Administering applications (assistance to applicants, examination, approval, etc.)	100-150 € / contract		500-800 € / 100 m (establish); 20-30 € / 100 m (maintain);
Contract and management of payments (incl. control of payments)			
Compliance control (farm inspections, monitoring, farm environmental accounting, cross checks)	100-150 € / farm*a	50-100 € / farm*a	50 € / farm*a
Evaluation of effectiveness (evaluation of impacts on environmental, agricultural and socio-economic aspects)	High	Medium	Low
Feedback on policy design and development	M a r g i n a l		
TOTAL	High	Low - medium	Low - medium

(Source: K. Knickel)

Table 10. **Estimated government's administrative and transaction costs for some key measures**

The AEM proposed must be discussed with stakeholders. The most relevant stakeholders are the individual farmers who have to implement the AEM. Other stakeholders we consulted in Saxony include: State Office for Agriculture, State Office for Environment, Saxon Administration Department of Dams, Saxonian State Institute for Agriculture, Saxon State Institute for Environment and Geology, Saxon Farmers Association, Nature Conservation Union, Institute for Nature Conservation, and Union of Landscape Conservation. Collaboration with stakeholders should consider: the experience they have with existing AEM; their awareness of environmental impacts and pressures; the required changes to agricultural practices, their capacity to implement changes; their views concerning the costs (e.g. income foregone and undertaking costs); and monitoring systems required to implement AEM.

For achieving policy targets, it is essential to apply monitoring and evaluation procedures (Table 11) as well as reporting systems. To evaluate the effectiveness of an AEM, evaluators (farmers, local administrators, independent evaluators and European Commission officers) must first be aware of its environmental objectives. AEMBAC aids this process by:

- Producing indicators for monitoring;
- Defining locally tailored baselines (EMRs) against which to evaluate effectiveness;
- Clearly defining objectives to be reached and evaluated; and
- Transparently explaining how objectives will be reached.

When evaluating an AEM, it is also important to consider the possible synergies and/or conflicts that may occur with other agricultural, rural development and socio-economic sector policies. Also any evaluation procedure should consider the possible benefits that an AEM can have on other environmental functions. For example, an AEM that maintains a habitat for its refugium function could also bring benefits to functions that improve the aesthetic quality of the landscape and control soil erosion. Not considering these collateral benefits risks underestimating the total benefits of the AEM.

Emphasis, for example, is on key species, critical substances and critical time periods. The frequency of records tends to be low (once per year) for most aspects. The main goal is to have a system of complementary and carefully targeted analyses, which appears more appropriate than the installation of very refined and very comprehensive agri-environmental accounting and monitoring systems.

No.	Indicators of the monitoring and evaluation scheme	GAP	Costs	Freq
Data originating from the environmental farm accounting system				
1	N-balance per plot and enterprise (kg/ha and kg/ha UAA = used arable land)	×	++	1-2
2	P-balance per plot and enterprise (kg/ha and kg/ha UAA)	×	++	1-2
3	K-balance per plot and enterprise (kg/ha and kg/ha UAA)	×	++	1-2
4	Date of liquid manure application (spring, autumn)	×	-	2-3
5	Total area with reduced fertilizer use (ha)		-	1
6	Pesticide use (amount per plot and enterprise) (□ or kg/ha)	×	++	1-2
7	Total area with reduced pesticide applications (ha)		-	1
8	Amount of mechanical plant protection measures (no.)			1
9	Proportion of minimum tillage per enterprise (% in total UAA)			1
10	Area without cultivation/operation during critical periods (ha)	(×)	+	1-2
11	Crop species diversity (Index or ratio)			1
12	Crop variety resistance and diversity per enterprise (varieties used)			1
13	Proportion of legumes (% of total UAA)		-	1
14	Proportion of cereals (% of total UAA)		-	1
15	Duration of land without vegetation cover (% of total growth period)		++	1
16	Average field parcel size (ha)		+	(1)
17	Amount of subsidies (□/ha UAA)		(+)	1
Data from special environmental investigations				
18	Protected habitats and ecological infrastructures on agricultural areas (ha and/or no.)	×	+	1
19	NO_3-content on permanent test areas in autumn (kg NO_3/ha)	(×)	++	1
20	Special measures for threatened wild species (key species; longer-term)		+	1
21	Effect of extensification on flora and vegetation (key species)		+	1
22	Effect of extensification on locusts (key species)		+	1
23	Effect of reduced use of pesticides (content of critical substances in water and soil)		++	2-3
24	Effects of measures against soil erosion (model data and data of communal level, costs of damages)		++	1-2
25	Effect of soil conservation measures on plant communities, vegetation, flora (key species)		++	1
26	Effect of soil conservation measures locusts, carbide beetles, butterflies, amphibians (key species)		++	1
27	Landscape metrics (coherence and diversity of landscape, characteristics of agric. areas) (%)		(++)	(1)
28	Quality of landscape elements (hedges, field borders, margins along rivers) (field surveys)		++	1

GAP: obligatory data recording due to existing environmental legislation (part of good agricultural practice; GAP)
Costs: ++ = very high; + high; +/- = average; - = low; -- = very low
Frequency: No. per year

(Source: M. Lütz and K. Knickel)

Table 11.
Aspects covered in the monitoring and evaluation scheme

We should not ignore that the monitoring of most aspects tends to be rather demanding and costly. Nevertheless, if the integration of environmental goals with agricultural support systems is really aimed at, it will be absolutely necessary to intensify and improve environmental monitoring systems. Only then it will be possible to facilitate an evaluation of the effectiveness of the measures and thus their continuous improvement.

Conclusion

The interface between environment, agriculture and society needs more attention in planning sustainable rural landscapes. Without considering these connections, the implementation of landscape and nature conservation into agricultural practice is not possible (Lütz and Bastian 2002). The AEMBAC methodology represents a valuable tool for landscape planning approaches, which are combining ecological and socio-economic points of view. AEMBAC offers ways to integrate scientific results into policy development both at local and at European levels. Premises of AEMBAC are that agro-ecosystems are multifunctional, that they provide multiple environmental goods and services, and that these can be valued and compared. The choice of policy targets will be always a political decision. However the approach proposed by AEMBAC will aid decision makers to define the policy targets by providing them relevant, accessible, scientifically supported information.

Notwithstanding the deficits in ecological knowledge and the methodological difficulties still existing (e.g. in view of thresholds or EMR), the application of AEMBAC is feasible and promising. Comparing with other approaches dealing with agri-environmental programmes, AEMBAC stands out for its coherent but flexible algorithm that includes the indicator approach, the assessment of landscape functions, and the consideration of ecological and socio-economic aspects, as well as local and regional peculiarities. Thus, AEMBAC gives the chance for analysing and planning sustainable agricultural landscapes in a multifunctional, comprehensive, holistic manner.

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