# ENVIEVAL

# Development and application of new methodological frameworks for the evaluation of environmental impacts of rural development programmes in the EU

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## Report D5.2

## Report on monitoring and data requirements for macro level methods

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SEVENTH FRAMEWORK PROGRAMME

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## List of Acronyms

| | |
|---|---|
| AE | Agri-Environment |
| AFI | Agricultural Footprint Index |
| APBS | Action Plan Benefit Score |
| AVAS | Aggregate Visual Amenity Score |
| CAP | Common Agricultural Policy |
| CGE | Computable General Equilibrium |
| CLC | Corine Land Cover |
| CMEF | Common Monitoring and Evaluation Framework |
| DEM | Digital Elevation Model |
| EEA | European Environment Agency |
| ESA | European Space Agency |
| FADN | Farm Accountancy Data Network |
| FBI | Farmland Bird Index |
| GHG | Greenhouse Gas |
| GIS | Geographic Information System |
| GNB | Gross Nutrient Balance |
| HNV | High Nature Value |
| IACS | Integrated Administration and Control System |
| LAU | Local Administrative Unit |
| MCA | Multi Criteria Analysis |
| MS | Member State |
| NUTS | Nomenclature of Territorial Units for Statistics |
| PCA | Principal Component Analysis |
| PG | Public Good |
| RDP | Rural Development Programme |

| | |
|---|---|
| RS | Remote Sensing |
| SPARD | Spatial Analysis of Rural Development measures |
| UAA | Utilised Agricultural Area |

# Executive Summary

Following the review of new methodological developments of macro-level evaluation methods, this report assesses the data requirements of the selected candidate methods to inform the allocation of method combinations to suitable public-good case studies in the partner countries. The assessment will consider for each method (differentiating between applications in the context of different public goods): the level of detail and type of data required, the geographic scale, dates of capture, data origin, the sensitivity of the methods to data quality, and the potential limitations of their use operationally if appropriate data are not available. The synthesis and comparison of the data requirements pay particular attention to the applicability of the methods to the case-study testing and the different case-study areas, and the evaluation challenges which can be addressed.

Following an outline of the objectives of the report in Section 1, Section 2 identifies the key dimensions of the data assessment and provides a short glossary defining some of the key terms. Section 3 summarises the proposed candidate combinations of macro-level methods and indicators for the public-good case study testing for which, in Section 4, the assessment of the data requirements is carried out. Section 4 starts with a list of key questions to be answered by the assessment and then reports in detail the data requirements of the different candidate methods and indicators for each public-good case study. Section 5.1 compares key findings of the assessment of the data requirements of the candidate methods for each public good, highlighting aspects for the applicability in the case studies and with respect to micro/macro linkages in RDP evaluations. This is followed by a first classification of the data requirements of the macro-level candidate methods and a short discussion of the emerging issues for the case study testing in Section 5.3. Finally, Section 6 synthesises key aspects for the guidelines of the databases for the case studies from a macro-level perspective.

The results of the assessment of the data requirements of the candidate methods for the different public goods inform the selection of the case-study areas and the combination of counterfactual, micro and macro level methods to be tested in those case-study areas. A particular emphasis has been placed on methods which focus on micro / macro linkages (e.g. hierarchical sampling, scaling methods and landscape metrics) and on net-impacts at macro level (e.g. economic modelling approaches, spatial econometrics and footprint method). For animal welfare, however, the emphasis has been on identifying a wide range of suitable indicators for the case study testing to address existing indicators gaps. The application of

macro level methods relies in many cases on large, or regionally representative, samples of farm level data. Specific issues in relation to farm level monitoring requirements and data are outlined in report D4.2, the assessment of data requirements at micro level.

A number of issues emerge from the assessment of the data requirements of the macro-level methods which are discussed for each public-good case study. For water quality, the data requirements of spatial econometric models and hierarchical sampling have been reviewed in this report. Spatial econometrics has recently moved more into the focus of RDP evaluations. For example, the EU project SPARD developed and tested the application of spatial econometrics for different economic and environmental impacts of RDPs. While data gaps constrain the use of spatial econometric models at micro level, such models have the potential to improve the evaluation of net environmental impacts at macro level. The review of the data requirements has shown that spatial econometrics requires a wide range of different (mainly secondary) data types which need to be available in the study areas of the water quality case studies to be able to test this method. In addition, if direct impacts on the water quality are to be assessed, representative samples of groundwater monitoring data need to be available.

The application of spatial econometrics for detailed regional impact assessments in the water quality case studies depends on the availability of sufficient monitoring data through farm surveys. The development of the logic models of the methodological evaluation frameworks in WP3 – WP5 needs to consider which counterfactual approaches and micro-level methods would be best suited to facilitate the application of spatial econometrics at macro level. Another constraining factor for the case study testing (as well as the broader use in RDP evaluations) is the complex processing requirements, which demand specific and advanced methodological skills from the users and evaluators.

Hierarchical sampling provides a strategic sampling framework across different scales and levels, developing a consistent framework to collate data at micro and macro levels. Thus, the main contribution of this method is to address the need for consistent micro-macro linkages using one consistent data set to analyse micro- and macro-level impacts. While data processing requirements are not as demanding as for spatial econometrics, the critical factor for the application of hierarchical sampling is the availability of large samples of monitoring data on water quality to allow for sufficient scope to design such complex multi-level sampling frameworks.

For biodiversity wildlife, the data requirements of the same methods (spatial econometric models and hierarchical sampling) have been reviewed. General aspects, such as the evaluation challenges addressed by this method, micro-macro linkages and data processing requirements, also apply in the context of biodiversity wildlife applications. Critical for their application in the biodiversity wildlife case studies is the availability of sufficient regional data points of the Farmland Bird Index or representative monitoring data on other direct indicators such as flowering plants of semi-natural habitats and population trends of agriculture-related butterfly species. An alternative for case-study areas without sufficient biodiversity monitoring data is the testing of the candidate macro-level methods in combination with a suitable indirect indicator such as stock and change of linear habitats and biotopes in agricultural landscapes.

For the macro-level part of the climate stability case studies, data requirements of economic modelling frameworks such as sector models and Computable General Equilibrium (CGEs) models have been assessed. The main advantage of these modelling frameworks is that they operate at (single or multi) sectoral level and thus provide a tool which can consider substitution effects between participating and non-participating farms, thus improving the assessment of net impacts at macro level. However, in particular regionally disaggregated modelling frameworks are data intensive and require substantial modelling and data-processing efforts. The application in the climate stability case studies (and in fact also generally in RDP evaluations) strongly depends on the availability of existing modelling frameworks which can be used, as the development of a new regional economic modelling framework would require too much time and resources. The allocation of climate stability case studies has taken this constraint into account. Alternatively, scaling methods can be combined with micro-level methods such as carbon footprint and farm surveys to generate macro-level impacts on climate stability.

The data requirements of spatial econometrics and multi-criteria methods have been reviewed for the application of evaluating macro-level animal welfare impacts. Generally, the issues raised for spatial econometrics in the context of water quality applications also apply here. Even more than for water quality case studies, the application of spatial econometrics to assess animal welfare impacts strongly depends on the quantity and quality of the monitoring data from farm visits. Multi-criteria assessments can be used to test different indicators and the application of indicator indices addressing the gap of suitable animal welfare indicators for RDP evaluations. A particularly interesting aspect of this method is that it can be applied for the micro and macro levels assessing the same indicators at farm and farm type (or livestock system) level as well as for specific policy measures and at overall programme level.

The macro-level application of both methods would directly build on micro-level data. This requires case-study areas with large samples of primary data from participating and non-participating farms to test different problem-related animal welfare indicators. The testing of new indicators is an important contribution to address the current gaps in RDP evaluations of animal welfare impacts. Linking the animal welfare case study with past and on-going projects gathering monitoring data on a wide range of different animal welfare aspects is crucial for the testing of new indicators and methods.

For the public good landscape, the data requirements of landscape metrics, footprint method and multifunctional hotspot and zoning were assessed. The selected methods link the macro-level evaluations of landscape impacts with contextual information and improve the determination of robust causal linkages. In particular landscape metrics provide an approach to include aspects such as landscape connectivity and pattern in the evaluation. Depending on the representativeness of micro-level data, the application of landscape metrics at macro level can build on micro-level data and thus ensure consistent micro-macro level linkages.

The methods strongly rely on spatial data on land use and land cover. Infrequent updates to existing databases is one the major limitations of their use for RDP evaluations. Remote sensing data can be used to address potential data gaps. The application of these methods depends on the availability of spatial land use and land cover data available in a timeframe which fits with RDP evaluations. The data requirements of the same methods were assessed for biodiversity HNV, as these two public goods use to large extent the same type of indicators.

The footprint method and multifunctional hotspots and zoning have also been assessed for their application for soil quality. In addition to the issues already mentioned above, the application of the methods for an impact assessment on soil quality also requires a good availability of monitoring data on soil quality in the case-study areas.

The assessment of the data requirements of the macro-level candidate methods highlights the importance of data issues for the selection of case-study areas to be able to test the robustness and added value of the candidate methods to the approaches currently used in RDP evaluations  The results also highlight key issues for the database development of the case studies, such as consistent approaches for aggregating and disaggregating data, and integrating different data sources and spatial and non-spatial data.

The next steps in the development of the guidelines for the case study databases comprise the synthesis of all emerging issues and questions from the assessment of the data requirements of counterfactuals, micro- and macro-level methods, the development of a step-by-step approach for the database development and a logic model providing a schematic overview and instructions how to develop the case study databases. Separate databases will be developed for each case study. The guidelines will provide a consistent framework for the development of the different case study databases focussing, for example, on consistent approaches for aggregating and disaggregating data, and integrating different data sources and spatial and non-spatial data.

# 1 Objectives of the Task

Following the review of new methodological developments of macro-level evaluation methods, this report assesses the data requirements of the selected candidate methods to inform the allocation of method combinations to suitable public-good case studies in the partner countries. The assessment will consider for each method (differentiating between applications in the context of different public goods) the level of detail and type of data required, the geographic scale, dates of capture, data origin, the sensitivity of the methods to data quality, and the potential limitations of their use operationally if appropriate data are not available. The synthesis and comparison of the data requirements pay particular attention to the applicability of the methods to the case-study testing and the different case-study areas, and the evaluation challenges which can be addressed.

The assessment of the data requirements of will be reviewed during and after the case-study testing with the aim to develop a classification of the data and monitoring requirements of the tested macro-level evaluation methods for the methodological handbook.

The objectives of the comparison of the data and monitoring requirements of the different macro level methods (Task 5.3) are to:

- inform selection of case-study areas in WP6 in terms of what kind of data need to be available in the areas to be able to test a method
- identify key aspects of the guidelines for the structure of the databases for the different public-good case studies
- inform the development of the logic models and the selection of method combinations for the public-good case studies in the partner countries
- provide the basis for a classification of the data requirements of the new evaluation methods during following the case study testing.

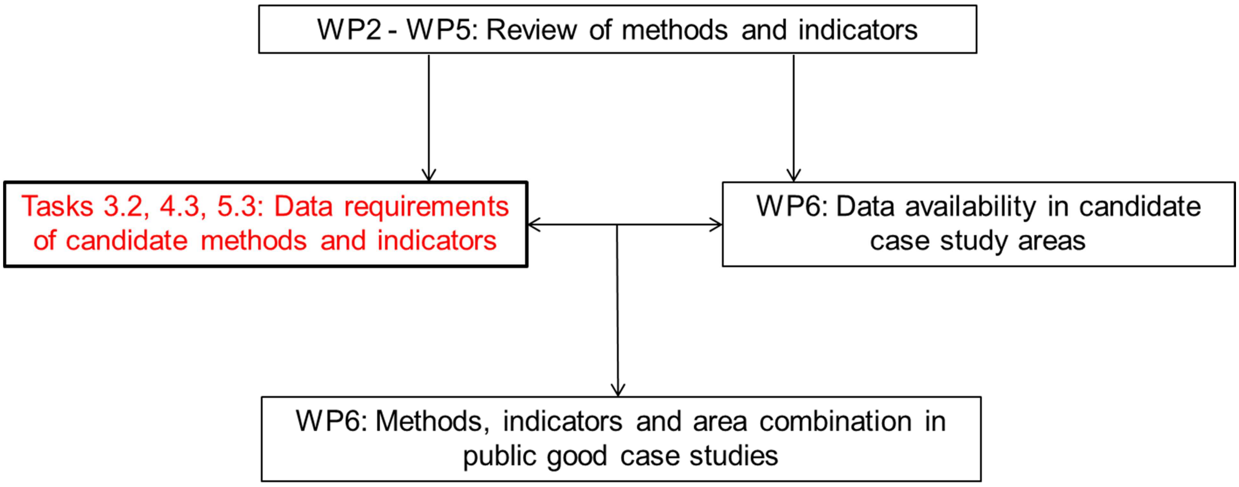


**Figure 1 Overview of the different parts of the data assessment in the case study design**

The report is structured as follows: Section 2 identifies the key dimensions of the data assessment and provides a short glossary defining some of the key terms. Section 3 summarises the proposed candidate combinations of macro-level methods and indicators for the public-good case study testing for which in Section 4 the assessment of the data requirements is carried out. Section 4 starts with a list of key questions to be answered by the assessment and then reports in detail the data requirements of the different candidate methods and indicators for each public-good case study. Section 5.1 compares key findings of the assessment of the data requirements of the candidate methods for each public good, highlighting aspects for the applicability in the case studies and with respect to micro/macro linkages in RDP evaluations. This is followed by a first classification of the data requirements of the macro-level candidate methods and a short discussion of the emerging issues for the case study testing in Section 5.3. Finally, Section 6 synthesises key aspects for the guidelines of the databases for the case studies from a macro-level perspective.

# 2 Definitions and Identification of Key Dimensions for the Assessment of the Data Requirements

This section provides an overview of the dimensions to be followed in the assessment of the data requirements of the candidate methods in section 4 and includes a short glossary of some definitions.

## 2.1 Definitions and Key Dimensions of the Assessment

Primary data - Data generated specifically for monitoring and evaluation, e.g. environmental monitoring programmes, surveys of beneficiaries and non-beneficiaries.

Secondary data - Data generated and processed for other purposes but of use for the evaluation, e.g. FADN, Census data and IACS.

**Table 1 Overview of the dimensions of the assessment**

| Upper level | Lower level | Comments / explanations |
|---|---|---|
| **Type of data** | Biophysical data | Data that describe/capture the natural components in the agricultural landscape/land (soil, water, habitats, biodiversity and land cover/use) |
| | Economic data | Data that describe the economic activities in agriculture, including the use of inputs of labour, capital, and goods and services to produce outputs of goods or services, either at farm, regional or national level. |
| | Social data | Data that describe the characteristics of the land managers and other relevant actors and their decision making |
| | Policy data | Data that describe the policy measures and programmes (e.g. including payment level, participation / uptake, measure requirements etc.) |
| **Primary data** | Data format | Refers to the format primary data need to have to be used with the method |
| | Data origin | Refers to data source and who (e.g. land managers, policy administration, evaluators etc.) has or needs to collate the data |
| | Data access | Are data freely available to evaluators or are certain access restrictions in place? |
| **Secondary data** | Data format | Format can refer to spatial and non-spatial databases. In relation to spatial data specifically it refers to raster, polygon, line or point data. |
| | Data origin | Refers to data source and from which organisation the data are available |
| | Data access | Are data freely available to evaluators or are certain access restrictions in place? |
| **Spatial dimensions** | Scales | Refers to spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon |
| | Levels | Refers to locations along a scale as the units of analysis that are located at different positions. |
| **Temporal dimensions** | Dates of capture | For which point in time are data available? |
| | Frequency of observations | Annual or periodic data |
| **Data processing** | | The required efforts to transform the type of data suitable for use by/in the methodology |

# 3 Overview of Candidate Methods, Public Good and Indicator Combinations

Based on the findings of the indicator and methodological reviews in WP2 – WP5 and the results of the first stakeholder consultations in WP9, a set of candidate methods and corresponding public goods and indicators have been identified. Table 2 provides an overview of the suggested method – public good (PG) – indicator combination at macro level for which a first assessment of the data requirements is reported in this deliverable. The applicability of the suggested combinations for the public-good case studies in the different partner countries has been discussed at the fourth project meeting in Aberdeen and provide the basis (from a macro-level perspective) for the allocation of counterfactual/micro- and macro-level method combinations to the different public-good case studies. A particular emphasis has been placed on methods which focus on micro/macro linkages (e.g. hierarchical sampling, scaling methods and landscape metrics) and on net-impacts at macro level (e.g. economic modelling approaches, spatial econometrics and footprint method). For animal welfare, however, the emphasis has been on identifying a wide range of suitable indicators for the case-study testing to address existing indicator gaps.

**Table 2 Overview of the candidate methods and suitable public goods and indicators (macro level)**

| Method | Public good | Indicator (to be selected by method experts in combination with PG case study teams and the AUA team) | | | |
|---|---|---|---|---|---|
| | | **CMEF impact indicator (if it exists)** | **Alternative direct indicator** | **Alternative direct indicator** | **Alternative in-direct indicator** |
| Landscape metrics | Landscape | - | Fragmentation of land parcels | Habitat patch shape | Spatial complexity |
| Landscape metrics | Biodiversity (HNV) | Percentage of Utilised Agricultural Area farmed to generate High Nature Value | Habitat connectivity | Habitat patch size | Vegetation quality index |
| Ecological footprints/life cycle analysis | Landscape | - | AE Footprint Index based on new CMEF | Footprint based on landscape indicators | Stock and change of linear habitats and biotopes in agricultural landscapes |
| Ecological footprints/life cycle analysis | Biodiversity (HNV) | Percentage of Utilised Agricultural Area farmed to generate High Nature Value | AE Footprint Index | Footprint based on landscape / HNV indicators | |
| Ecological footprints/life cycle analysis | Soil | Soil erosion by water | Soil Organic Matter in arable land (also CMEF) | AE Footprint Index | |
| Multi-functional hotspots and landscape zoning | Landscape | - | Aggregate visual amenity score (AVAS) | Estimated visitor numbers | Protection of landscapes and specific natural elements & Stock and change of linear habitats and biotopes in agricultural landscapes |
| Multi-functional hotspots and landscape zoning | Biodiversity (HNV) | Percentage of Utilised Agricultural Area farmed to generate High Nature Value | Biodiversity Action Plan Benefit scores (APBS) | High Natural Value Index (crop diversity index & stocking density index) | % UAA under Natura 2000 |
| Multi-functional hotspots and landscape zoning | Soil | Soil erosion by water | Soil Organic Matter in arable land (also CMEF) | Soil benefit score | |
| Hierarchical sampling | Biodiversity wildlife | Farmland Bird Index | | | Stock and change of linear habitats and biotopes in agricultural landscapes |
| Hierarchical sampling | Water quality | Gross Nutrient Balance (GNB-N and GNB-P) | Mineral N content in autumn | Nitrate leaching | Pesticide / fertiliser applications to arable land |
| Hierarchical sampling | Water quality | Water abstraction in agriculture | | | Irrigated area Irrigation technique |
| Scaling methods: up scaling | Water quality | Gross Nutrient Balance (GNB-N and GNB-P) | Mineral N content in autumn | Nitrate leaching | Pesticide / fertiliser applications to arable land |
| Scaling methods: Up-scaling | Climate | GHG emissions from agriculture | Total net emissions from agriculture (including soils) | Direct use of energy in agriculture | Production of renewable energy from agriculture |
| Economic modelling frameworks, e.g. CGEs | Climate | GHG emissions from agriculture | Total net emissions from agriculture (including soils) | Direct use of energy in agriculture | Production of renewable energy from agriculture |

| **Method** | **Public good** | **Indicator (to be selected by method experts in combination with PG case study teams and the AUA team)** | | | |
|---|---|---|---|---|---|
| | | **CMEF impact indicator (if it exists)** | **Alternative direct indicator** | **Alternative direct indicator** | **Alternative in-direct indicator** |
| Spatial econometrics | Water quality | Gross Nutrient Balance (GNB-N and GNB-P) | Nitrate pollution | Nitrogen quantity used per hectare of utilised agriculture area | Pesticide / fertiliser applications to arable land |
| Spatial econometrics | Biodiversity wildlife | Farmland Bird Index | Flowering plants of semi-natural habitats | Population trends of agriculture related butterfly species | Stock and Change of linear habitats and biotopes in agricultural landscapes |
| Spatial econometrics | Biodiversity HNV | Percentage of Utilised Agricultural Area farmed to generate High Nature Value | High Natural Value Index (crop diversity index & stocking density index) | Spatial complexity | Vegetation quality index |
| Spatial econometrics | Animal welfare | - | Quality of livestock housing (e.g. cow comfort index) | Disease indicators (e.g. lameness, mortality rates) | Grazing area / outdoor access |
| Mixed method approach | Animal welfare | - | Quality of livestock housing (e.g. cow comfort index) | Disease indicators (e.g. lameness, mortality rates) | Grazing area / outdoor access |
| Multi-criteria evaluation method | Animal welfare | - | Animal welfare index | Welfare quality index | |

# 4 Assessment of the Data Requirements of the Selected Methods

This section provides a detailed assessment of the data requirements of the public good – method – indicator combinations summarised in Table 2 above. In addition to combinations assessed below, mixed method approaches (combining a qualitative impact assessment at macro level with quantitative methods used at micro level) and different approaches scaling up micro-level data and assessments to macro level will be considered in the public-good case studies. Mixed method approaches are, for example, considered to assess animal welfare impacts at macro level and scaling approaches are, in particular, considered for water quality and climate stability case studies (see also Table 2 above).

The assessment of the data requirements of the candidate methods follows a template of eight key dimensions or questions, which have been developed jointly for the micro- and macro-level methods.

1. What types of data are needed (specify what kind of biophysical, economic, social and policy data are needed)?
2. Which of those data types are required as primary data? Specify the type of data and outline required sampling strategy and size, data format and origin and issues in relation to data access.
3. Which of those data types are required as secondary data? Explain the required sampling size or number of data points, data format and origin and issues in relation to data access for each type of data.
4. How does the method incorporate spatial dimensions? At what scales and levels do the data need to be available?
5. How does the method consider temporal dimensions? What are the dates of capture and the frequency of the required data? Does this fit with the temporal dimensions of the evaluation framework?
6. Explain the type and extent of data processing work required to apply the method.
7. Assess the sensitivity of the methods to data quality.
8. Assess the constraints or consequences for the application of the methods if appropriate data are not (fully) available.

## 4.1 Economic Modelling Framework: Sector Models and Computable General Equilibrium Models (CGE)

### 4.1.1 Sector models– climate stability – all indicators

1. Type of data:

   - IACS or/and aggregated (sectoral) payment data for CAP and RDP measures
   - Data on intervention logics of the different measures to adequately implement the different policy measures into the sectoral modelling framework
   - FADN and agricultural census data
   - Greenhouse gas emissions:
     - Data on greenhouse gas emissions from agricultural practices ($CO_2$ plus all emissions of $CH_4$ and $N_2O$) during the production process, such as the application of fertilisers and manure, livestock emissions, stored animal manure, and land use changes
     - IPCC data on greenhouse gas emissions
   - Direct use of energy in agriculture:
     - Data on direct energy use in agriculture

2. Primary data: Generally, no primary data needed. However, depending on the level of application, primary data on changes in agricultural practices and related changes in GHG emissions might be helpful to fill possible data gaps.

3. Secondary data:

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| FADN | Aggregated data or/and large samples to enable regional / national aggregation or representation | Value and physical units | FADN database | Data available |
| Census | | Physical units (e.g. ha, FTE, t) | Census databases, Ministries | Aggregated data available<br>Access restricted for detailed data |
| Payment data | | Euro/ha | Managing authorities | Access for evaluators granted |
| GHG data | | Physical units (such as grams, tonnes, etc.) or $CO_2$ equivalent (grams $CO_2$ equivalent, tonnes $CO_2$ equivalent, etc.) | Eurostat, EEA, national & regional statistics (regional level data: processing required) | Data available |
| Direct energy use | | Kgoe or Toe (Kilograms or tonnes of oil equivalent) per ha per year | Eurostat, FADN and KTBL databases | Data available at national and regional level and for sub-sectors |

| | | | | |
|---|---|---|---|---|
| | | Direct Energy Inputs – sum of consumed electricity, and solid, liquid and gaseous fuels ($GJ \cdot ha^{-1}$, GJ/LU) | | |

4. Spatial aspects: Sector models allow for non-spatial and spatial analysis of RDP impacts on GHG emissions, although most applications of sector models are non-spatial, at least in a stricter sense. Given the rather aggregated nature of many existing sector models NUTS 0 and NUTS 1 levels are the most frequently applied spatial levels for sector models. At those spatial levels sector models can consider substitution effects within a sector. Widely used sector models exist at those spatial levels.

5. Temporal dimensions: Sector models are calibrated for a specific base year and establish new short-term or longer-term equilibriums depending on the selected scenarios or shocks implemented into the model. This provides the flexibility to adjust the base year and implemented shocks according to the duration and scope of the RDP programme period. Dynamic sector models can trace changes in the variables and indicators through a certain period, for example in annual intervals, and can thus produce a result for each year of the RDP programme period. FADN data and census data are available on an annual basis.

6. Data processing: Sector models require different data processing tasks. The most substantial data processing tasks are in relation to the disaggregation needed to analyse the GHG emission impact of policy-induced changes in different production systems or farm types and in relation to regional disaggregations in the model, if the assessment of GHG emission impacts are to be analysed below national level. In addition and similarly to a CGE framework, the integration of different units and transfers from volume to value data require further data processing as well as the construction of the potentially complex modelling framework. If possibilities exist to use, or at least to build on, already existing modelling frameworks, this would reduce the extent of required data processing for evaluators.

7. Sensitivity to data quality: Results of the sector models strongly depend on the quality of the data used to calibrate the model. Assumptions and approaches used to disaggregate the modelling framework into multiple regions and sub-sectors (production systems or markets) have an important influence on the quality of the data and the modelling results. Lack of detailed representation of the intervention logic of

RDP measures in aggregated modelling frameworks can reduce the feasibility and robustness of the results.

8. Consequences of data gaps: Smaller data gaps can be dealt with through data 'manipulations' and assumptions. However, this increases the uncertainty and decreases the robustness of the results.

### 4.1.2 CGEs – climate stability – all indicators

1. Type of data:
    - Input – Output tables at national or regional level
    - IACS or/and aggregated payment data for CAP and RDP measures
    - Data on intervention logics of the different measures to adequately implement the different policy measures into the economic modelling framework
    - FADN and agricultural census data, depending on the level of disaggregation of the agricultural sector and production systems in the modelling framework
    - Economic data of other sectors (e.g. down and upstream sectors), depending on the scope of the model
    - Greenhouse gas emissions:
        - Data on greenhouse gas emissions from agricultural practices ($CO_2$ plus all emissions of $CH_4$ and $N_2O$) during the production process, such as the application of fertilisers and manure, livestock emissions, stored animal manure, and land use changes
        - IPCC data on greenhouse gas emissions
    - Direct use of energy in agriculture:
        - Data on direct energy use in agriculture
2. Primary data: Generally, no primary data needed. However, depending on the level of application, primary data on changes in agricultural practices and related changes in GHG emissions might become valuable. Household or/and farm surveys might be needed to obtain additional farm and household data.
3. Secondary data:

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Input-Output tables | Aggregated data | Value units in Euro | Official statistics | Data available |

| | | | | |
|---|---|---|---|---|
| | or/and large samples to enable regional / national aggregation or representation | (base year) | (regional level data: processing required) | |
| FADN | | Value and physical units | FADN database | Data available |
| Census | | Physical units (e.g. ha, FTE, t) | Census databases, Ministries | Aggregated data available<br>Access restricted for detailed data |
| Payment data | | Euro/ha | Managing authorities | Access for evaluators granted |
| GHG data | | Physical units (such as grams, tonnes, etc.) or $CO_2$ equivalent (grams $CO_2$ equivalent, tonnes $CO_2$ equivalent, etc.) | Eurostat, EEA, national & regional statistics<br>(regional level data: processing required) | Data available |
| Direct energy use | | Kgoe or Toe (Kilograms or tonnes of oil equivalent) per ha per year<br>Direct Energy Inputs – sum of consumed electricity, and solid, liquid and gaseous fuels ($GJ \cdot ha^{-1}$, GJ/LU) | Eurostat, FADN and KTBL databases | Data available at national and regional level and for sub-sectors |

4. Spatial aspects: CGE models allow for non-spatial and spatial analysis of RDP impacts on GHG emissions, although most applications of CGE models are non-spatial, at least in a stricter sense. Given the overall economic and rather aggregated nature of many existing CGE modelling frameworks NUTS 0 and NUTS 1 levels are the most appropriate and most frequently applied spatial levels for CGE models. At those spatial levels CGE models can consider substitution effects within and between different sectors. Widely used modelling frameworks exist at those spatial levels.

5. Temporal dimensions: Comparative-static CGE models are calibrated for a specific base year and establish new short-term or longer-term equilibriums depending on the selected scenarios or shocks implemented into the model. This provides the flexibility to adjust the base year and implemented shocks according to the duration and scope of the RDP programme period. Dynamic CGE models can trace changes in the variables and indicators through a certain period, for example in annual intervals, and can thus produce a result for each year of the RDP programme period. Input-output tables are often only updated every two to three years, which impacts on the possible base year, while other required data sources such as GHG accounts, FADN data or census data are available on an annual basis.

6. Data processing: CGE models require different data processing tasks. The most substantial data processing tasks are in relation to the sectoral disaggregation needed to analyse the GHG emission impact of policy-induced changes in different production systems or farm types and in relation to regional disaggregations (e.g. of the input – output tables or GHG emission inventory data) in the model, if the assessment of GHG emission impacts are to be analysed below national level. In some cases NUTS 1 level data exist, but in many cases further regionalised data do not exist, e.g. in terms of regional input-output statistics and GHG emission data, and thus need to be derived through disaggregation exercises and/or from additional data collection. In addition, the integration of different units and transfers from volume to value data require further data processing as well as the construction of the rather complex modelling framework. If possibilities exist to use, or at least to build on, already existing modelling frameworks, this would reduce the extent of required data processing for evaluators.
7. Sensitivity to data quality: Results of the CGE models strongly depend on the quality of the data used to calibrate the model. Assumptions and approaches used to disaggregate the sectoral and regional modelling framework have an important influence on the quality of the data and the modelling results. Lack of detailed representation of the intervention logic of RDP measures in aggregated modelling frameworks can reduce the feasibility and robustness of the results.
8. Consequences of data gaps: Smaller data gaps can be dealt with through data 'manipulations' and assumptions. However, this increases the uncertainty and decreases the robustness of the results.

## 4.2 Spatial Econometrics

### 4.2.1 Spatial econometrics – water quality - all indicators

1. Type of data:
    - Policy related variables such as uptake and payment data for CAP and RDP measures (IACS)
    - Data on intervention logics of the different measures
    - Land use and farm data (e.g. Census and FADN data)
    - Data on water quality (depending on selected indicator):

- Gross nutrient balance (GNB): Nitrogen and Phosphorus in inputs (fertiliser, manure, feed) (in kgN/year) and Nitrogen and Phosphorus in outputs (milk, wheat, potatoes, roughage) (in kgN/year)
- Nitrate pollution
- Nitrogen quantity used per hectare of utilised agriculture area: Nitrogen in inputs in fertiliser and manure and land management data
- Pesticide / fertiliser applications to arable land

2. Primary data: Soil, water and input use monitoring data at farm level (participating and non-participating farms) could be needed to address data gaps at regional level (e.g. NUTS 3 levels) and improve the database for macro-level analysis. The indicator nitrate pollution requires ground water and/or river monitoring data.
3. Secondary data:

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Policy related variables | Large | Aggregated payment data ( Euro / ha and measure) and uptake data (ha under measure) with geographical references | IACS, Managing authorities | Access for evaluators granted |
| Land use, output and input data, structural variables | Large (depending on level of analysis) | Value and physical units, Euro / ha and kg / ha (etc.) with geographical references | FADN database Census databases, Ministries | Data available Access restricted for detailed data |
| Water quality data, GNB | National Regional (requires disaggregation of national data and / or sufficiently large sample of farm level data) | Balance / surplus in kg / ha with geographical references | Eurostat FADN database Census database Farmer surveys | Data at national level freely available at Eurostat |

4. Spatial dimensions: This method explicitly incorporates spatial aspects in the assessment. For water quality spatial econometrics methods and models have been successfully used for EU impact analysis at NUTS 0 and NUTS 1 levels (e.g. in the SPARD project). At those levels the application can build on existing national data available from Eurostat and other freely available databases. However, for the evaluation of environmental impacts of national and regional RDPs data are required at NUTS 2 and NUTS 3 level. Such detailed regional assessments require either the disaggregation of national data to regional level or depends on the availability of sufficient monitoring data on nutrient balances and input and output data through farm surveys and/or existing farm statistics. In the latter case, micro-level data at farm level

need to be aggregated to regional level to spatially explicitly represent different farming regions.

5. Temporal dimensions: Spatial econometric models can use annual data or be applied to a base year and impact year, e.g. according to the RDP periods.
6. Data processing: Spatial econometric models require different data processing tasks including:
    - Building the econometric base models for modelling and integrating water quality indicators, agricultural production functions, input demand functions, farm and site specific characteristics, and managerial qualities
    - Modifications of original data for, and integration of, different units into the modelling framework
    - Data processing requirements differ between the different indicators: Calculation of GNB indicator at regional level and nitrate pollution have higher data processing requirements than nitrogen quantity used per hectare or pesticide / fertiliser applications on arable land
    - Regional analysis: Substantial task of disaggregating data from national accounts and statistics to regional levels or aggregating farm-level data to regional level.
7. Sensitivity to data quality: The application and the results of the spatial econometric models are very sensitive to the available quantity and quality of the required data and thus require case-study areas with a comprehensive database of land use, farm management and characteristics and water quality data at regional level.
8. Consequences of data gaps: Smaller data gaps can be dealt with through data 'manipulations' and assumptions. However, this increases the uncertainty and decreases the robustness of the results.

### 4.2.2 Spatial econometrics – biodiversity wildlife - all indicators

1. Type of data:
    - IACS or/and aggregated payment data for CAP and RDP measures
    - Data on intervention logics of the different measures
    - Land use and farm data
    - Land cover data (Corine and LUCAS)
    - Biodiversity data:
        - Farmland Bird Index (FBI): Bird monitoring data

  - Flowering plants of semi-natural habitats: Monitoring data on plant indicators on agricultural land
  - Population trends of agriculture-related butterfly species: Monitoring data on butterfly species on agricultural land
  - Stock and change of linear habitats and biotopes in agricultural landscapes: Habitat and biotope data (IACS)
2. Primary data: Depending on the selected indicator, the following primary monitoring data are needed: Farmland bird monitoring data, monitoring data on plant indicators and butterfly species. Relatively large samples are needed to achieve representativeness at regional level (e.g. NUTS 3 level).
3. Secondary data:

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Policy-related variables | Large | Aggregated payment data (Euro / ha and measure) and uptake data (ha under measure) with geographical references | Managing authorities | Access for evaluators granted |
| Land use, output and input data, structural variables | Large (depends on level of analysis) | Value and physical units, Euro / ha and kg / ha (etc.) with geographical references | FADN database Census databases, Ministries | Data available Access restricted for detailed data |
| Land cover | Large | GIS data, polygon/raster format | Corine Land Cover (periodic) LUCAS survey (every three years), remote sensing data | Data available |
| Farmland Bird Index | Large (for more detailed regional analysis) | Occurrence of indicator species on sample plots | National bird monitoring (annual) | Data available |

4. Spatial aspects: As above and point 7 below.
5. Temporal dimensions: Spatial econometric models can use annual data or be applied to a base year and impact year, e.g. according to the RDP periods. FBI, FADN and Census data are updated annually, while LUCAS and CLC data are updated periodically. Remote-sensing data could be used to fill land cover data gaps.
6. Data processing: Spatial econometric models require different data processing tasks including:
   - Building the econometric base models for modelling and integrating biodiversity indicators, agricultural production functions, input demand functions, land-cover data, site-specific characteristics, and managerial qualities

- Modifications of original data for, and integration of, different units into the modelling framework
- Data processing requirements differ between the different indicators: Indicators based on secondary data (e.g. IACS) have lower data-processing requirements than indicators using primary monitoring data (e.g. monitoring data on plant indicators and butterfly species)
- Regional analysis: Substantial task of disaggregating data from national accounts and statistics to regional levels or aggregating farm-level data to regional level

7. Sensitivity to data quality: The feasibility of applying spatial econometrics to biodiversity indicators such as the Farmland Bird Index and other direct fauna and flora indicators at regional level (e.g. NUTS 3) depends on the availability of sufficient monitoring data in the different case-study areas (and member states more generally).
8. Consequences of data gaps: Smaller data gaps can be dealt with through data ‘manipulations’ and assumptions. However, this increases the uncertainty and decreases the robustness of the results.

### 4.2.3 Spatial econometrics – biodiversity HNV – all indicators

1. Type of data:
    - IACS or/and aggregated payment data for CAP and RDP measures
    - Data on intervention logics of the different measures
    - Land use and farm data
    - Land-cover data (Corine and LUCAS)
    - Habitat data
    - Natura 2000 and designated-area data
2. Primary data: No primary data needed.
3. Secondary data: All of the above listed data types are secondary data.

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Policy related variables | Large | Aggregated payment data ( Euro / ha and measure) and uptake data (ha under measure) with geographical references | Managing authorities | Access for evaluators granted |
| Land use, output and input data, structural variables | Large (depends on level of analysis) | Value and physical units, Euro / ha and kg / ha (etc.) with geographical references | FADN database Census databases, Ministries | Data available Access restricted for detailed data |
| Land cover | Large | GIS data, polygon/raster format | Corine Land Cover (periodic) LUCAS survey (every three years), remote sensing data | Data available |
| Habitat data | Large | Landscape features and habitats within a certain raster (e.g. one square km) Estimates of stock in kilometres | Habitat surveys, e.g. British Countryside Survey | Data available |
| Designated areas | Large | Spatial data on location and size of designated sites | EEA | Data available |

4. Spatial aspects: As above.
5. Temporal dimensions: Spatial econometric models can use annual data or be applied to a base year and impact year, e.g. according to the RDP periods. FADN and Census data are updated annually, while LUCAS, CLC and habitat data are updated periodically. Remote sensing data could be used to fill land cover data gaps.
6. Data processing: Spatial econometric models require different data-processing tasks including:
    - Building the econometric base models modelling and integrating biodiversity indicators, agricultural production functions, input demand functions, land cover data, site specific characteristics, and managerial qualities
    - Modifications of original data for, and integration of, different units into modelling framework
    - Calculation of biodiversity indicator at regional level
    - Regional analysis: Substantial task of disaggregating data from national accounts and statistics to regional levels or aggregating farm-level data to regional level
7. Sensitivity to data quality: The availability of a wider range of secondary data for different HNV indicators suggests higher potential for the application of spatial econometric methods for the macro-level assessment. This was also confirmed in the

SPARD project, where spatial econometrics was used for RDP assessments at NUTS 2 level.

8. Consequences of data gaps: Smaller data gaps can be dealt with through data 'manipulations' and assumptions. However, this increases the uncertainty and decreases the robustness of the results.

### 4.2.4 Spatial econometrics – animal welfare – all indicators

1. Type of data:
    - IACS or/and aggregated payment data for RDP measures
    - Data on intervention logics of the different measures
    - Land use and farm data (e.g. Census and FADN)
    - Livestock data
    - Animal welfare data: such as animal information systems (e.g. HIT database in Germany), quality and classification of livestock housing and health/disease issues
2. Primary data: Requires primary data obtained at micro level through farm surveys and visits. This includes data:
    - on resource-based indicators on the quality and classification of livestock housing and outdoor access
    - on problem-oriented indicators covering different livestock disease issues
3. Secondary data: All of the above listed data types are secondary data.

| **Data type** | **Sample size** | **Data format** | **Data origin** | **Data access** |
|---|---|---|---|---|
| Policy related variables | Large | Aggregated payment data (Euro / ha and measure) and uptake data (LU under measure) with geographical references | Managing authorities | Access for evaluators granted |
| Land use, livestock husbandry data, structural variables | Large (depends on level of analysis) | Value and physical units (LU / ha, $m^2$ / LU, number of animals (etc.) ) with geographical references | FADN database Census databases, Ministries | Data available Access restricted for detailed data |
| Animal information systems | Large | Farm level (registered animals) | HIT database (Identification and Information System for Animals) | Data available |

4. Spatial aspects: The macro level or regional assessments depends on the availability of sufficient monitoring data on animal health and welfare indicators through farm surveys and/or existing farm statistics (e.g. HIT database in Germany). Micro-level

data at farm level need to be aggregated to regional level to represent different farming regions in a spatially explicit way.

5. Temporal dimensions: Spatial econometric models can use annual data or be applied to a base year and impact year, e.g. according to the RDP periods. FADN and Census data are updated annually. Primary data collated at micro level will reflect the animal welfare state of a certain point in time or, ideally, be carried out at a minimum of two different points in time.
6. Data processing: Spatial econometric models require different data processing tasks including:
   - Building the econometric base models modelling and integrating animal welfare indicators, agricultural production functions, input demand functions, livestock databases, site specific characteristics, and managerial qualities
   - Modifications of original data for and integration of different units into modelling framework
   - Aggregation of animal welfare indicators at regional level
   - Regional analysis: Substantial task of aggregating farm-level data to regional level
7. Sensitivity to data quality: The suitability of spatial econometric methods for the macro-level assessment of animal welfare impacts strongly depends on the availability of sufficient farm-level data on animal health and welfare indicators. This largely relies on primary data. However, the applicability of spatial econometric methods increases if databases are available for animal health indicators (e.g. the benchmarking system in Scotland).
8. Consequences of data gaps: Smaller data gaps can be dealt with through data ‘manipulations’ and assumptions. However, this increases the uncertainty and decreases the robustness of the results.

   The application at regional level requires large samples of farm-level data. However, the collation of such large farm-level samples is costly and time-consuming. In the case of bigger data gaps or smaller available samples, other econometric methods such as multivariate analysis can be used to assess impacts according to different farm or livestock types.

## 4.3 Hierarchical Sampling

### 4.3.1 Hierarchical sampling – water quality – all indicators

1. Type of data:
   - IACS or/and aggregated payment data for RDP measures
   - Data on intervention logics of the different measures
   - Land use and farm data
   - Land-cover data
   - Spatial data on elevation, topography, biogeographical regions and soil conditions
   - Data on water quality (depending on selected indicator):
     - Gross nutrient balance: Nitrogen and Phosphorus in inputs (fertiliser, manure, feed) (in kgN/year) and Nitrogen and Phosphorus in outputs (milk, wheat, potatoes, roughage) (in kgN/year)
     - Nitrate pollution
     - Nitrogen quantity used per hectare of utilised agriculture area (UAA): Nitrogen in inputs in fertiliser and manure and land management data
     - Pesticide / fertiliser applications to arable land
2. Primary data: Monitoring data on water quality indicators are needed. Multi-order hierarchical arrangement methods used to allow for assessment for water quality impacts from field (micro) to catchment and regional level (macro).
3. Secondary data:

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Policy related variables | Large | Aggregated payment data (Euro / ha and measure) and uptake data (ha under measure) with geographical references | Managing authorities | Access for evaluators granted |
| Land use, output and input data, structural variables | Medium (depends on level of analysis) | Value and physical units, Euro/ha and kg/ha (etc.) with geographical references | FADN database Census databases, Ministries | Data available Access restricted for detailed data |
| Land cover | Medium | GIS data, polygon/raster format | Corine Land Cover (periodic) LUCAS survey (every three years), remote sensing data | Data available |
| Spatial data on elevation, topography, biogeographical regions and soil conditions | Medium | GIS data, Polygon | Various GIS databases | Data availability might vary |

4. Spatial aspects: Sampling strategy is specifically designed to consider relationships between different spatial levels and scales. The sampling can be designed for different spatial dimensions and can integrate different levels / scales (e.g. field, farm and landscape level). Integrates spatial data sets and data need to be available with geographic references/codes.

5. Temporal dimensions: Can be used with annual data or data for base year and impact year, e.g. according to the RDP periods.
6. Data processing: Hierarchical sampling methods require different data-processing tasks including:
    - Multi-level observations and indicators (covering both participants and non-participants) need to be integrated in a consistent analytical framework
    - Data-processing requirements also depend on econometric or statistical methods selected in combination with hierarchical sampling
7. Sensitivity to data quality: Testing of different hierarchical sampling strategies in the public-good case studies depends on the availability of detailed and widespread monitoring data on water quality on participating and non-participating farms and ground water and/or rivers (depending on selected indicator). The extent of available data and sampling size determines the choice of econometric and statistical methods to analyse the observations and sampling results.
8. Consequences of data gaps: Data gaps restrict the scope for testing hierarchical sampling strategies, as additional monitoring data can most likely not be generated during the case studies.

### 4.3.2 Hierarchical sampling – biodiversity wildlife – all indicators

1. Type of data:
    - IACS or/and aggregated payment data for RDP measures
    - Data on intervention logics of the different measures
    - Land use and farm data
    - Land-cover data
    - Spatial data on elevation, topography, biogeographical regions and soil conditions
    - Biodiversity data:
        a. Farmland bird index (FBI): Bird monitoring data
        b. Flowering plants of semi-natural habitats: Monitoring data on plant indicators on agricultural land

c. Population trends of agriculture-related butterfly species: Monitoring data on butterfly species on agricultural land
d. Stock and change of linear habitats and biotopes in agricultural landscapes: Habitat and biotope data (IACS)

2. Primary data: Monitoring data on different biodiversity indicators (see above) are needed. Multi-order hierarchical arrangement methods used to allow for assessment for biodiversity impacts from field (micro) to catchment and regional level (macro).
3. Secondary data:

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Policy related variables | Large | Aggregated payment data (Euro / ha and measure) and uptake data (ha under measure) with geographical references | Managing authorities | Access for evaluators granted |
| Land use, output and input data, structural variables | Medium (depends on level of analysis) | Value and physical units, Euro / ha and kg / ha (etc.) with geographical references | FADN database Census databases, Ministries | Data available Access restricted for detailed data |
| Land cover | Medium | GIS data, polygon/raster format | Corine Land Cover (periodic) LUCAS survey (every three years), remote sensing data | Data available |
| Spatial data on elevation, topography, biogeographical regions and soil conditions | Medium | GIS data, Polygon | Various GIS databases | Data availability might vary |

4. Spatial aspects: Sampling strategy is specifically designed to consider relationships between different spatial levels and scales. The sampling can be designed for different spatial dimensions and can integrate different levels / scales (e.g. field, farm and landscape level). Integrates spatial data sets and data need to be available with geographic references / codes.

5. Temporal dimensions: Can be used with annual data or data for base year and impact year, e.g. according to the RDP periods.
6. Data processing: Hierarchical sampling methods require different data processing tasks including:
   - Multi-level observations and indicators (covering both participants and non-participants) need to be integrated in a consistent analytical framework
   - Data-processing requirements also depend on econometric or statistical methods selected in combination with hierarchical sampling

7. Sensitivity to data quality: Testing of different hierarchical sampling strategies in the public good case studies depends on the availability of detailed and widespread monitoring data on biodiversity indicators on participating and non-participating farms. The extent of available data and sampling size determines the choice of econometric and statistical methods to analyse the observations and sampling results.
8. Consequences of data gaps: Data gaps restrict the scope for testing hierarchical sampling strategies, as additional monitoring data can most likely not be generated during the case studies. Without sufficient monitoring data on direct biodiversity indicators hierarchical sampling can be tested in combination with a suitable indirect indicator such as stock and change of linear habitats and biotopes in agricultural landscapes.

## 4.4 Method Landscape Metrics

### 4.4.1 Landscape metrics - landscape – fragmentation index, habitat patch shape, spatial complexity.

1) Types of data needed:
   - Area of farmland participating in RDP
   - Land cover
   - Land use
   - Remote Sensing (RS) data
   - Validation data for RS analysis
   - Landscape character areas
2) No need for primary data
3) The data required are secondary data, which require adequate detail to be able to distinguish differences in land use and land cover with the participating and non-participating areas. Existing land-cover/land-use data can be used; however the level of detail in the classification will determine the extent to which meaningful detail for measuring is present or absent.  The minimum mappable areas of the data should be 1ha.

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Land cover | | GIS data, Polygon/ raster | CORINE, regional land cover data | Data available |
| Land use | Large (depending on level of analysis) | GIS data, Polygon/ raster | LUCAS, FADN database, Census databases, | Data available |
| Remote Sensing data | Large | GIS data, | ESA (European Space | Data available |

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| (satellite/aerial photos) | | Raster | Agency) | |
| Landscape character areas | Medium | GIS data, Polygon | Regional data | Where they exist they are accessible |

4) The method can be used for assessment at different spatial levels, either by using different types of resolution data (but due to the data dependency caution needs to be taken in the comparison between the results of different levels) or by aggregating the results of detailed assessment. The minimum mappable areas of the data should be at least 1ha meaning a resolution of at least 100m raster, but 0.25 ha, i.e. 50m raster would be more useful.

5) Assessment at the beginning and end of RDP programme. Existing land cover/land use data are regularly updated; however they may not be in sync with the RDP reporting cycle to provide useful impact assessment. The application of RS data (including aerial photography) can be used to fill the data gap and create a meaningful time series. RS data have the advantage that for much of EU they are both temporally and spatially more detailed. Due to cloud cover, the availability for certain areas maybe limited but generally temporally more flexible and compatible with the RDP reporting cycle.
6) Data processing requires:
   - Creation of time series through updating of land cover and land-use data with RS data.
   - Conversion of data to raster format
   - Calculation of the fragmentation index using Fragstats, ArcGIS Patch Analyst or R
7) Data constraints can potentially prohibit meaningful comparison (i.e. ability to measure change (temporal) or ability to compare results across EU (spatial)). In addition, it may impair the ability to measure the impact of RDP on this public good.
8) Both the resolution of data and the extent of the analysis determine the extent of error in the impact assessment.

### 4.4.2 Landscape metrics - biodiversity (HNV) - % UAA farmed to generate HNV, habitat connectivity, habitat patch size.

1) Types of data needed:
   - Area of farmland participating in RDP
   - Area of HNV
   - Land cover
   - RS data

- Habitat and vegetation data
- Designated areas

2) No need for primary data

3) The data required are secondary data, which require adequate detail to be able to distinguish differences in land use and land cover with the participating and non-participating areas. Existing land-cover/land-use data can be used; however the level of detail in the classification will determine the extent to which meaningful detail for measuring is present or absent. The minimum mappable areas of the data should be 1ha.

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Land cover | | GIS data, Polygon/ raster | CORINE, regional land cover data | Data available |
| Land use | Large (depending on level of analysis) | GIS data, Polygon/ raster | LUCAS, FADN database, Census databases, | Data available |
| Remote Sensing data (satellite/aerial photos) | Large | GIS data, Raster | ESA (European Space Agency) | Data available |
| Landscape character areas | Medium | GIS data, Polygon | Regional data | Where they exist they are accessible |

4) The method can be used for assessment at different spatial levels, either by using different types of resolution data (but due to the data dependency caution needs to be taken in the comparison between the results of different levels) or by aggregating the results of detailed assessment. The minimum mappable areas of the data should be at least 1ha meaning a resolution of at least 100m raster, but 0.25 ha, i.e. 50m raster would be more useful.

5) Assessment at the beginning and end of RDP programme. Existing land-cover/land-use data are regularly updated; however they may not be in sync with the RDP reporting cycle to provide useful impact assessment. The application of RS data (including aerial photography) can be used to fill the data gap and create a meaningful time series. RS data have the advantage that for much of EU they are both temporally and spatially more detailed. Due to cloud cover, the availability for certain areas maybe limited but generally temporally more flexible and compatible with the RDP reporting cycle.

6) Data processing requires:

- Creation of time series through updating of land-cover and land-use data with RS data.
- Conversion of data to raster format
- Calculation of the fragmentation index using Fragstats, ArcGIS Patch Analyst or R

7) Data constraints can potentially prohibit meaningful comparison (i.e. ability to measure change (temporal) or ability to compare results across EU (spatial)). In addition it may impair the ability to measure the impact of RDP on this public good.

8) Both the resolution of data and the extent of the analysis determine the extent of error in the impact assessment.

### 4.4.3 Landscape metrics - biodiversity (HNV) - vegetation quality index

1) Types of data needed:
   - Area of farmland participating in RDP
   - Area of HNV
   - Land cover
   - Habitat and vegetation data
   - Designated areas
2) Random sampled hierarchal survey of HNV areas of RDP participants and not participants
3) The data required are secondary data, which require adequate detail to be able to distinguish differences in land use and land cover with the participating and non-participating areas. Existing data can be used however the level of detail in the classification will determine the extent to which meaningful detail for measuring is present or absent. The minimum mappable areas of the data should be 0.25ha.

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Area of HNV | Large | GIS data, Polygon | | |
| Land cover | Large | GIS data, Polygon/raster | CORINE, regional land cover data | Data available |
| Habitat data | Large | Landscape features and habitats within a certain raster (e.g. one square km) Estimates of stock in kilometres | Habitat surveys, e.g. British Countryside Survey | Data available |
| Digital Elevation Model (DEM) | Large | GIS data, Raster | | |
| Designated areas | Large | GIS data, Polygon | Natura2000, Regional data | Data available |

4) The method can be used for the assessment at different spatial levels, either by using different types of resolution data but, due to the data dependency, caution needs to be taken in the comparison between the results of different levels, or by aggregating the results of detailed assessment. The minimum mappable areas of the data should be at least 1ha meaning a resolution of at least 100m raster but 0.25 ha, i.e. 50m raster would be more useful.

5) Assessment at the beginning and end of RDP programme. Existing land cover/land use and biodiversity monitoring data are regularly updated; however they may not be in sync with the RDP reporting cycle to provide useful impact assessment. Where the available land-cover and land-use data prove to be limiting, the temporal dimension of the assessment application of RS (including aerial photography) can be used to fill the data gap. RS data have the advantage that for much of EU they are both temporally and spatially more detailed. Due to cloud cover, the availability for certain areas may be limited but generally temporally more flexible and compatible with the RDP reporting cycle.
6) Data processing requires:
    - Creation of time series through updating of land cover and land use data with RS data
    - Conversion of data to raster format
    - Calculation of the fragmentation index using Fragstats, ArcGIS Patch Analyst or R.
7) Data constraints can potentially prohibit meaningful comparison (i.e. ability to measure change (temporal) or ability to compare results across EU (spatial)). In addition, it may impair the ability to measure the impact of RDP on this public good.
8) Both the resolution of data and the extent of the analysis determine the extent of error in the impact assessment.

## 4.5 Ecological Footprint

### 4.5.1 Ecological footprint - landscape – AE footprint index based on new CMEF, footprint based on landscape indicators and habitats/biotopes in agricultural landscapes.

Footprint analysis by its nature incorporates multiple indicators. Footprint data requirement is determined by the indicators included in the analysis. The AFI has been developed for farm-level assessment. The objective is to modify the method for use at a macro level by modifying the criteria, indicators and data for use at macro level.

1) Types of data needed:
    - Area of farmland participating in RDP
    - Area of HNV
    - Land cover
    - Land use

- RS data
- Landscape character areas
- Habitat data
- Designated areas
- Visibility data
- Perception data
- UAA data

2) No need for primary data
3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Area of HNV | Large | GIS data, Polygon | | |
| Land cover | Large | GIS data, Polygon/ raster | CORINE, regional land cover data | Data available |
| Land use | Large (depending on level of analysis) | GIS data, Polygon/ raster | LUCAS, FADN database, Census databases, | Data available |
| Remote Sensing data (satellite/aerial photos) | Large | GIS data, Raster | ESA (European Space Agency) | Data available |
| Landscape character areas | Medium | GIS data, Polygon | Regional data | Where they exist they are accessible |
| Habitat data | Large | Landscape features and habitats within a certain raster (e.g. one square km) Estimates of stock in kilometres | Habitat surveys, e.g. British Countryside Survey | Data available |
| Designated areas | Large | GIS data, Polygon | Natura2000, Regional data | Data available |
| Digital Elevation Model (DEM) | Large | GIS data, Raster | | |

4) The method itself is flexible in relation to its demand for data; however the spatial dimension of the results is determined by the data with the poorest spatial detail and the best possible results will be gained if data used have the same spatial detail.

5) The data for this methodology range from frequent monitoring data to near static data. The potential of assessing a baseline and one RDP period is likely to be conducted only with partially updated information.

6) Data processing requires:
    - Criteria need to be formulated and matrix for the assessment of measures versus public goods through specific indicators needs to be developed.

7) The objective is to develop a more quantitative basis for the AFI, which is reliant on data. However, in the absence of data, it is possible to use qualitative data.

8) It is possible to make an assessment of change, but with greater uncertainty/error, and the ability to compare the results between MS may be reduced.

### 4.5.2 Ecological footprint - biodiversity (HNV) - % of UAA farmed to generate HNV, AE footprint index, footprint based on landscape / HNV indicators

1) Type of data
   - UAA data
   - Area of HNV
   - Land cover data
   - RS data
   - Habitat data
   - Designated areas
   - Area of farmland participating in RDP
2) Habitat survey data of RDP and non RDP areas, hierarchical sampled survey
3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS, data, Polygon | IACS | Access for evaluators granted |
| Area of HNV | Large | GIS data, Polygon | | |
| Land cover | Large | GIS data, Polygon/raster | CORINE, regional land cover data | Data available |
| | | | | |
| Habitat data | Large | Landscape features and habitats within a certain raster (e.g. one square km) Estimates of stock in kilometres | Habitat surveys, e.g. British Countryside Survey | Data available |
| Designated areas | Large | Polygon | Natura2000, Regional data | Data available |
| Remote Sensing data (satellite/aerial photos) | Large | Raster | ESA (European Space Agency) | Data available |

4) Farm level data (RDP) will be assessed in the context of neighbouring areas to assess connectivity and diversity/spatial complexity.

5) The temporal dimension is largely determined by the frequency of the land-cover data although RS data can be used to fill the gaps.

6) Criteria need to be formulated and matrix for the assessment of measures versus public goods through specific indicators needs to be developed.

7) The objective is to develop a more quantitative basis for the AFI, which is reliant on data. However in the absence of data it is possible to use qualitative data.

8) It is possible to make an assessment of change, but with greater degree of uncertainty/error, and the ability to compare the results between MS may be reduced.

### 4.5.3 Ecological footprint - soil - soil quality indicators (soil erosion by water), soil organic matter in arable land, AE footprint index.

1) Types of data needed:
    - Area of farmland participating in RDP
    - Soil data
    - Land cover
    - Farm management data
    - Digital Elevation Model (DEM)
2) Farm survey data
3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Land cover | Large | GIS data, Polygon/raster | CORINE, regional land cover data | Data available |
| Land use and management | Large (depending on level of analysis | GIS data, Polygon/raster | LUCAS, FADN database, Census databases Data available | |
| Digital Elevation Model (DEM) | Large | GIS, data, Raster | | |
| Soil data | Large | GIS data | Soil Survey or modelled data | |

4) The data from soil monitoring are commonly not aligned with RDP activities. Up and down scaling will be required. This process and the data resulting from it should be at a level of detail that is one level below the reporting spatial units, i.e. if reporting at NUTS3 than the data should be at NUTS4 i.e. LAU1.

5) The monitoring data are limited in temporal dimension. The potential of assessing a baseline and one RDP period is constraint by the availability of monitoring data.

6) Criteria need to be formulated and matrix for the assessment of measures versus public goods through specific indicators needs to be developed.

7) The objective is to develop a more quantitative basis for the AFI, which is reliant on data. However in the absence of data it is possible to use qualitative data.

8) It is possible to make an assessment of change, but with a greater degree of uncertainty/error, and the ability to compare the results between MS may be reduced.

## 4.6 Multifunctional Hotspots and Landscape Zoning

This analysis is specifically taking on board multiple indicators rather than a single one.

### 4.6.1 Landscape zoning - landscape - visual amenity score

1) Types of data needed:
   - Area of farmland participating in RDP
   - Land cover
   - Population data
   - General preference for the amount of selected landscape feature
   - Visibility of selected features
   - Density of transport infrastructure
2) No need for primary data
3) The data required are secondary data, which require adequate detail to be able to distinguish differences in land use and land cover with the participating and non-participating areas. A reasonable data resolution for case-study area would be 25m raster.

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Land cover | Large | GIS data, Polygon/raster | CORINE | Data available |
| Population data | Large | GIS data, Polygon | EUROSTAT | Data available |
| Visibility data | Large | GIS data, Raster | Modelled | |
| Transport infrastructure | Large | GIS data, Raster | Modelled from topographical data | |

4) The indicator is created using different data sources. The level of detail is determined by the data with the coarsest resolution. Where possible scaling can be used to bring the data resolution closer together.
5) Land cover, population and infrastructure data are updated on regular basis; however they may not be updated in line with the timing of the RDP. Possibility is to update the published data with RS data for the RDP period.
6) The data in raster format will be used to create input data and the visual amenity score in ArcGIS or R.
7) Depending on the sizes of the features selected (for example woodland) the resolution of the data is important to be able to assess the indicator. For example, if data are only available at 1km$^2$, the error in the visual amenity score will be high for the case-study area.

8) This method has previously been used for prediction rather than measurement of change. The consequences of the data constraints are that it reduces the effectiveness of the method to measure change, hence the impact of RDP

### 4.6.2 Landscape zoning - landscape - estimated visitor numbers

1) Types of data needed:
    - Area of farmland participating in RDP Population centres
    - Roads (Access)
    - Access facilities on site (forests)
    - Land cover
    - Visitor numbers
2) No need for primary data
3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Land cover | Large | GIS data, Polygon/raster | CORINE | |
| Population data | Large | GIS data, Polygon | EUROSTAT | Data available |
| Road (access) data | Large | GIS data, line | National geodatabases (e.g. ATKIS in D) | Data can be bought or agreement needed |
| Access facilities on site (forests) | Large | GIS data, point | | |

4) The indicator requires use of different data sources. The level of detail is determined by the data with the coarsest resolution. Where possible scaling can be used to bring the data resolution closer together.

5) Land cover, population and infrastructure data are updated on regular basis; however they may not be updated in line with the timing of the RDP. Possibility is to update the published data with RS data for the RPD period.

6) The data in raster format will be used to calculate the indicator in ArcGIS or R.

7) Depending on the sizes of the features selected (for example woodland) the resolution of the data is important to be able to assess the indicator. For example if data are only available at 1km$^2$ the error in the visual amenity score will be high for the case-study area.

8) This method has previously been used for prediction rather than measurement of change. The consequences of the data constraints are that it reduces the effectiveness of the method to measure change, hence the impact of RDP

### 4.6.3 Landscape zoning - landscape - protection of landscapes and specific natural elements

1) Types of data needed:
   - Area of farmland participating in RDP landcover
   - Designation criteria
   - Habitat data
2) Monitoring protected features in agricultural areas.
3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Land cover | Large | GIS data, Polygon/raster | CORINE | Data available |
| Habitat data | Large | Landscape features and habitats within a certain raster (e.g. one square km) Estimates of stock in kilometres | Habitat surveys, e.g. British Countryside Survey | Data available |
| Designated areas | Large | GIS data, Polygon | Natura2000, Regional data | Data available |

4) The method can be used for the assessment at different spatial levels, either by using different type of resolution data but due to the data dependency caution needs to be taken in the comparison between the results of different levels, or by aggregating the results of detailed assessment. The minimum mappable areas of the data should be at least 0.25 ha, i.e. 50m raster, but 0.1 ha, i.e. 25m raster, would be more useful to measure changes in habitat created due to RDP.

5) Existing land-cover data are regularly updated; however they may not be in sync with the RDP reporting cycle to provide useful impact assessment. Where the available land-cover and land-use data prove to be limiting, the temporal dimension of the assessment application of RS (including aerial photography) can be used to fill the data gap. RS data have the advantage that, for much of EU, they are both temporally and spatially more detailed. Due to cloud cover, the availability for certain areas may be limited but generally temporally more flexible and compatible with the RDP reporting cycle.

6) Data in raster format can be calculated using ArcGIS or R.

7) It may impair the ability to measure the impact of RDP on this public good.

8) This method has previously been used for prediction rather than measurement of change. The consequences of the data constraints are that it reduces the effectiveness of the method to measure change, hence the impact of RDP

### 4.6.4 Landscape zoning - Biodiversity (HNV) - % of UAA farmed to generate HNV

1) Types of data needed:

- Area of farmland participating in RDP
- Land cover
- Areas of HNV
- Digital Elevation Model (DEM)

2) No primary data required

3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Area of HNV | Large | GIS data, Polygon | HNV monitoring database | Data available |
| Land cover | Large | GIS data, Polygon/raster | CORINE, regional land cover data | Data available |
| Digital Elevation Model (DEM) | Large | GIS data, Raster | Topographic maps, aerial surveys | Data partly available |

4) The data required are secondary data, which require adequate detail to be able to distinguish differences in land use and land cover with the participating and non-participating areas.

5) The method can be used for the assessment at different spatial levels, either by using different type of resolution data but, due to the data dependency, caution needs to be taken in the comparison between the results of different levels, or by aggregating the results of detailed assessment. The minimum mappable areas of the data should be at least 0.25 ha, i.e. 50m raster but 0.1 ha, i.e. 25m raster, would be more useful to measure changes in habitat created due to RDP.

6) Existing land-cover data are regularly updated; however they may not be in sync with the RDP reporting cycle to provide useful impact assessment. Where the available land-cover and land-use data prove to be limiting, the temporal dimension of the assessment application of RS (including aerial photography) can be used to fill the data gap. RS data have the advantage that for much of EU they are both temporally and spatially more detailed. Due to cloud cover the availability for certain areas may be limited but generally temporally more flexible and compatible with the RDP reporting cycle.

7) Data in raster format can be calculated using ArcGIS or R

8) It may impair the ability to measure the impact of RDP on this public good. This method has previously been used for prediction rather than measurement of change. The

consequences of the data constraints are that it reduces the effectiveness of the method to measure change, hence the impact of RDP

### 4.6.5 Landscape zoning - Biodiversity (HNV) - Biodiversity Action Plan Benefit scores

1) Types of data needed:

- Habitats that meet the requirements for target biodiversity action species (mammals and birds)
- Species Distribution Atlas

2) No primary data required

3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Habitat data | Large | Landscape features and habitats within a certain raster (e.g. one square km) Estimates of stock in kilometres | Habitat surveys, e.g. British Countryside Survey | Data available |
| Species distribution | Large | GIS data | Species distribution atlases | Data available |

4) The data required are secondary data, which require adequate detail to be able to distinguish differences in land use and land cover with the participating and non-participating areas. Given the scale of the data from the distribution atlases the data need to be down-scaled for use in the analysis.
5) Species distribution atlases are published periodically, varying by species and EU member state.
6) Required data processing include:
    a. Downscaling of distribution atlas data for different species
    b. Calculation of the Biodiversity Action Plan benefit score
7) Sensitivity to data quality: the scores are modelled outcomes using survey data and sound spatial statistics.

### 4.6.6 Landscape zoning - Biodiversity (HNV) - High Nature Value Index

1) Types of data needed:

- Area of farmland participating in RDP
- Land cover
- High nature value data
- RS data
- Validation data for RS analysis

2) No need for primary data

3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Area of HNV | Large | GIS data, Polygon | HNV monitoring database | Data available |
| Land cover | Large | GIS data, Polygon/raster | CORINE, regional land cover data | Data available |
| Remote Sensing data (satellite/aerial photos) | Large | Raster | ESA (European Space Agency) | Data available |
| Validation data | Large | GIS data | LUCAS | Data available |

4) The method can be used for the assessment at different spatial levels, either by using different type of resolution data or by using aggregating the results of detailed assessment. The minimum mappable areas of the data should be at least 0.25 ha, i.e. 50m raster but 0.1 ha, i.e. 25m raster, would be more useful to measure changes in habitat created due to RDP.

5) Existing land-cover and habitat-monitoring data are regularly updated; however they may not be in sync with the RDP reporting cycle to provide useful impact assessment. Where the available land-cover and land-use data prove to be limiting, the temporal dimension of the assessment application of RS (including aerial photography) can be used to fill the data gap. RS data have the advantage that, for much of EU, they are both temporally and spatially more detailed. Due to cloud cover the availability for certain areas maybe limited but generally temporally more flexible and compatible with the RDP reporting cycle.

6) Data in raster format can be calculated using ArcGIS or R

7) It may impair the ability to measure the impact of RDP on this public good.

8) Both the resolution and the extent of the analysis determine the extent of error in the impact assessment.

### 4.6.7 Landscape zoning - biodiversity (HNV) - % UAA under Natura 2000

1) Types of data needed:
    - Area of farmland participating in RDP Landcover - CORINE
    - Nature 2000
    - RS data
    - Validation data for RS analysis

2) No need for primary data

3)

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Designated areas | Large | GIS data, Polygon | Natura2000, Regional data | Data available |
| Remote Sensing data (satellite/aerial photos) | Large | Raster | ESA (European Space Agency) | Data available |
| Validation data | Large | GIS data | LUCAS | Data available |

4) The method can be used for the assessment at different spatial levels, either by using different type of resolution data but due to the data dependency caution needs to be taken in the comparison between the results of different levels, or by using aggregating the results of detailed assessment. The minimum mappable areas of the data should be at least 0.25 ha, i.e. 50m raster but 0.1 ha, i.e. 25m raster, would be more useful to measure changes in habitat created due to RDP.

5) Existing land-cover data are regularly updated; however they may not be in sync with the RDP reporting cycle to provide useful impact assessment. Where the available land-cover data prove to be limiting, the temporal dimension of the assessment application of RS (including aerial photography) can be used to fill the data gap. RS data have the advantage that for much of EU they are both temporally and spatially more detailed. Due to cloud cover, the availability for certain areas maybe limited but generally temporally more flexible and compatible with the RDP reporting cycle.

6) Data in raster format can be calculated using ArcGIS or R

7) It may impair the ability to measure the impact of RDP on this public good.

8) Both the resolution and the extent of the analysis determine the extent of error in the impact assessment.

### 4.6.8 Landscape zoning - soil - soil erosion by water

1) Types of data needed:
   - Area of farmland participating in RDP
   - Soil data
   - Land cover
   - Farm management data
   - Digital Elevation Model (DEM)
2) No primary data required

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Area of farmland participating in RDP | Large | GIS data, Polygon | IACS | Access for evaluators granted |
| Land cover | Large | GIS data, Polygon/raster | CORINE, regional land cover data | Data available |
| Land use and management | Large (depending on level of analysis) | GIS data, Polygon/ raster | LUCAS, FADN database, Census databases, | Data available |
| Soil data | Large | GIS data, Polygon/raster | Survey data or modelled data | Data partly available |
| Digital Elevation Model (DEM) | Large | GIS data, Raster | Topographic maps, aerial surveys | Data partly available |

3) The data should be at a level of detail that is one level below the reporting spatial units, i.e. if reporting at NUTS3 than the data should be at NUTS4 i.e. LAU1.

4) The data for this methodology range from frequent monitoring data to near-static data. The potential of assessing a baseline and one RDP period is likely to be conducted only with partially updated information.

5) Criteria need to be formulated and a matrix for the assessment of measures versus public goods through specific indicators needs to be developed.

6) The objective is to develop a more quantitative basis for the AFI, which is reliant on data. However in the absence of data it is possible to use qualitative data.

7) It is possible to make an assessment of change, but with a greater degree of uncertainty/error, and the ability to compare the results between MS may be reduced.

## 4.7 Multi-Criteria Analysis (and Principal Component Analysis)

### 4.7.1 Multi-criteria analysis – animal welfare - all indicators

1. Type of data:
    - Policy related variables
    - Data on intervention logics of the different measures
    - Livestock system and farm data
    - Data on animal welfare indicator (depending on selected indicator):
        - Animal Welfare Index: Consists of indicators on welfare, health and management of farm animals (animal-based indicators and farm / environment indicators)
        - Result-oriented indicator approach:
2. Primary data: Requires monitoring data from farm surveys and visits of evaluators. Sample strategy of selected farms needs to cover a representative sample of different livestock and husbandry systems and include participating and non-participating farmers

3. Secondary data:

| Data type | Sample size | Data format | Data origin | Data access |
|---|---|---|---|---|
| Policy related variables | Large | Aggregated payment data (Euro / LU or farm and measure) and uptake data | Managing authorities | Access for evaluators granted |
| Livestock and farm data | Large | Physical units, LU / ha, $m^2$ / LU, number of animals (etc.) | FADN database<br>Census databases, Livestock databases such as HIT in Germany | Data available |

4. Spatial dimensions: This method is based on farm-level data which can be aggregated and analysed at different regional levels. Instead of spatial variations, differentiation of different farm types and livestock systems and husbandry systems are more important for animal welfare impacts. Principal Component Analysis (PCA) can be used for hierarchical classification of different animal welfare factors / indicators (not across spatial dimensions).

5. Temporal dimensions: Livestock and farm data are updated annually, but primary data from farm visits are collated for one or two points in time (either to analyse differences in the current state of animal welfare on participating and non-participating farms or to analyse differences in changes in animal welfare indicators over time). More frequent farm visits become very time and cost intensive. Secondary data are available annually.

6. Data processing: Multi-Criteria Analysis (MCA) requires different data processing tasks, including:

   - Constructing and assessing the index indicators (can require expert workshops to validate inclusion and weights of different indicators in index or to validate the general suitability of new indicators).
   - Consistent and robust integration of primary, secondary and qualitative data/information
   - Econometric and statistical analysis of relationships between different factors/indicators and policy measures (e.g. principal component analysis etc.).
   - Regional analysis: Aggregation of analytical framework to regional level

7. Sensitivity to data quality: The application and the results of the strongly depend on the quantity and quality of the monitoring data from farm visits. Case-study application requires the existence of primary data from farm visits. To some extent additional data could be collated.
8. Consequences of data gaps: See above.

# 5 Comparison of the Data and Monitoring Requirements of the Candidate Methods

This section provides a summary of the assessment of the data requirements of the different methods highlighting differences in the principal requirements with respect to data types and their level of details, how methods consider spatial and temporal dimensions and required data processing. The assessments were carried out in the context of a few public good examples for which the applications of the methods were seen as suitable. However, this does not exclude the principal possibility of applying the methods for the impact assessment of other public goods. The identification of data availability and data quality as the two of the main problems in the evaluation of environmental impacts of RDPs during the reviews and stakeholder interviews highlights the importance of the comparative assessment of the data requirements of the candidate methods to ensure that the new evaluation methods are tested in case-study areas which provide an adequate quantity and quality of required data and to ensure that those dimensions are consistently considered in the logic models of the new methodological handbook. The assessment of the data requirements will be reviewed during and after the case-study testing with the aim to develop a classification of the data and monitoring requirements of the tested macro-level evaluation methods for the methodological handbook. A first attempt to provide a classification of the data requirements of the candidate methods is provided in Section 5.2, using a scoring approach.

Section 5.1 summarises and compares key findings of the assessment of the data requirements of the candidate methods for each public good, highlighting aspects for the applicability in the case studies and with respect to micro/macro linkages in RDP evaluations. This is followed by a first classification of the data requirements of the macro-level candidate methods and a short discussion of the emerging issues for the case-study testing in Section 5.3.

## 5.1 Summary of Key Aspects of the Data Requirements

The following tables highlight similarities and differences in the principal data requirements with respect to data types, level of detail, spatial and temporal dimensions, data processing, applicability in case-study areas and micro/macro linkages.

## Summary table – water quality:

| Dimensions | Spatial econometrics | Hierarchical sampling |
|---|---|---|
| Type of data | • Wide range of different data needed to integrate environmental indicators, agricultural production functions, input demand functions, farm and site specific characteristics, and managerial qualities in the econometric models<br>• Application at macro level largely relies on secondary data (e.g. IACS, FADN, Census, Eurostat, CLC and LUCAS). | • Required data types vary between the different scales and levels of the sampling set<br>• A range of different secondary data needed at the upper levels such as topographic, soil conditions, land use and farm management data.<br>• Secondary datasets: e.g. IACS, FADN, Census, Eurostat, CLC and LUCAS |
| Primary monitoring data | • Soil, water and input use monitoring data at farm level (participating and non-participating farms) could be needed to address data gaps at regional level and improve the database for macro level analysis.<br>• The indicator nitrate pollution requires ground and / or freshwater monitoring data. | • Monitoring data on water quality aspects needed at field and farm levels |
| Sample size | • Large | • Medium |
| Spatial dimension | • Method can be applied at different spatial levels, but most useful application for RDP evaluation with detailed regional data (e.g. NUTS 3 or municipality levels)<br>• Data need to be available with geographic references / codes | • Flexible design which reflects different spatial dimensions and can integrate different levels / scales (e.g. field, farm and landscape levels)<br>• Data need to be available with geographic references / codes |
| Temporal dimension | • Can be used with annual data or data for base year and impact year, e.g. according to the RDP periods. | • Can be used with annual data or data for base year and impact year, e.g. according to the RDP periods. |
| Processing requirements | • Substantial data processing requirements, which demand specific methodological skills and interests from the developer / user | • Complex sampling design of multi-level observations and indicators (both participants and non-participants)<br>• Data processing requirements also depend on econometric or statistical methods selected in combination with hierarchical sampling |
| Applicability in case-study areas | • Complex models which can deliver results on net-impacts at macro level<br>• Requires case-study areas with a comprehensive database of land use, farm management and characteristics and water quality data at (farm and) regional level. | • Systematic and consistent sampling method, which can be combined with different econometric and statistical methods<br>• Requires case-study areas with a good availability of monitoring data on water quality |
| Micro – macro linkage | • Depends on availability of soil, water and input use monitoring data at farm level for participating and non-participating farms which can provide a representative database for regional / macro level assessment. | • Design of hierarchical sampling allows to combine or to link micro and macro level analysis using one consistent sampling and data set.<br>• Conclusions on impacts can be drawn from available data at micro and macro level |

## Summary table – climate stability:

| Dimensions | Economic modelling framework, CGEs | Economic modelling framework, sector models |
|---|---|---|
| Type of data | • A CGE model requires aggregated data representative for the region or country.<br>• Sectorally and regionally disaggregated CGE models are very data intensive.<br>• Requires data from input – output statistics, GHG inventory and agricultural data bases (e.g. IACS, FADN, Census, and Eurostat). | • Requires aggregated data representative for the sector and region / country.<br>• Depending on the level of disaggregation into sub-sectors and regions, models can be data intensive.<br>• Requires data from GHG inventory and agricultural data bases (e.g. IACS, FADN, Census, and Eurostat). |
| Primary monitoring data | • Generally, no primary data needed. However, depending on the level of application, primary data on changes in agricultural practices and related changes in GHG emissions might become valuable. | • Generally, no primary data needed. However, depending on the level of application, primary data on changes in agricultural practices and related changes in GHG emissions might become valuable. |
| Sample size | • Medium / large (in particular regionalised | • Medium |

| Dimensions | Economic modelling framework, CGEs | Economic modelling framework, sector models |
|---|---|---|
| | modelling frameworks are data intensive) | |
| Spatial dimension | • Method used for non-spatial and spatial applications.<br>• Mainly used at NUTS 0 and NUTS 1 levels | • Method used for non-spatial and spatial applications.<br>• Mainly used at NUTS 0 and NUTS 2 levels |
| Temporal dimension | • Flexibility to select base year and implemented shocks according to the duration and scope of the RDP period.<br>• Dynamic CGE models can trace changes in the variables and indicators through a certain period, for example in annual intervals.<br>• But input-output tables often only updated periodically | • Flexibility to select base year and implemented shocks according to the duration and scope of the RDP period.<br>• Dynamic sector models can trace changes in the variables and indicators through a certain period, for example in annual intervals. |
| Processing requirements | • Substantial data processing requirements, in particular for regional applications as regionalised data such as regional input-output statistics and GHG emission data might not be available, and thus need to be derived through disaggregation exercises or through data collection.<br>• Application often only feasible, if already existing modelling frameworks can be used. | • Particular data processing requirements are needed with respect to the disaggregation needed to analyse the GHG emission impact of policy-induced changes in different production systems or farm types and in relation to regional disaggregations<br>• Availability of existing modelling frameworks increases the feasibility of application |
| Applicability in case-study areas | • Complex models which can consider substitution effects within and between different sectors.<br>• Requires large scale case-study areas and the availability of regional economic data sets to regionalise the modelling framework.<br>• Depends on availability of existing modelling frameworks which can be used. | • Rather complex models which can consider substitution effects within a sector.<br>• Requires large scale case-study areas.<br>• Depends on availability of existing modelling frameworks which can be used in case studies. |
| Micro – macro linkage | • Difficult to link with micro level methods without substantial modelling efforts<br>• Potentially through consistent application of up- or downscaling of available farm level or regional data | • Potentially through consistent application of up- or downscaling of available farm level or regional data |

## Summary table – animal welfare:

| Dimensions | Spatial econometrics | Multi-criteria assessment |
|---|---|---|
| Type of data | • In addition to policy related data, husbandry and farm data are needed.<br>• Application at macro level largely relies on primary data on animal welfare indicators collected at farm level and/or the availability of animal information systems or databases. | • In addition to policy related data, husbandry and farm data are needed.<br>• Application at macro level largely relies on primary data on animal welfare indicators collected at farm level.<br>• Expert workshops can be used to define or validate suitability and/or weights of different indicators. |
| Primary monitoring data | • Requires monitoring data from farm surveys and visits. | • Requires monitoring data from farm surveys and visits. |
| Sample size | • Sample needs to cover a representative sample of different livestock and husbandry systems and include participating and non-participating farmers.<br>• Regional analysis thus requires large and costly samples | • Sample needs to cover a representative sample of different livestock and husbandry systems and include participating and non-participating farmers. |
| Spatial dimension | • Farm level data are aggregated and analysed at different regional levels.<br>• Different farm types and livestock husbandry systems are key dimensions for animal welfare impacts. | • Farm level data are aggregated and analysed at different regional levels.<br>• Different farm types and livestock husbandry systems are key dimensions for animal welfare impacts. |
| Temporal dimension | • Livestock and farm data are updated annually, but primary data from farm visits are collated for one or two points in time. More frequent farm visit become very time and cost intensive.<br>• Secondary data are available annually. | • Livestock and farm data are updated annually, but primary data from farm visits are collated for one or two points in time. More frequent farm visit become very time and cost intensive.<br>• Secondary data are available annually. |

| Dimensions | Spatial econometrics | Multi-criteria assessment |
|---|---|---|
| Processing requirements | • Substantial data processing requirements, e.g. the aggregation of animal welfare indicators at regional level, demand certain mathematical skills and interests from the developer / user | • Particular data processing tasks are the construction of indicator indices and the integration of primary, secondary and qualitative data and information. |
| Applicability in case-study areas | • Complex models which can deliver results on net-impacts at macro level<br>• Method can be tested with different indicators.<br>• The application and the results of the strongly depend on the quantity and quality of the monitoring data from farm visits.<br>• Case study application requires the existence of large samples of primary data from farm visits. | • Method can be used to test different indicators and the application of indicator indices addressing the gap of suitable animal welfare indicators for RDP evaluations.<br>• The application and the results of the strongly depend on the quantity and quality of the monitoring data from farm visits.<br>• Case study application requires the existence of primary data from farm visits. To some extent additional data could be collated. |
| Micro – macro linkage | • Macro level analysis would directly build on micro level data. | • Macro level analysis would directly build on micro level data.<br>• Same indicators and method can be (has to be) used. |

## Summary table – landscape:

| Dimensions | Landscape metrics | Ecological footprinting | Multifunctional hotspot & zoning |
|---|---|---|---|
| Data type | • Spatial data regarding land cover and land use | • Wide range of data types (including modelled and qualitative data) | • Limited range of spatial data types beyond just land cover and land use |
| Primary monitoring data | • Habitat survey data | • Possibly habitat survey data | • No |
| Sample size | • Large | • Medium/large | • Large |
| Spatial dimension | • The method can be applied to different spatial levels. Given the data dependency of the method ideally the minimum mappable area of the indicator should determine the level. | • Due to the multiple indicators included in this method being derived from data with different spatial dimensions, its dimension is determined by the poorest data. Aggregation to administrative units is possible | • The method can be applied at different spatial levels depending on the resolution of the input data. |
| Temporal dimension | • Monitoring frequency approximately per decade but not in sync with RDP programme cycle, | • Beginning and End assessment constraint by data availability | • Monitoring frequency approximately per decade but not in sync with RDP programme cycle, |
| Processing requirements | • Creation of timeseries by data updating using RS.<br>• Processing requires spatial analytical /GIS skills. | • Pre-processing of the indicator data included in the assessment. Creation of criteria for the assessment. | • Pre-processing of data and spatial analysis requiring GIS skills |
| Applicability in case-study areas | • Links evaluation with contextual information and improves assessment of causal linkages (assess connectivity and pattern)<br>• Applicability depends on availability of required spatial data and processing skills | • Expert assessment included in the footprint method can help applying this method in case-study areas with poorer data | • Applicability depends on availability of required spatial data and processing skills |
| Micro – macro linkage | • Macro level can build on micro level analysis | • Micro and macro level assessment will select level specific criteria for indicators | • No direct link between micro and macro levels |

## Summary table – biodiversity (HNV):

| Dimensions | Landscape metrics | Ecological footprinting | Multifunctional hotspot & zoning |
|---|---|---|---|
| Data type | • Spatial data regarding land cover and land use as well as HNV data | • Wide range of data types | • Range of different data types |
| Primary monitoring data | • Habitat survey data | • No | • No |
| Sample size | • Medium | • Medium/high | • Large |
| Spatial dimension | • The method can be applied to different spatial levels. Given the data dependency of the method ideally the minimum mappable area should be appropriate for indicator and HNV | • Due to the multiple being derived from data with different spatial dimensions, its dimension is set by the poorest data.<br>• Aggregation to administrative units is possible | • The method can be applied at different spatial levels depending on the resolution of the input data. |
| Temporal dimension | • Monitoring frequency approximately per decade but not in sync with RDP programme cycle, | • Beginning and end assessment constraint by data availability | • Monitoring frequency approximately per decade but not in sync with RDP programme cycle, |
| Processing requirements | • Creation of timeseries by data updating using RS.<br>• Processing requires spatial analytical /GIS skills. | • Pre-processing of the indicators included in the assessment. Creation of criteria for assessment. | • Pre-processing of data and spatial analysis requiring GIS skills |
| Applicability in case-study areas | • Links evaluation with contextual information and improves assessment of causal linkages (assess connectivity and pattern)<br>• Applicability depends on availability of required spatial data and processing skills | • Expert assessment included in the footprint method can help applying this method in case-study areas with poorer data | • Applicability depends on availability of required spatial data and processing skills |
| Micro – macro linkage | • Macro level can build on micro level analysis | • Micro and macro level assessments will select level specific indicators and criteria | • No direct link between micro and macro levels |

## Summary table – biodiversity wildlife

| Dimensions | Spatial econometrics | Hierarchical sampling |
|---|---|---|
| Data type | • Wide range of different data needed to integrate biodiversity data, input demand functions, farm and site specific characteristics, and managerial qualities in the econometric models<br>• Application with direct biodiversity indicators largely relies on sufficient monitoring data (e.g. FBI data at regional level and see below)<br>• Application with indirect indicators largely relies on secondary data. | • Required data types vary between the different scales and levels of the sampling set<br>• A range of different secondary data needed at the upper levels such as topographic, soil conditions, land use and farm management data.<br>• Secondary datasets: e.g. IACS, FADN, Census, Eurostat, CLC and LUCAS |
| Primary monitoring data | • Depending on the selected indicator, different primary monitoring data on farmland birds, plant indicators or/ and butterfly species are required. | • Monitoring data on different biodiversity indicators are needed. Multi-order hierarchical arrangement methods allow assessment of biodiversity impacts from field (micro) to catchment and regional level (macro). |
| Sample size | • Medium / large (to achieve representativeness at regional level) | • Medium |
| Spatial dimension | • The method can be applied to different spatial levels. Given the data dependency of the method ideally the minimum mappable area should be | • Flexible design which reflects different spatial dimensions and can integrate different levels / scales (e.g. field, farm and landscape levels)<br>• Data need to be available with geographic |

| | | |
|---|---|---|
| | appropriate for wildlife indicators | references / codes |
| Temporal dimension | • Can be used with annual data or data for base year and impact year, e.g. according to the RDP periods. | • Can be used with annual data or data for base year and impact year, e.g. according to the RDP periods. |
| Processing requirements | • Substantial data processing requirements, which demand specific methodological skills and interests from the developer / user | • Complex sampling design of multi-level observations and indicators (both participants and non-participants)<br>• Data processing requirements also depend on econometric or statistical methods selected in combination with hierarchical sampling |
| Applicability in case-study areas | • Complex models which can deliver results on net-impacts at macro level<br>• Requires case study areas with a comprehensive database of land use, farm management and characteristics and biodiversity data at (farm and) regional level. | • Systematic and consistent sampling method, which can be combined with different econometric and statistical methods<br>• Requires case-study areas with a good availability of monitoring data on biodiversity |
| Micro – macro linkage | • Depends on availability of biodiversity monitoring data at farm level for participating and non-participating farms which can provide a representative database for regional / macro level assessment. | • Design of hierarchical sampling allows to combine or to link micro and macro level analysis using one consistent sampling and data set.<br>• Conclusions on impacts can be drawn from available data at micro and macro level |

**Summary table – soils:**

| Dimensions | Ecological footprinting | Multifunctional hotspot & zoning |
|---|---|---|
| Data type | • Range of data types related to the indicator | • Range of different data types |
| Primary monitoring data | • Soil survey data | • Soil survey data, farm survey data |
| Sample size | • Medium/high | • |
| Spatial dimension | • While the assessment will take place at NUTS3 level, the data processing should take place at a more detailed level (field/farm data) before aggregation to NUTS3 level. | • The method can be applied at different spatial levels depending on the resolution of the input data. |
| Temporal dimension | • Soil monitoring is infrequent and for RDP purposes static | • Soil monitoring is infrequent and for RDP purposes static |
| Processing requirements | • Modelling and spatial analysis necessary to generate relevant indicator data.<br>• Select indicator and criteria for analysis | • Pre-processing of data and spatial analysis requiring GIS skills |
| Applicability in case-study areas | • Expert assessment included in the footprint method can help applying this method in case-study areas with poorer data | • Applicability depends on availability of required spatial data and processing skills |
| Micro – macro linkage | • Micro and macro level assessment will select level specific indicators and criteria | • No direct link between micro and macro levels |

## 5.2 Classification of Data Requirements of the Macro-level Candidate Methods (Scoring Approach)

To classify the data requirements of the macro level candidate methods a scoring approach is proposed, broadly following the same structure as outlined in Deliverable D4.2. Four scores have thus been assigned in relation to the different dimensions of the data requirements assessed in section 4 and summarised in section 5.1: Low (+), Low/Medium (++), Medium/High (+++), High (++++).

The assessment of the data requirements will be reviewed during and after the case-study testing with the aim to develop a classification of the data and monitoring requirements of the tested macro-level evaluation methods for the methodological handbook. This will also involve a stakeholder consultation with evaluators and policy-makers to validate (and improve the robustness of) the results of the scoring outcome and classification of the data requirements of the different macro level methods.

Low (+) scores for the different dimensions indicate that:

- Complex requirements of a wide range of primary and secondary data
- Data requirements include types of data which are generally not available
- Substantial efforts to collate new primary data are required
- Method cannot deal with multiple spatial dimensions and / or spatial dimension of data do not overlap with requirements of RDP evaluations
- Temporal dimensions are weakly considered and / or the temporal dimension of data is not consistent with those required for RDP evaluations
- The required data processing is very complex and requires specific methodological expert skills
- Applicability to case study testing is limited due to lack of evaluation challenges addressed and requires comprehensive databases for case-study areas and / or specific primary data and / or methodological skills.
- Method considers micro or macro level in isolation and results cannot easily be aggregated or disaggregated.

Low/Medium (++) scores for the different dimensions indicate that:

- Complex requirements of a wide range of primary and secondary data
- Few types of data are generally not available
- Some efforts to collate new primary data are required
- Method has limited flexibility to deal multiple spatial dimensions and/or spatial dimension of data overlap poorly with requirements of RDP evaluations
- Method has limited flexibility to consider temporal dimensions and / or the temporal dimension of few data types is consistent with those required for RDP evaluations
- The required data processing is complex and requires specific methodological expert skills

- Addresses at least one of the main evaluation challenges, requires comprehensive databases for case-study areas and / or specific primary data and methodological skills.
- Method can be used at micro or macro level. Conclusions for the other level can be derived. For more robust linkages method needs to be combined with a scaling method.

Medium/High (+++) scores for the different dimensions indicate that:

- A wide range of secondary data and few primary data are required
- Required data types are generally available
- Smaller efforts to collate new primary data are required
- Method has flexibility to deal multiple spatial dimensions and / or spatial dimension of data overlap with requirements of RDP evaluations
- Method has flexibility to consider temporal dimensions and / or the temporal dimension of most data types is consistent with those required for RDP evaluations
- The required data processing is less complex and requires limited specific methodological expert skills
- Addresses at least one of the main evaluation challenges, few specific data requirements and methodological skills required.
- Method can be used at micro or macro level and / or provides a consistent approach to aggregate and disaggregate data / results between micro and macro levels

High (++++) scores for the different dimensions indicate that:

- A wide range of secondary data are required
- Required data types are available
- No primary data need to be collated
- Method can integrate multiple spatial dimensions and spatial dimension of data can be adjusted to the requirements of RDP evaluations
- Method can consider temporal dimensions in a flexible way consistent with those required for RDP evaluations; dynamic effects can be considered
- Limited amount of data processing required which does not require specific methodological expert skills

- Can address several evaluation challenges and / or required data should be generally available across case-study areas.
- Method integrates micro and macro level data into a consistent single framework

It is however important to keep in mind that a poor score for data types and data processing does not imply that the method delivers poor evaluation results. Methods with a poor scoring for those dimensions can deliver excellent evaluation results. The poor scoring simply indicates that their application in RDP evaluations will require a wide range of complex data types, substantial efforts to generate and process the data and demand specific methodological skills from the evaluators.

### Water quality

| Dimensions | Spatial econometrics | Hierarchical sampling |
|---|---|---|
| Type of data | ++ | +++ |
| Primary monitoring data | +++ | ++ |
| Sample size | ++ | +++ |
| Spatial dimension | ++ | +++ |
| Temporal dimension | +++ | +++ |
| Processing requirements | + | ++ |
| Applicability in case-study areas | ++ | +++ |
| Micro – macro linkage | +++ | ++++ |

### Climate stability

| Dimensions | Economic modelling frameworks, e.g. CGEs | Economic modelling frameworks, e.g. sector models |
|---|---|---|
| Type of data | ++ | ++ |
| Primary monitoring data | ++++ | ++++ |
| Sample size | ++ | ++ |
| Spatial dimension | +++ | +++ |
| Temporal dimension | ++ | +++ |
| Processing requirements | ++ | ++ |
| Applicability in case-study areas | ++ | ++ |
| Micro – macro linkage | + | ++ |

### Animal welfare

| Dimensions | Spatial econometrics | Multi-criteria assessment |
|---|---|---|
| Type of data | ++ | +++ |
| Primary monitoring data | ++ | ++ |
| Sample size | ++ | +++ |
| Spatial dimension | ++ | ++ |
| Temporal dimension | +++ | ++ |
| Processing requirements | + | +++ |
| Applicability in case-study areas | ++ | +++ |
| Micro – macro linkage | +++ | +++ |

### Landscape

| Dimensions | Landscape metrics | Ecological footprinting | Multifunctional hotspot & zoning |
|---|---|---|---|
| Data type | +++ | +++ | +++ |
| Primary monitoring data | +++ | +++ | +++ |
| Sample size | + | + | + |
| Spatial dimension | +++ | ++ | +++ |

| | | | |
|---|---|---|---|
| Temporal dimension | + | ++ | + |
| Processing requirements | +++ | +++ | ++ |
| Applicability in case-study areas | +++ | +++ | ++ |
| Micro – macro links | +++ | ++ | + |

### Biodiversity (HNV)

| Dimensions | Landscape metrics | Ecological footprinting | Multifunctional hotspot & zoning |
|---|---|---|---|
| Data type | +++ | ++ | ++ |
| Primary monitoring data | +++ | +++ | +++ |
| Sample size | + | + | + |
| Spatial dimension | +++ | ++ | +++ |
| Temporal dimension | + | ++ | + |
| Processing requirements | +++ | +++ | ++ |
| Applicability in case-study areas | +++ | ++ | ++ |
| Micro – macro linkage | +++ | ++ | + |

### Biodiversity wildlife

| Dimensions | Spatial econometrics | Hierarchical sampling |
|---|---|---|
| Type of data | ++ | +++ |
| Primary monitoring data | ++ | ++ |
| Sample size | ++ | +++ |
| Spatial dimension | +++ | +++ |
| Temporal dimension | +++ | +++ |
| Processing requirements | + | ++ |
| Applicability in case study areas | ++ | +++ |
| Micro – macro linkage | +++ | ++++ |

### Soils

| Dimensions | Ecological footprinting | Multifunctional hotspot & zoning |
|---|---|---|
| Data type | + | + |
| Primary monitoring data | ++ | + |
| Sample size | + | + |
| Spatial dimension | ++ | +++ |
| Temporal dimension | + | + |
| Processing requirements | ++ | ++ |
| Applicability in case-study areas | ++++ | ++++ |
| Micro – macro linkage | ++ | +++ |

## 5.3 Discussion of Emerging Issues for Case Study Testing

The results of the assessment of the data requirements of the candidate methods for the different public goods inform the selection of the case-study areas and the combination of counterfactual, micro- and macro-level methods to be tested in those case-study areas. A particular emphasis has been placed on methods which focus on micro/macro linkages (e.g. hierarchical sampling, scaling methods and landscape metrics) and on net-impacts at macro level (e.g. economic modelling approaches, spatial econometrics and footprint method). For animal welfare, however, the emphasis has been on identifying a wide range of suitable indicators for the case-study testing to address existing indicators gaps. A number of issues emerge from the assessment of the data requirements of the macro-level methods which are discussed for each public-good case study.

For water quality, the data requirements of spatial econometric models and hierarchical sampling have been reviewed in this report. Spatial econometrics has recently moved more into the focus of RDP evaluations. For example, the EU project SPARD developed and tested the application of spatial econometrics for different economic and environmental impacts of RDPs. While data gaps constrain the use of spatial econometric models at micro level, such models have the potential to improve the evaluation of net environmental impacts at macro level. The review of the data requirements has shown that spatial econometrics requires a wide range of different (mainly secondary) data types which need to be available in the study areas of the water quality case studies to be able to test this method. In addition, if direct impacts on the water quality shall be assessed, representative samples of groundwater monitoring data need to be available. The application of spatial econometrics for detailed regional impact assessments in the water quality case studies depends on the availability of sufficient monitoring data through farm surveys. The development of the logic models of the methodological evaluation frameworks in WP3 – WP5 needs to consider which counterfactual approaches and micro-level methods would be best suited to facilitate the application of spatial econometrics at macro level. Another constraining factor for the case study testing (as well as the broader use in RDP evaluations) is the complex processing requirements, which demand specific and advanced methodological skills from the users and evaluators.

Hierarchical sampling provides a strategic sampling framework across different scales and levels, developing a consistent framework to collate data at micro and macro levels. Thus, the main contribution of this method is to address the need for consistent micro-macro linkages using one consistent data set to analyse micro- and macro-level impacts. While data processing requirements are not as demanding as for spatial econometrics, the critical factor for the application of hierarchical sampling is the availability of large samples of monitoring data on water quality to allow for sufficient scope to design such complex multi-level sampling framework.

For biodiversity wildlife, the data requirements of the same methods (spatial econometric models and hierarchical sampling) have been reviewed. General aspects such as the evaluation challenges addressed by this method, micro-macro linkages and data processing requirements also apply in the context of biodiversity wildlife applications. Critical for their application in the biodiversity wildlife case studies is the availability of sufficient regional data points of the farm land bird index or representative monitoring data on other direct indicators such as flowering plants of semi-natural habitats and population trends of agriculture related butterfly species. An alternative for case studies areas without sufficient biodiversity monitoring data is the testing of the candidate macro level methods in combination with a suitable indirect indicator such as stock and change of linear habitats and biotopes in agricultural landscapes.

For the macro-level part of the climate stability case studies, data requirements of economic modelling frameworks such as sector models and Computable General Equilibrium (CGE) models have been assessed. The main advantage of these modelling frameworks is that they operate at (single or multi) sectoral level and thus provide a tool which can consider substitution effects between participating and non-participating farms, thus improving the assessment of net impacts at macro level. However, in particular regionally disaggregated modelling frameworks are data intensive and require substantial modelling and data processing efforts. The application in the climate stability case studies (and in fact also generally in RDP evaluations) strongly depends on the availability of existing modelling frameworks which can be used, as the development of a new regional economic modelling framework would require too much time and resources. The allocation of climate stability case studies has taken this constraint into account. Alternatively, scaling methods can be combined with micro-level methods such as carbon footprint and farm surveys to generate macro-level impacts on climate stability.

The data requirements of spatial econometrics and multi-criteria methods have been reviewed for the application of evaluating macro-level animal welfare impacts. Generally, the issues raised for spatial econometrics in the context of water quality applications also apply here. Even more than for water quality case studies, the application of spatial econometrics to assess animal welfare impacts strongly depends on the quantity and quality of the monitoring data from farm visits. Multi-criteria assessments can be used to test different indicators and the application of indicator indices addressing the gap of suitable animal welfare indicators for RDP evaluations. A particularly interesting aspect of this method is that it can be applied for the micro- and macro-levels assessing the same indicators at farm and farm type (or livestock system) level as well as for specific policy measures and at overall programme level.

The macro-level application of both methods would directly build on micro-level data. This requires case-study areas with large samples of primary data from participating and non-participating farms to test different problem-related animal welfare indicators. The testing of new indicators is an important contribution to address the current gaps in RDP evaluations of animal welfare impacts. Linking the animal welfare case study with past and on-going projects gathering monitoring data on a wide range of different animal welfare aspects is crucial for the testing of new indicators and methods.

For the public good landscape, the data requirements of landscape metrics, footprint method and multifunctional hotspot and zoning were assessed. The selected methods link the macro-level evaluations of landscape impacts with contextual information and improve the determination of robust causal linkages. In particular, landscape metrics provides an approach to include aspects such as landscape connectivity and pattern in the evaluation. Depending on the representativeness of micro-level data, the application of landscape metrics at macro level can build on micro-level data and thus ensure consistent micro-macro level linkages.

The methods strongly rely on spatial data on land use and land cover. Infrequent updates to existing databases is one the major limitations of their use for RDP evaluations. Remote sensing data can be used to address potential data gaps. The application of these methods depends on the availability of spatial land use and land-cover data available in a timeframe which fits with RDP evaluations. The data requirements of the same methods were assessed for biodiversity HNV, as these two public goods use to large extent the same type of indicators.

The footprint method and multifunctional hotspots and zoning have also been assessed for their application for soil quality. In addition to the issues already mentioned above, the application of the methods for an impact assessment on soil quality also requires a good availability of monitoring data on soil quality in the case-study areas.

The assessment of the data requirements of the macro-level candidate methods highlights the importance of data issues for the selection of case-study areas to be able to test the robustness and added value of the candidate methods to the approaches currently used in RDP evaluations  The results also highlight key issues for the database development of the case studies such as consistent approaches for aggregating and disaggregating data, and integrating different data sources and spatial and non-spatial data.

# 6 Key Aspects for the Structure of the Databases for the Case Studies from a Macro-level Perspective

Generally, the guidelines for the database development for the different case studies need to cover aspects such as the definition of indicators and other variables included in the selected methods, type of data and the size of the required samples or populations, data formats, data rights, spatial disaggregations, a protocol for the consistent integration of data from multiple sources (i.e. with different formats and scales and levels), protocols for aggregating and anonymising individual farm and firm data, quality and validation procedures and the documentation of the database. The aim of the guidelines is to ensure consistency between the different case study databases to enable a comparison of the tests of the evaluation methods across case studies.

Specifically from the first assessment of the data requirements of the candidate methods at macro level, the following key aspects and questions for the case study database development can be derived:

- Indicators and other variables: Needs to cover environmental indicators and a wide range of farm / land management variables, wider socio-economic and policy variables. Are all indicators and variables captured in sufficient detail?
- Data types: Most commonly used data types are land use and farm management data from FADN, Census, and Eurostat, CLC and LUCAS databases. Some methods also require primary data on environmental indicators at farm and field level. Primary data are particular important for water quality, soil quality, biodiversity wildlife and animal welfare macro level assessments.
- Sample size / population covered: Does the resource include an appropriate population in terms of size, coverage and representativeness? Separate consideration of participating farms / areas and non-participating farms / areas.
- Data formats: Non-spatial data: volume and value formats, spatial data: polygon and raster format; time series of annual data and periodical data. Are there any breaks or changes in data collection over time or the whole population during the evaluation period?
- Spatial disaggregation: Possible and desired spatial disaggregation varies between NUTS 1 and LAU 2 levels. Database needs to allow for disaggregation from national

to regional level as well as enable aggregation from field / farm level to regional level. How can micro and macro level data be consistently integrated?

- Consistent integration of multiple data sources: Macro level methods combine the use of spatial and non-spatial data across different scales and levels. Are the data sources and data systems compatible in metrics / units and terminology? How can different data sources be merged?
- Quality and consistency checks: Which case study or method-specific quality checks are needed: the extraction process, data merging, study variables, assumptions, etc.?

The next steps in the development of the guidelines for the case-study databases comprise the synthesis of all emerging issues and questions from the assessment of the data requirements of counterfactuals, micro- and macro-level methods, the development of a step-by-step approach for the database development and a logic model providing a schematic overview and instructions how to develop the case study databases. Separate databases will be developed for each case study. The guidelines will provide a consistent framework for the development of the different case study databases focusing, for example, on consistent approaches for aggregating and disaggregating data, and integrating different data sources and spatial and non-spatial data.