ART Schriftenreihe 17 | September 2012

Biodiversity Indicators for European Farming Systems

Guidebook Summary

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This document summarisis the Guidebook to farmland biodiversity indicators which results of the EU FP7 research project “BioBio - Biodiversity indicators for organic and low-input farming systems” (KBBE 227661). The Guidebook (in English) and the indicator factsheets are available at www.biobio-indicator.org

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Editorial

Publisher	Research Station Agroscope Reckenholz-Tänikon ART CH-8046 Zürich Telefon +41 (0)44 377 71 11 info@agroscope.ch, www.agroscope.ch
Editing	Susanne Riedel, ART
Cover picture	Gabriela Brändle, ART
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Content

Farmland biodiversity indicators in Europe

Arable and pastoral farmland constitutes a dominant land use in Europe, accounting for over 47% (210 million hectares) of the EU-27. An estimated 50% of all European species are reliant on agricultural habitats. Consequently, some of the most critical conservation issues today relate to changes in farming practices which directly affect the wildlife on farms and adjacent habitats.

Figure 1: The three components of farmland biodiversity:
(a) Habitats in a gently rolling landscape of central Europe;
(b) Plant species of a mountain meadow in the Alps; and
(c) Traditional pig breeds of the Hungarian Puszta.
Photo: (a) G. Brändle,
(b) G. Lüscher; (c) F. Herzog, Agroscope

Farmland biodiversity is determined by habitat, species and genetic diversity (Figure 1). Due to its complexity, biodiversity cannot be measured as such, and it is assumed that no single all-inclusive index for biodiversity can be devised. Ideally, indicators represent biodiversity as a whole AND are sensitive to environmental conditions resulting from e.g. land use and agricultural management practices.

Historically, farming activities have substantially increased the diversity of European landscapes by introducing arable fields, grasslands, orchards, etc., primarily at the expense of the forest which previously dominated the European continent. More recently, intensification and specialisation have led to a simplification of agricultural landscapes and a loss of (semi-natural) habitats. At the same time, the tendency is for marginal farmland to be abandoned, which also leads to a loss of farmland habitats and the associated species.

The European Union monitors agri-environmental indicators (IRENA) and the status of farmland biodiversity (SEBI) in particular. The majority of indicators are based on statistical data on farm management practices and on reports of the member states about the status of rare or threatened species and habitats listed in the Habitats Directive. The only more common species monitored are the populations of common farmland birds and of grassland butterflies, despite the fact that common species are the ones that interact with farming practices, provide services or cause damage, since they make the greatest contribution to ecosystem functions.

European farms are highly diverse in terms of size, production type, etc. Most farms consist of both production habitats (crop fields, orchards, grasslands, etc.) and semi-natural elements (e.g. hedgerows and extensively managed grasslands). In many instances the fields of an individual farm are separated by other farmers' fields, or by land put to non-agricultural use (Figure 2). In most situations, therefore, a farm does not constitute an ecologically meaningful unit. It is, however, a unit for decision-making (by the farmer). Moreover, agricultural and agri-environmental policies primarily address the farm scale. This is the justification for developing farm-scale biodiversity indicators.

The BioBio indicator project

The objective of the research project BioBio (Biodiversity indicators for organic and low-input farming systems, EU FP7, KBBE-227161, 2009–2012) was to identify a set of biodiversity indicators which are (i) scientifically sound, (ii) generic at the European scale and (iii) relevant and useful for stakeholders. BioBio applied a two-step indicator-filtering approach (Figure 3).

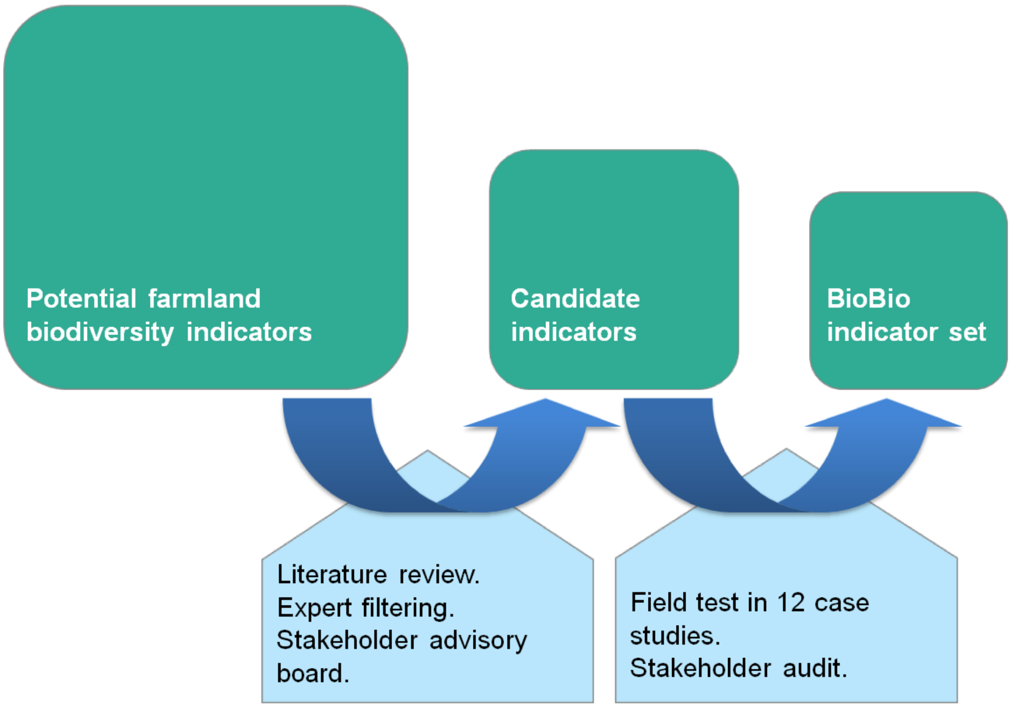


Figure 3: The first step of indicator filtering consisted in a literature review and a first stakeholder consultation. In the second step, the candidate indicators were tested in 12 European case studies. Indicator values were evaluated with respect to redundancies, coherence, applicability across Europe, etc., and unsuitable indicators were discarded. The remaining indicators were audited by the Stakeholder Advisory Board.

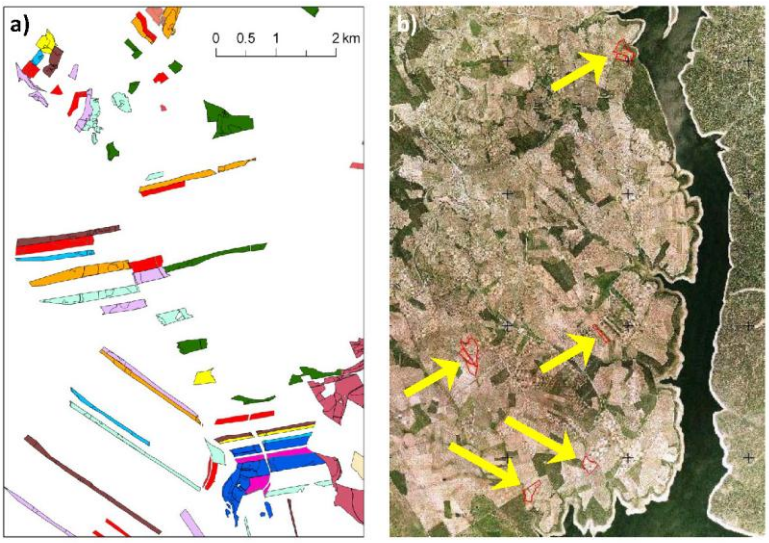
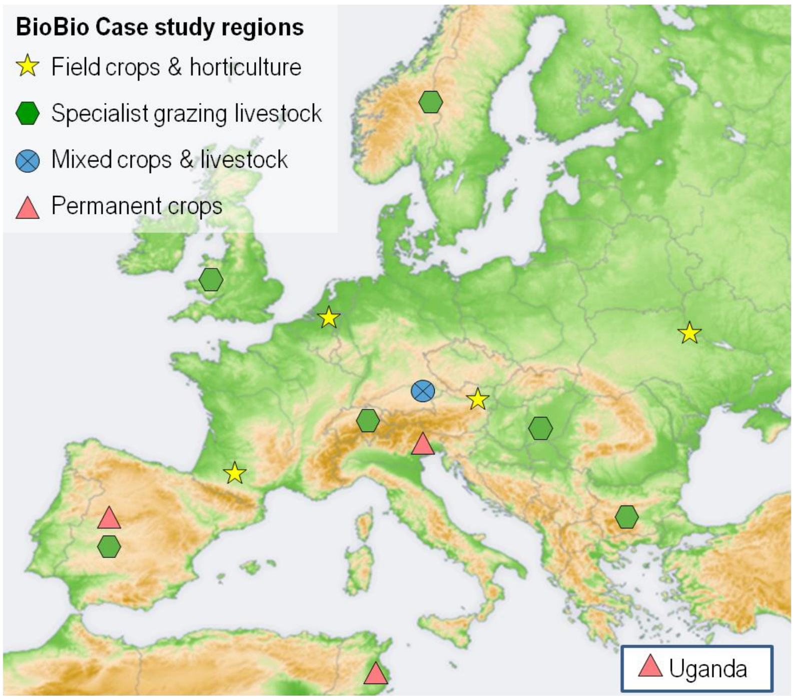


Figure 2: (a) Unconsolidated smallholdings in Norway. Fields belonging to a specific farm are the same colour. (b) Scattered plots of an olive farm in Extremadura, Spain. Although they are not ecologically meaningful units (in terms of biodiversity), farms represent decision-making units for farmers, administrative bodies and policy-makers. Source: (a) W. Fjellstad, NFLI, (b) G. Moreno, UEX

BioBio case studies

Case-study regions (Figure 4) were homogeneous in terms of biogeographical conditions and farming types. They cover low to medium intensive organic and non-organic farming; very intensive conventional farming, industrial animal production, etc. were not covered. In each region, 14 – 20 farms were selected. In regions containing both organic and non-organic farms, farms of both systems were randomly sampled. In 'high nature-value farming' regions (mostly specialist grazing livestock farms), a larger number of farms were screened, and farms were selected along a gradient of livestock density.
Indicators were measured according to a standard protocol. The broader applicability of the core indicators was then tested in three case studies in Tunisia, Ukraine and Uganda.

Case study	N° of farms
Austria	16*
France	16*
Netherlands	14*
Bulgaria	16
Switzerland	19*
Hungary	18
Norway	12*
Wales	20*
Spain	10
Germany	16*
Italy	18*
Spain	20*
Tunisia	20*
Ukraine	6
Uganda	16*



* Organic and non-organic farms

Figure 4: Location, farm type and number of farms examined in 15 BioBio case study regions.

Arable Farming Systems

Austria: Arable Farming System in the Pannonian lowlands

France: Arable Farming System in Gascony, southwest France

Horticulture

Netherlands: Horticulture in the eastern part of the provinces of Gelderland and Noord Brabant

Grassland systems

Bulgaria: Semi-Natural Low-Input Grassland in the Smolyan region of the Rhodopes Mountains of south-central Bulgaria

Switzerland: Mountain Grassland with Cattle in Obwalden, central Switzerland

Hungary: Semi-Natural Low-Input Grassland in the Homokhatsag High Nature Value Area in Central Hungary between the Danube and Tisza rivers

Norway: Grassland with Sheep in Nord-Østerdal, in northern Hedmark County

Wales: Mountain Grassland with Sheep or Cattle, or Mixed Upland Farming in the west of mainland UK

Spain: Mediterranean Low-Input Dryland Tree Crops (Dehesas) in the Extremadura region

Mixed farming system

Germany: Mixed Farming System in the Tertiary Hills of the Alpine Foothills in southern Germany

Permanent crops

Italy: Vineyards in the Veneto region in northeastern Italy

Spain: Olive Plantations in the northern part of Tierras de Granadilla in the Extremadura region of west-central Spain

The BioBio indicator system

Scientific testing and the subsequent stakeholder audit yielded a complementary set of 23 indicators with minimum redundancies within the components of habitat-, species- and genetic (livestock, crops) diversity as well as farm management indicators (Table 1). Whereas 16 indicators are relevant for all farm types, seven apply only to specific farm types. For example, using crop-related indicators only makes sense on farms with a significant percentage of arable crops. Grassland- and farm-animal-related indicators can only be applied on specialist grazing or mixed crops/livestock farms.

Table 1: BioBio indicator set. These indicators have passed scientific and practical testing as well as the stakeholder audit. Indicators which are restricted to specific farm types are indicated by (1) Field crops and horticulture, (2) Specialist grazing livestock, (3) Mixed crops – livestock, (4) Permanent crops.

Indicators for the Genetic Diversity of Livestock and Crops	
Breeds (2), (3)	Number and amount of different breeds
CultDiv	Number and amount of different varieties
CropOrig (1),(3)	Origin of crops
Species Diversity Indicators	
Plants	Vascular plants
Bees	Wild bees and bumblebees
Spiders	Spiders
Earthworms	Earthworms
Habitat Diversity Indicators	
HabRich	Habitat richness
HabDiv	Habitat diversity
PatchS	Average size of habitat patches
LinHab	Length of linear elements
CropRich (1), (3)	Crop richness
ShrubHab	Percentage of farmland with shrubs
TreeHab (1), (2), (3)	Tree cover
SemiNat	Percentage of semi-natural habitats
Farm Management Indicators	
EnerIn	Total direct and indirect energy input
IntExt	Intensification/Extensification
MinFert	Area with use of mineral nitrogen fertiliser
NitroIn	Total nitrogen input
FieldOp	Field operations
PestUse (1), (3), (4)	Pesticide use
AvStock (2), (3), (4)	Average stocking rate
Graze (2), (3)	Grazing intensity

Indicators for crop and livestock genetic diversity

Genetic variability is the basis of life. Farmers and breeders have developed a multitude of crop varieties and animal breeds to suit their needs, and to stabilise and increase productivity. Information on livestock breeds and crop cultivars used on each farm was tested as a surrogate for genetic diversity. These tools are very simple, addressing neither diversity on the gene level nor environmental influence. Molecular genetic methods are technologically demanding, expensive, and require further development for general application. Therefore, three simple indicators based on crop-cultivar and livestock-breed information collected in farmer interviews are proposed to assess genetic resources of crops and livestock.

Cultivar Diversity (CultDiv)

A cultivar represents a plant species that has been created or selected intentionally, can be distinguished from other cultivars and can be maintained through propagation. The term “cultivar” is used to differentiate accessions of one agricultural plant species. The Unit is average number of cultivars across all species on farm. Application of various cultivars on farm will increase resistance and also resilience after abiotic (temperature, drought) and biotic (pests, diseases) disturbances. In contrast, agricultural systems dominated by only one cultivar might be more susceptible to any kind of disturbance.

Origin of Crops (CropOrig)

Origin of cultivated accessions is an indicator based on landraces cultivated on farm. A landrace is a local variety of a domesticated plant species highly adapted to local conditions due to natural selection and evolutionary processes. Compared to cultivars landraces are heterogeneous, but less yielding. The Unit is percentage of landraces grown on farm, measured across all crop species and varieties. Landraces play an important role for crop breeding as well as for the in situ conservation of genetic resources. An increase in landraces on farm may be due to farmers’ preference towards the enhancement of variability of crops, but also due to taking over responsibility for the conservation of genetic resources. A decrease of landraces on farm might cause a unpredictable and tremendous loss of gene pools.

Number and Amount of Different Breeds (Breeds)

This indicator evaluates the genetic diversity of domesticated breeds of livestock. The Unit of measurement is the number of breeds per species per farm. Specialisation of farms to livestock from mixed farming and recent, further specialisation into dairy or meat production has driven significant declines in the use of multiple livestock species and breeds at the farm level. This process has accounted for declines in livestock genetic resources. The consequence may be a future limitation on the extent of resilience to environmental change that can be bred into the modern, commercial breeds of domestic livestock. Traditional breeds are often best adapted to pasturing and preserving marginal, species rich grasslands.

Species diversity indicators

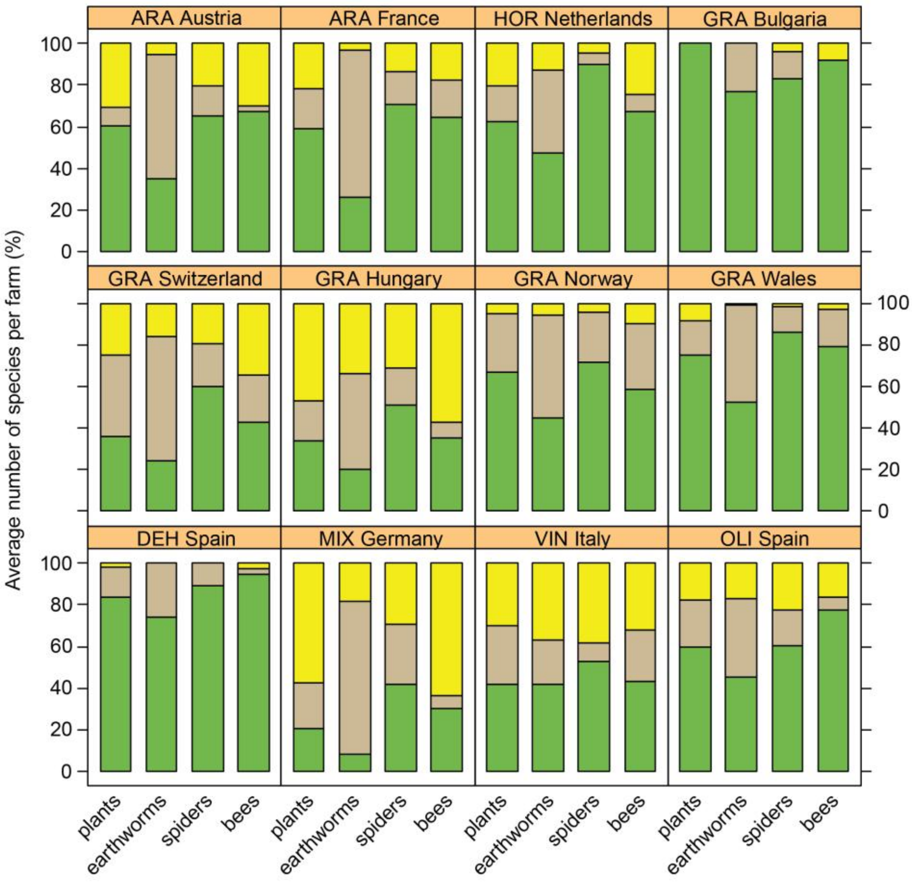
The BioBio species diversity indicators operate at local to intermediate scales and cover the four major ecological functions which are relevant for farming: Primary production (plants), degradation of organic material (earthworms), pollination (wild bees and bumblebees), predation (spiders). The emphasis on invertebrates, in addition to vascular plants, reflects the contribution of invertebrates to overall species diversity, arthropods alone making up about 65% of the species number of all multicellular organisms. Moreover, they are relatively easy to monitor, provide relevant information on general environmental conditions, include emblematic species, react quickly to environmental changes, and substantial datasets are available in various European countries.

In the BioBio approach, species are sampled on one representative plot of each habitat type. There are several ways then to estimate species richness of the farm. In BioBio, "gamma diversity" is used, which consists of the total number of species found on the farm (all habitat types compiled) per taxon.

Interpretation of species richness indicators is straightforward. A higher indicator value is normally connected to higher biodiversity. However, there is no information on population structure and species composition. This means that there is no information whether an increase in indicator values maybe due to valuable or endemic species or habitat generalists or invasive species. To derive information on the quality of composition or conservation values, etc. sub-indicators or other analysis need to be used.

For most taxa in most case study regions a considerable number of species depend exclusively on semi-natural habitats (Figure 5). Earthworms seem to have the lowest dependence on semi-natural habitats. In some case study regions (e.g. Hungary, Germany, Italy) there is also a considerable share of species which exclusively depend on cultivated habitats.

Figure 5: Percentage of plant, earthworm, spider and bee species exclusively found in semi-natural habitats (green stack), cultivated forage and food crop fields (yellow stack) or in both (grey stack).
ARA = arable,
HOR = horticulture,
GRA = grassland,
DEH = Dehesa,
MIX = mixed farming,
VIN = vineyard,
OLI = olive plantation.



Vascular Plants (Plants)

Vascular plants are primary producers which dominate most terrestrial ecosystems, shaping our physical environment and forming the basis of food chains. They constitute an important part of agricultural landscape biodiversity and provide food, shelter, breeding sites, refuges, etc. for a wide range of other organisms. Most mammals, birds, invertebrates and insects are directly or indirectly dependent on one or more plant species and diversity of vascular plants may therefore indicate diversity of other organisms.

Wild Bees and Bumblebees (Bees)

Wild bees are pollinators of selected crops and wild flowering plants and as such are sensitive to the diversity and continuity of pollen and nectar supply throughout spring and summer. There is concern about recent, significant declines recorded for this group and that the economically important associated ecosystem service of crop and orchard pollination may be compromised. Domestic bees were not recorded. A decrease in indicator value can reflect reduced densities of flowers from intensive arable farming, high stocking densities of livestock or increased inputs of nitrogen fertiliser. Favourable changes may also be a response to e.g., increased linear elements composed of flowering plants and rank grassland where small mammals may be active and leave abandoned holes as potential bee nest sites.

Spiders (Spiders)

Spiders are predators found in crops, pastures and all kinds of semi-natural habitats on farmland. The actual species composition of spiders depends upon the availability of insect prey and the architecture of the plant species, providing anchorage for webs produced by many species. A reduction in indicator value can reflect reduced incidence of semi-natural habitats, increased uniformity of vegetation caused by high stocking densities of livestock or mortality caused by increased inputs of pesticides. Favourable changes may also be a response to e.g., increased linear elements and rank grassland which provides greater opportunity for web-building spiders.

Earthworms (Earthworms)

Earthworms contribute to physical, chemical and biological soil processes, thus affecting the productivity of farms. They are key soil detritivores, essential for composting and recycling soil nutrients, enhancing thus soil fertility whilst contributing to build the soil structure and to soil aeration and water infiltration. A decreasing indicator value can reflect (i) reduced soil litter and soil organic matter caused by ploughing, application of pesticides and herbicides, loss of soil biological fertility (microorganism abundance) ...; (ii) increased soil compaction caused by machinery use and/or high stocking densities of livestock. Favourable changes may indicate an increase of the organic matter content and recycling, soil health and overall soil biodiversity caused by the shift from mineral to organic fertilisation, maintenance of non-ploughed and/or non-productive habitats (e.g. linear elements, grasslands in arable farms ...), conservation of wet areas, etc.

Habitat indicators

BioBio proposes a system for classifying the farm habitats (Figures 6, 7). Common lands, forest and aquatic habitats not used for agricultural purposes, and urban habitats are excluded. The farm area is subdivided into (1) Intensively farmed land, including all crop fields and grasslands managed for the primary purpose of agricultural production, and (2) Semi-natural habitats. Both categories are then subdivided, depending on the presence of trees. Aquatic habitats are classified as semi-natural.

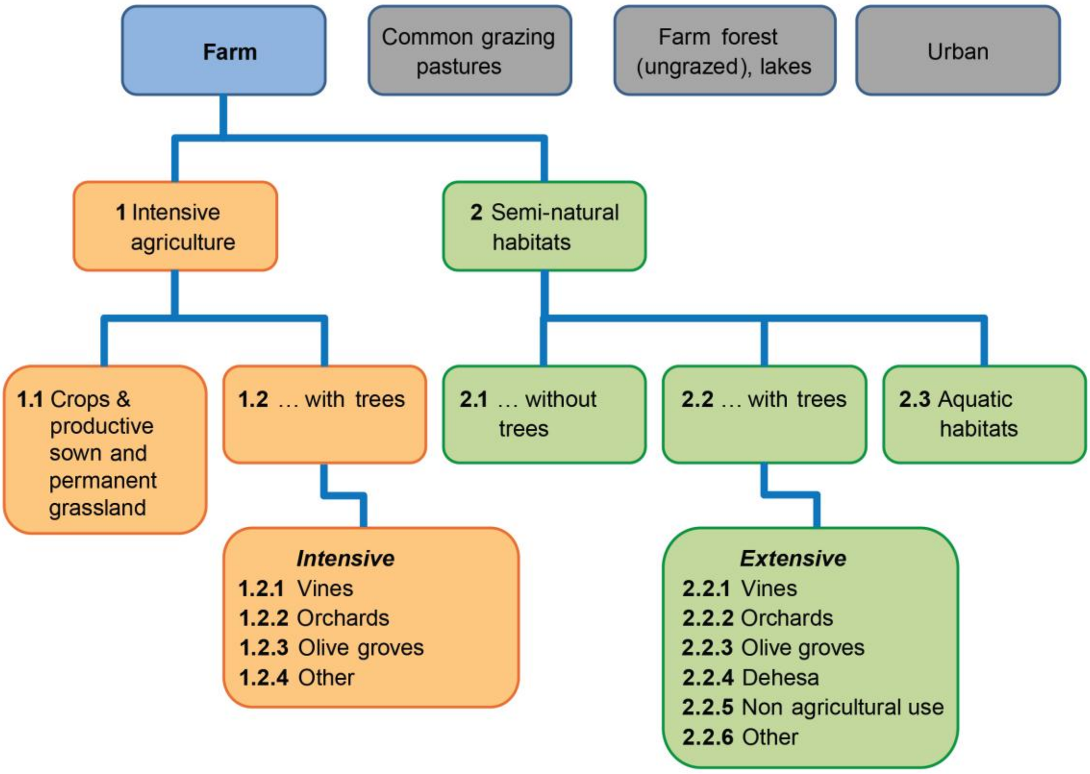


Figure 6: Farm habitat types are classified into categories. The majority of the farmland of most farms consists of category-1 land – 'Intensive agriculture' – interspersed with 'Semi-natural habitats' (category 2) consisting mainly of linear elements with or without trees or shrubs.

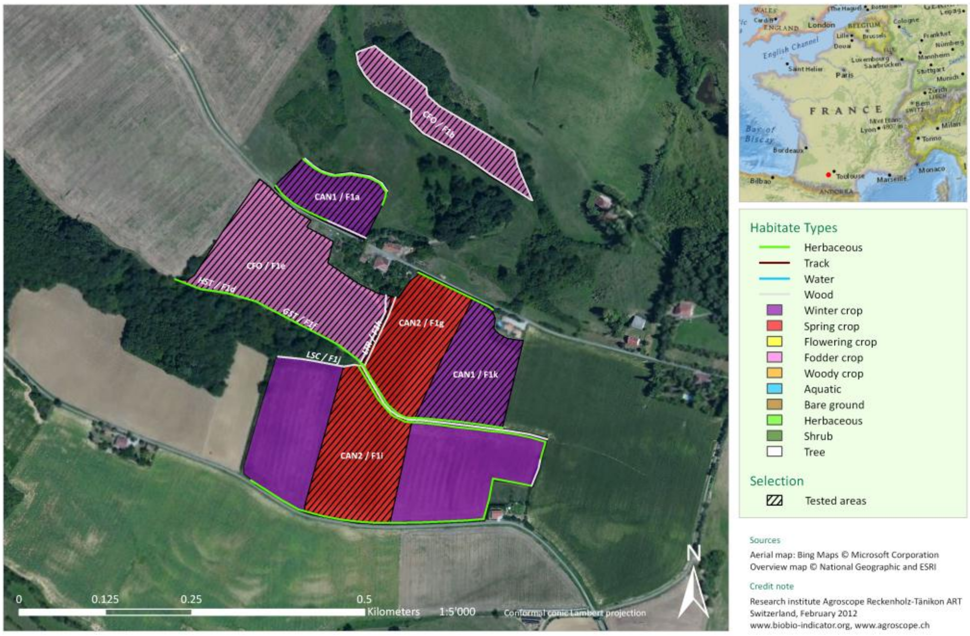


Figure 7: Habitat map for a case study farm in France. Habitats were mapped according to a European approach based on General Habitat Categories. It shows the observed linear and areal habitats. Areal habitats consist mainly of different crop types "Tested areas" refers to habitats which were selected for species sampling.

Indicators capturing the composition of the farm habitats

Habitat Richness (HabR)
Number of habitat types occurring on a farm. Habitats considered are intensively farmed habitats as well as extensively farmed and semi-natural habitats. The Unit of measurement is number of habitats per hectare of farm area. Higher values of HabR indicate a higher potential of species to be present on the farm.

Habitat Diversity (HabDiv)
Diversity of habitats available on the farm, including linear habitats, taking into account both the number of habitat types and their relative proportions of the total farm area. The Unit of measurement is the Shannon Index. When the area of the different habitat types is evenly distributed the farm will have a higher diversity value than farms where one or two habitat types dominate.

Patch Size (PatchS)
Average size of habitat patches on a farm. The Unit of measurement is hectares. Patch Size complements the indicators Habitat Richness and Habitat Diversity.

Linear Habitats (LinHab)
Length of hedgerows, grassy strips, streams, stone walls, etc. which are on the farm or directly adjacent. The Unit of measurement is meters per hectare. Linear habitats are classified as semi-natural because of their proven importance for the maintenance of farmland wildlife.

Indicators relating to specific habitat types

Crop Richness (CropRich)
Number of crops cultivated on a farm. The Unit of measurement is the number of crop types per hectare of farm area. Crop Richness is similar to Habitat Richness but is restricted to arable, fruit and vegetable crops. Crop Richness has been shown to positively correlate with the diversity of arthropods in arable landscapes.

Shrub Habitats (ShrubHab)
Share of the total farm area covered by shrubs. The Unit of measurement is the percentage of the farm area. A certain share of Shrub Habitat may be beneficial for farmland species diversity but it is also an indicator of land abandonment. Interpretation therefore requires consideration of the wider landscape context.

Tree Habitats (TreeHab)
Relates to fruit trees, ornamental trees, vines and pastured forest as well as to hedgerows and semi-natural woodland elements. The Unit of measurement is % of farm area. Trees and shrubs are permanent, overwintering plants and offer habitats for various arthropods, birds and small mammals. The indicator is of interest mostly for arable and grassland farms, which only have a relatively low share of tree habitats.

"Normative" indicator

Semi-natural Habitats (SemiNat)
Share of semi-natural habitats on the farm. The Unit of measurement is percent of farm area. The value of SemiNat depends on the classification of habitats as semi-natural or not. In BioBio the habitats mapped in 12 case study regions were classified according to the General Habitat Categories, linear elements and Annex I habitats also qualified as semi-natural. This is an attempt for a categorization of habitats at the European level. National categorizations may be more relevant and meaningful to farmers and stakeholders.

All indicators can be further detailed into sub-indicators.

Management related indicators

Farm management affects farmland biodiversity. Eight management indicators relating to energy and nutrient input (Total Energy Input, Expenditure on Inputs, Use of Mineral Nitrogen, Total Nitrogen Input), pesticide applications (Pesticide Use), disturbance by mechanical operations (Field Operations) and pressure by livestock (Average Stocking Rate, Grazing Intensity) have been identified. They allow to assess the intensity of farm management and can be correlated to direct habitat and species indicators.
The effect of management indicators on species indicators becomes visible when the whole spectrum of farming intensity is examined. The BioBio case study regions covered the extensive to medium-intensive range. Therefore, the relation between management and species indicators is not always very strong. Moreover, correlations between farm management and the state indicators of biodiversity differed from case study to case study. For each case study, the analysis revealed distinctive combinations of farm management indicators to correlate with direct indicators of biodiversity.

Total Direct and Indirect Energy Input (EnerIn)

Evaluates the consumption of direct energy (fuel, electricity) and indirect energy (synthetic fertilisers, pesticides, feedstuff and machinery) for production of crops and livestock. **Unit:** GJ per ha farmland. Alternatively: equivalent litre of fuel per ha farmland. The indicator must be interpreted together with other indicators with regard to its effect on biodiversity. If an increase is due to the expansion of machinery, this may negatively affect species via changes in the habitat structure (e.g 'Patch size', 'Habitat richness'). Increased input of indirect energy from the application of fertiliser and pesticides may directly affect species diversity.

Intensification/Extensification: Expenditure on Inputs (IntExt)

Computed from annual expenditures on fertiliser, crop protection and concentrate feed stuff (IRENA indicator 15). The **Unit** of measurement is Euros (€) per ha farmland. Must be interpreted with caution, taking monetary factors (exchange rate, inflation) into account. Rising expenses for external inputs suggest a trend towards more intensive forms of farming. For almost all BioBio case studies, the indicators of expenditures and of energy input showed similar trends and were positively correlated. Negative correlations with some species diversity indicators were found in several case studies.

Area with Use of Mineral Nitrogen Fertiliser (MinFert)

Based on the proportion of farmland where mineral-based nitrogen fertiliser is applied. **Unit** of measurement: % of farmland with use of mineral Nitrogen fertiliser. A decrease indicates that the share of land treated with readily soluble mineral nitrogen is decreasing. In marginal regions, fewer land treated with mineral fertiliser may signal the abandonment of agriculture. An increase in the indicator is related to more widespread use of mineral fertiliser. This may indicate a trend to more intensive farming or the expansion of arable land to extensively managed areas.

Nitrogen Input (NitroIn)

Estimates the quantity of nitrogen input (total and sub-indicators: organic, mineral, symbiotic fixation). The **Unit** of measurement is average input of nitrogen on farm-level (kg N per ha farmland). Rising values for nitrogen input indicate that intensification of farms is in progress. The combination with other farm management indicators or with habitat indicators allows to trace potential causes (e.g. raised stocking rates, changes in land-use) and to evaluate threats for biodiversity.

Pesticide Use (PestUse)

This indicator measures the frequency of pesticide application on the farm. The **Unit** of measurement is the area-weighted average of number of pesticide applications. Sub-indicators relate to herbicide, fungicide and insecticide use. Although this is a very simple measure, correlations with species diversity have been observed in the literature as well as in BioBio case studies.

Field Operations (FieldOp)

Quantifies the number of mechanised field operations in crop fields and grassland. The **Unit** of measurement is the area-weighted average number of field operations. Related (sub-)indicators are Mowing Frequency, Mowing Timing, Soil Cultivation. An increase will lead to disruptions and disturbances of plant and animal populations on the plot. Various correlations to species diversity indicators occurred in BioBio case studies.

Average Stocking Rate (AvStock)

The indicator measures the number of livestock in relation to the available forage area. The **Unit** of measurement is the number of livestock units per hectare. Sub-indicators relate to either the total farm area or the forage area. Stocking rates tend to be lower on organic farms due to maximum limits set under the organic regulations; and to restrictions on inputs and on animal medicines which are often used to support artificially high stocking levels, which then have a detrimental effect on biodiversity.

Grazing Intensity (Graze)

This indicator evaluates the intensity of grazing. **Unit:** Number of livestock units per hectare grazing area. A rise in the indicator value indicates stronger pressure on the land. This implies increased levels of nutrients on the pastures which may lead to a decrease of plant species diversity and an introduction of competitive, vigorously growing nitrophilous species.

Practicalities: How to record the indicators?

The four categories of the BioBio indicator set are measured using three mutually complementary approaches (Figure 8):

- Habitat diversity indicators are obtained via habitat mapping at farm scale;
- Species diversity indicators are obtained by specific field-recording methods;
- Crop- and livestock genetic diversity indicators and farm management indicators are obtained through interviews with farmers.

The indicator campaign starts with the selection of the farms. Depending on the purpose of the campaign, selection criteria must be carefully applied in order to ensure that the sample is representative. The farmer is then contacted and an initial general interview is conducted, during which the farmer's consent, other necessary information, and a map of the farm should be obtained.

The map defines the area whose habitats are mapped according to the approach of BioBio / EBONE. The selection of plots for species sampling is based on the habitat map, with one plot per habitat type being selected at random. This means that species sampling can only begin once habitat mapping is complete. In BioBio, data recording in its entirety took place within a year, but spreading the data recording over two years is also an option. On arable farms the habitat map would then require updating for fields under crop rotation. Standard BioBio methods for species recording should be used. Whilst vegetation recording can easily be done shortly after the habitat mapping, arthropod sampling must be conducted three times – in the spring, summer, and late summer – in order to cover the entire season. The survey concludes with a detailed farm interview on the genetic diversity of crops and livestock, and on farm management.

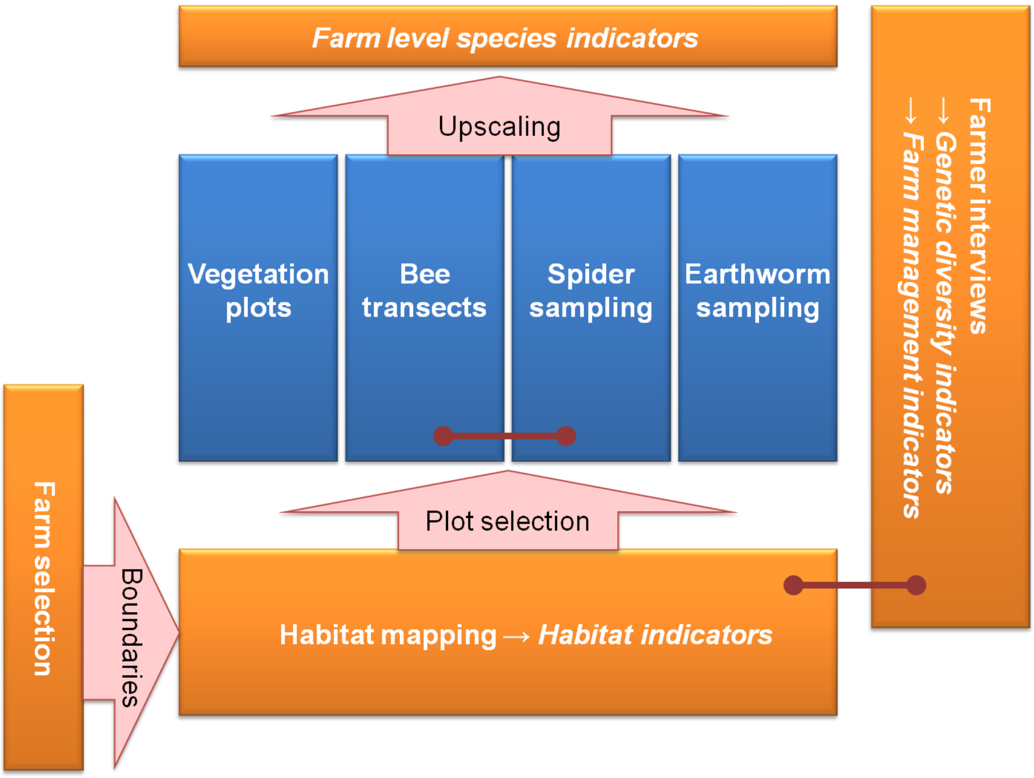


Figure 8: Workflow of a BioBio indicator campaign.

The effort to evaluate the indicators for an average farm is about 15 person days, with equal shares of skilled and unskilled labour. Labour makes up about 75% of the total cost, the rest are consumables (equipment, vehicles, etc.) and the taxonomic cost for identification of the captured invertebrates. There were important differences, however, in labour effort and costs between BioBio case study regions, depending on farm size, farm type, complexity of the farms, etc.

Stakeholders’ perception of biodiversity

BioBio indicators were selected by iterative interaction between researchers and stakeholders. Stakeholders interested in biodiversity consist of representatives of public bodies (national and regional administrative bodies), research and education organisations, farmers’ organisations, consumers' associations, and numerous NGOs dedicated to the conservation of nature and the environment.

Thierry Fabian wants to evaluate the environmental benefit of producing French cheeses and cider with a geographical indication. Biodiversity indicators could be used to characterise the area of a PDO (Protected Designation of Origin) product. Since 1991, *Peter Mayrhofer* has been developing the Ecopoint system in Lower Austria in the frame of the agro-environmental schemes. He is interested in measuring the direct impact on biodiversity of this environmental scheme. In order to assess the benefit of agri-environmental measures on biodiversity in Wallonia, *Thierry Walot* needs direct indicators that require a moderate expenditure of effort to apply. *Claudio De Paola* requires biodiversity indicators in order to compare his experience in the Ticino Italian Regional Park with others. *Patrick Ruppol* wishes to provide organic farmers in Belgium with a tool for measuring their sustainability. *Eva Corral* is focused on measuring European farmers’ efforts to support biodiversity at farm level. In Spain, *Eduardo de Miguel* wants biodiversity indicators that reflect the real impacts of farming practices. *Jörg Schuboth* needs genetic biodiversity indicators to measure the decrease in fruit varieties in Germany and to promote their preservation. *Simeon Marin* wants to evaluate the impact of farmland abandonment in the Bulgarian mountains.

On the whole, stakeholders prefer generic to specific indicators. A set of indicators is also more highly rated than one or two aggregated indicators. Habitat and farm management indicators are given high ratings by the stakeholders, as they are easier to record and more often used in their work.

How do farmers value biodiversity?

Focus groups (Figure 9) revealed the wealth of assessment approaches and wide range of benefits farmers attach to biodiversity: ethical, social, economic and environmental values were mentioned in almost all of the groups. These results suggest that in addition to monetary incentives, the ethos and emotional response of farmers are important drivers of pro-biodiversity farming.

Figure 9: Focus group meeting in Hungary. Photo: Á. Kalóczkai, SIU

Providing clear information (i.e. which can be understood by less-well-educated people) and training – in particular collective training where experiences can be shared – is important for providing farmers with the minimum background necessary for understanding issues concerning biodiversity. This can allow them to conduct better “cost-benefit analyses” for their farms, not only in monetary terms. It may be possible to encourage farmers to protect biodiversity with soft policy tools, such as raising awareness and greater involvement of farmers in designing pro-biodiversity policies.

Application beyond Europe

As an outreach activity, the wider applicability of the BioBio biodiversity indicators was tested in other agro-ecological zones and in a different policy context. The three case studies span a gradient of increasing difference to the European case studies:

- Low input organic and non-organic olive groves in Tunisia, quite similar to the olive groves in Extremadura, Spain;
- Mixed, low-input and intensive arable farming systems in Ukraine, somewhat comparable to the mixed farming system in Germany but with much larger fields and farms;
- Organic and non-organic subsistence farming in Uganda, utterly different from the European case studies.

Whilst the BioBio approach was generally applicable, it needs adaptations and further development for implementation beyond Europe:

- Sampling design: It needs to be adapted to the large scale farms and landscape in the Ukraine (e.g. more than one species plot is needed in a field of 100 ha or more);
- Habitat indicators: The habitat key cannot grasp the diversity of smallholder intercropping in Uganda and needs to be further developed for application in the tropics.
- Species indicators: Taxonomic expertise is lacking in Tunisia and in Uganda. Earthworms were hardly present in Tunisia due to prolonged drought.
- Genetic diversity of crops and livestock: Indicators performed similarly as in the European case study regions. Uganda was the only case study with a substantial share of landraces (Figure 10).
- Management indicators: The socio-economic context, the level of farmers' education and of technology are different in Tunisia and in Uganda compared to the European case studies and the questionnaire would need to be adapted accordingly.

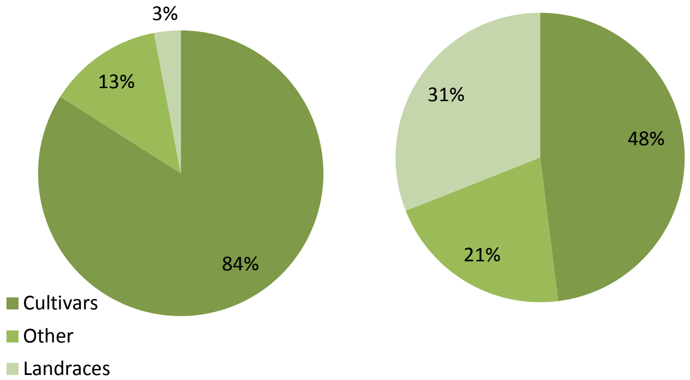


Figure 10: The indicator Crop Origin (CropOrig) *seems more useful in traditional subsistence farming in Uganda than in modern European farming.European case studies, 195 farms, 5 landraces(left); Uganda, 16 farms, 37 landraces (right).*

For practical implementation it would be necessary to adapt the indicator set to lower levels of available resources (funding, knowledge, infrastructure and institutions).

Figure 11: large scale arable farming systems in Ukraine, intercropped olive plantation in Tunisia and intercropping with pineapple and banana in Uganda. Photo: S. Yashchenko, BTNAU, S. Garchi, INRGREF, Ch. Nkwiine, Makarere

Conclusions: From survey to monitoring

We recommend to use a certain percentage of the budget of the European Common Agricultural Policy to evaluate the effects of the policy. The BioBio indicator set can be used for evaluating the effects on farmland biodiversity. A regional classification of the European farms has been developed (Figure 12) and 0.25% of the CAP budget would allow to sample a reasonable number of farms in those regions.

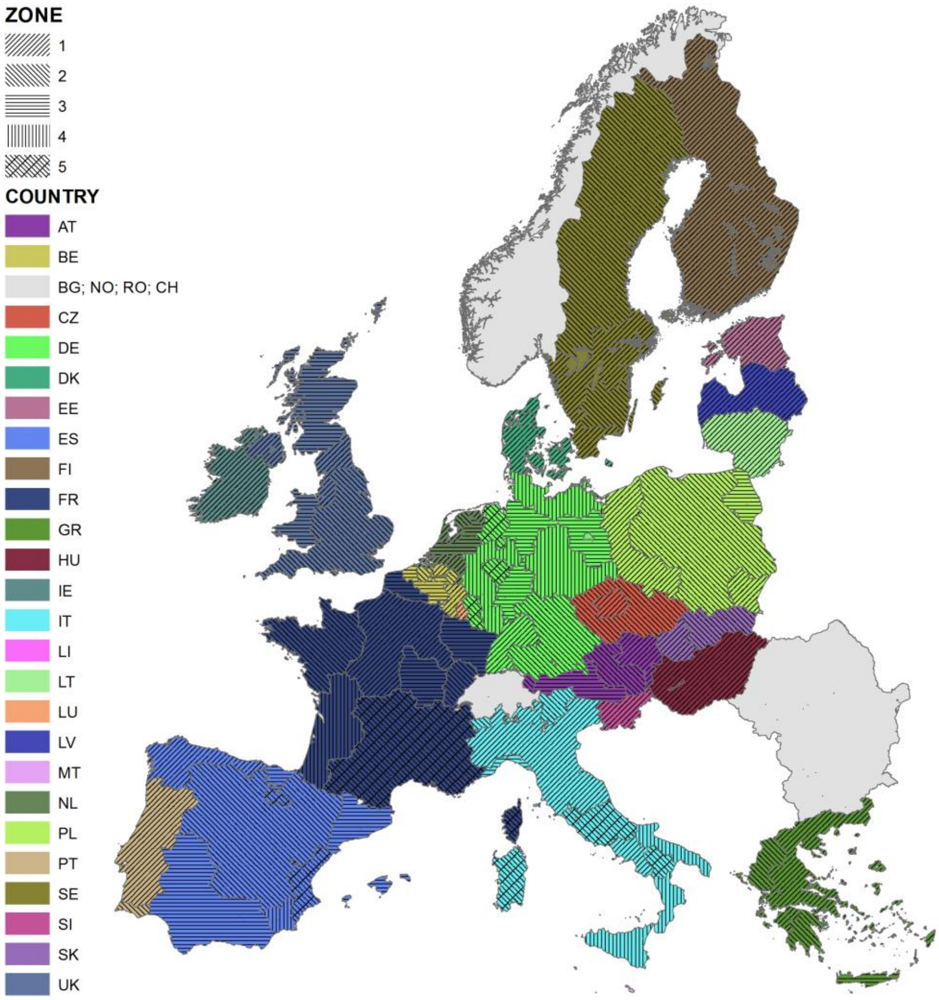


Figure 12: BioBio monitoring zones based on farm statistics (NUTS2) and on environmental regions. Their intersection leads to up to five zones per country. In each zone eight farm types are differentiated. Results could be reported per farm type per zone.

BioBio has been a research project. Based on its findings the pilot phase could start which should consist of testing the BioBio approach in a selected number of those regions. In particular, farm types which have not been tested in BioBio should be examined as well as intensive, conventional farming. The results would allow to further adapt the indicator set and to refine and establish the methodology. Subsequently the routine phase could commence for which we propose a rolling survey (5 year intervals).

The BioBio indicators relate to the farm scale, which has the advantage of directly linking driving forces (farm management) to the status of biodiversity. However, many farms are not consolidated (scattered plots) and farms are dynamic over time. We therefore recommend to complement the BioBio farm scale monitoring with a landscape scale biodiversity monitoring in order to obtain comprehensive and consistent information about the status of European farmland biodiversity.

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