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COMMISSION DECISION (EU) 2018/813

of 14 May 2018

on the sectoral reference document on best environmental management practices, sector environmental performance indicators and benchmarks of excellence for the agriculture sector under Regulation (EC) No 1221/2009 of the European Parliament and of the Council on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS)

(Text with EEA relevance)

(OJ L 145, 8.6.2018, p. 1)

Corrected by:

►**C1** Corrigendum, OJ L 92, 1.4.2019, p. 9 (2018/813)

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COMMISSION DECISION (EU) 2018/813

of 14 May 2018

on the sectoral reference document on best environmental management practices, sector environmental performance indicators and benchmarks of excellence for the agriculture sector under Regulation (EC) No 1221/2009 of the European Parliament and of the Council on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS)

(Text with EEA relevance)

Article 1

The sectoral reference document on best environmental management practice, sector environmental performance indicators and benchmarks of excellence for the agriculture sector for the purposes of Regulation (EC) No 1221/2009 is set out in the Annex to this Decision.

Article 2

This Decision shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

It shall apply from 5 October 2018.

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ANNEX

1. INTRODUCTION

This Sectoral Reference Document (SRD) is based on a detailed scientific and policy report ([1]) ('Best Practice Report') developed by the European Commission's Joint Research Centre (JRC).

Relevant legal background

The Community eco-management and audit scheme (EMAS) was introduced in 1993, for voluntary participation by organisations, by Council Regulation (EEC) No 1836/93 ([2]). Subsequently, EMAS has undergone two major revisions:

— Regulation (EC) No 761/2001 of the European Parliament and of the Council ([3]);

— Regulation (EC) No 1221/2009.

An important new element of the latest revision, which came into force on 11 January 2010, is Article 46 on the development of SRDs. The SRDs have to include best environmental management practices (BEMPs), environmental performance indicators for the specific sectors and, where appropriate, benchmarks of excellence and rating systems identifying performance levels.

How to understand and use this document

The eco-management and audit scheme (EMAS) is a scheme for voluntary participation by organisations committed to continuous environmental improvement. Within this framework, this SRD provides sector-specific guidance to the agriculture sector and points out a number of options for improvement as well as best practices.

The document was written by the European Commission using input from stakeholders. A Technical Working Group, comprising experts and stakeholders of the sector, led by the JRC, discussed and ultimately agreed on the best environmental management practices, sector-specific environmental performance indicators and benchmarks of excellence described in this document; these benchmarks in particular were deemed to be representative of the levels of environmental performance that are achieved by the best performing organisations in the sector.

The SRD aims to help and support all organisations that intend to improve their environmental performance by providing ideas and inspiration as well as practical and technical guidance.

([1]) The scientific and policy report is publicly available on the JRC website at the following address: http://susproc.jrc.ec.europa.eu/activities/emas/documents/AgricultureBEMP.pdf. The conclusions on best environmental management practices and their applicability as well as the identified specific environmental performance indicators and the benchmarks of excellence contained in this Sectoral Reference Document are based on the findings documented in the scientific and policy report. All the background information and technical details can be found there.

([2]) Council Regulation (EEC) No 1836/93 of 29 June 1993 allowing voluntary participation by companies in the industrial sector in a Community eco-management and audit scheme (OJ L 168, 10.7.1993, p. 1).

([3]) Regulation (EC) No 761/2001 of the European Parliament and of the Council of 19 March 2001 allowing voluntary participation by organisations in a Community eco-management and audit scheme (EMAS) (OJ L 114, 24.4.2001, p. 1).

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The SRD is primarily addressed to organisations that are already registered with EMAS; secondly to organisations that are considering registering with EMAS in the future; and thirdly to all organisations that wish to learn more about best environmental management practices in order to improve their environmental performance. Consequently, the objective of this document is to support all organisations in the agriculture sector to focus on relevant environmental aspects, both direct and indirect, and to find information on best environmental management practices, as well as appropriate sector-specific environmental performance indicators to measure their environmental performance, and benchmarks of excellence.

How SRDs should be taken into account by EMAS-registered organisations:

Pursuant to Regulation (EC) No 1221/2009, EMAS-registered organisations are to take SRDs into account at two different levels:

1. When developing and implementing their environmental management system in light of the environmental reviews (Article 4(1)(b)):

   Organisations should use relevant elements of the SRD when defining and reviewing their environmental targets and objectives in accordance with the relevant environmental aspects identified in the environmental review and policy, as well as when deciding on the actions to implement to improve their environmental performance.

2. When preparing the environmental statement (Article 4(1)(d) and Article 4(4)):

   (a) Organisations should consider the relevant sector-specific environmental performance indicators in the SRD when choosing the indicators ([4]) to use for their reporting of environmental performance.

   When choosing the set of indicators for reporting, they should take into account the indicators proposed in the corresponding SRD and their relevance with regards to the significant environmental aspects identified by the organisation in its environmental review. Indicators need only be taken into account where relevant to those environmental aspects that are judged as being most significant in the environmental review.

   (b) When reporting on environmental performance and on other factors regarding environmental performance, organisations should mention in the environmental statement how the relevant best environmental management practices and, if available, benchmarks of excellence have been taken into account.

([4]) According to Annex IV (B.e.) of the EMAS Regulation, the environmental statement shall contain ‘a summary of the data available on the performance of the organisation against its environmental objectives and targets with respect to its significant environmental impacts. Reporting shall be on the core indicators and on other relevant existing environmental performance indicators as set out in Section C’. Annex IV — Section C states that ‘each organisation shall also report annually on its performance relating to the more specific environmental aspects as identified in its environmental statement and, where available, take account of sectoral reference documents as referred to in Article 46.’

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They should describe how relevant best environmental management practices and benchmarks of excellence (which provide an indication of the environmental performance level that is achieved by best performers) were used to identify measures and actions, and possibly to set priorities, to (further) improve their environmental performance. However, implementing best environmental management practices or meeting the identified benchmarks of excellence is not mandatory, because the voluntary character of EMAS leaves the assessment of the feasibility of the benchmarks and of the implementation of the best practices, in terms of costs and benefits, to the organisations themselves.

Similarly to environmental performance indicators, the relevance and applicability of the best environmental management practices and benchmarks of excellence should be assessed by the organisation according to the significant environmental aspects identified by the organisation in its environmental review, as well as technical and financial aspects.

Elements of SRDs (indicators, BEMPs or benchmarks of excellence) not considered relevant with regards to the significant environmental aspects identified by the organisation in its environmental review should not be reported or described in the environmental statement.

EMAS participation is an ongoing process. Every time an organisation plans to improve its environmental performance (and reviews its environmental performance) it shall consult the SRD on specific topics to find inspiration about which issues to tackle next in a step-wise approach.

EMAS environmental verifiers shall check if and how the SRD was taken into account by the organisation when preparing its environmental statement (Article 18(5)(d) of Regulation (EC) No 1221/2009).

When undertaking an audit, accredited environmental verifiers will need evidence from the organisation of how the relevant elements of the SRD have been selected in light of the environmental review and taken into account. They shall not check compliance with the described benchmarks of excellence, but they shall verify evidence on how the SRD was used as a guide to identify indicators and proper voluntary measures that the organisation can implement to improve its environmental performance.

Given the voluntary nature of EMAS and SRD, no disproportionate burdens should be put on the organisations to provide such evidence. In particular, verifiers shall not require an individual justification for each of the best practices, sector-specific environmental performance indicators and benchmarks of excellence which are mentioned in the SRD and not considered relevant by the organisation in light of its environmental review. Nevertheless, they could suggest relevant additional elements for the organisation to take into account in the future as further evidence of its commitment to continuous performance improvement.

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Structure of the Sectoral Reference Document

This document consists of four chapters. Chapter 1 introduces EMAS' legal background and describes how to use this document, while Chapter 2 defines the scope of this SRD. Chapter 3 briefly describes the different best environmental management practices (BEMPs) ([5]) together with information on their applicability. When specific environmental performance indicators and benchmarks of excellence could be formulated for a particular BEMP, these are also given. However, defining benchmarks of excellence was not possible for all BEMPs because in some areas either there was limited data available or the specific conditions (farm type, business model, climate, etc.) vary to such an extent that a benchmark of excellence would not be meaningful. Some of the indicators and benchmarks are relevant for more than one BEMP and are thus repeated whenever appropriate. Finally, Chapter 4 presents a comprehensive table with a selection of the most relevant environmental performance indicators, associated explanations and related benchmarks of excellence.

2. **SCOPE**

This SRD addresses the environmental performance of the activities of the agriculture sector. In this document, the agriculture sector is considered consisting of organisations belonging to NACE code divisions from A1.1 to A1.6 (according to the statistical classification of economic activities established by Regulation (EC) No 1893/2006 of the European Parliament and of the Council ([6]). This includes all animal and annual and perennial crop production.

These organisations are the target group of this document. Figure 2.1 presents a schematic overview of the scope of this document and shows the interaction of the target group with other organisations.

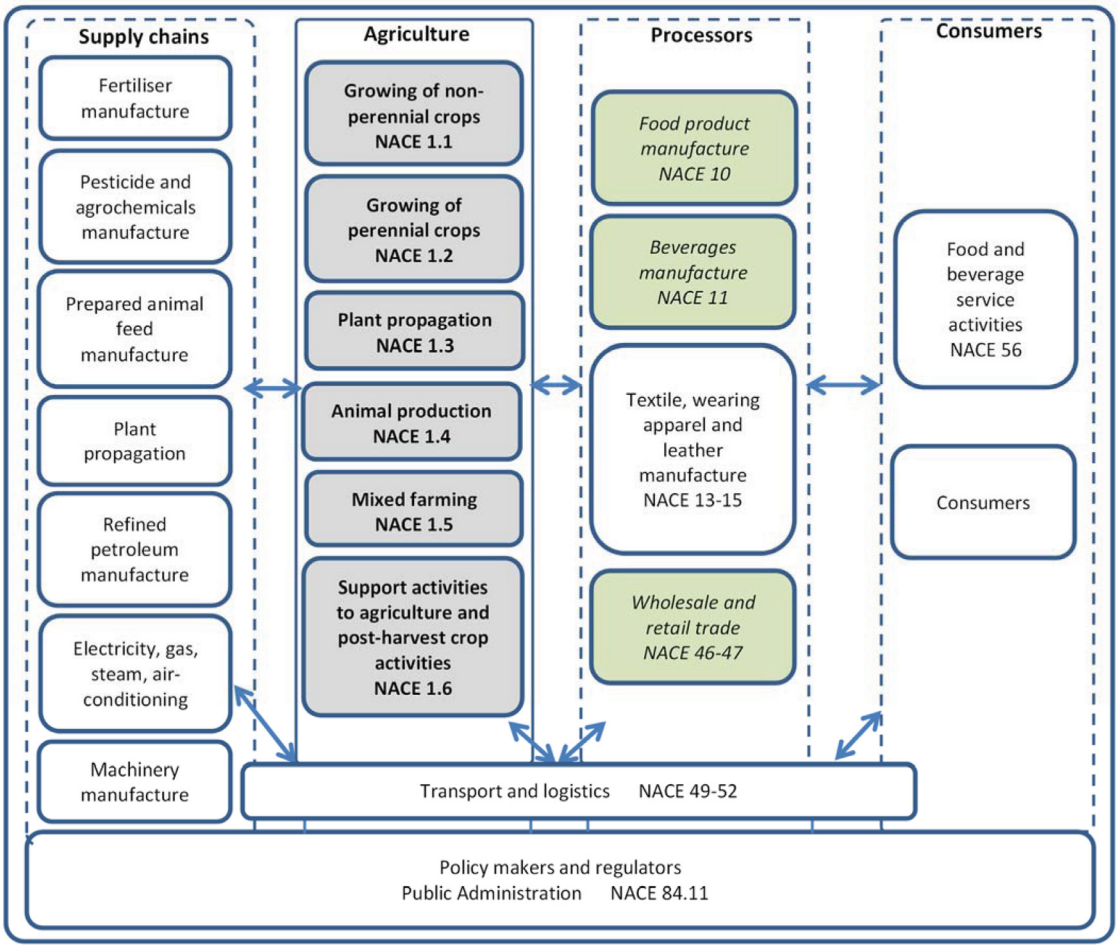
([5]) A detailed description of each of the best practices, with practical guidance on how to implement them, is available in the 'Best Practice Report' published by the JRC and available online at: http://susproc.jrc.ec.europa.eu/activities/emas/documents/AgricultureBEMP.pdf. Organisations are invited to consult it if interested in learning more about some of the best practices described in this SRD.

([6]) Regulation (EC) No 1893/2006 of the European Parliament and of the Council of 20 December 2006 establishing the statistical classification of economic activities NACE Revision 2 and amending Council Regulation (EEC) No 3037/90 as well as certain EC Regulations on specific statistical domains (OJ L 393, 30.12.2006, p. 1).

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Figure 2.1

Schematic overview of the scope of this SRD: the target groups of the document are shown in bold font in boxes with light grey background; their most relevant interactions with other sectors are also shown; the sectors that are addressed by other SRDs are shown in italic font in boxes with light green background



Besides its direct target group, this SRD can be also useful to other actors, such as farm advisors.

This SRD is structured according to the different agricultural activities, as presented in Table 2.1.

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Table 2.1

Structure of the agriculture SRD

Section	Description	Target group
3.1 Sustainable farm and land management	This section covers cross cutting issues related to landscape planning, energy and water efficiency, biodiversity, use of environmental management systems and engagement of consumers with responsible consumption.	All farms
3.2 Soil quality management	This section deals with the management of the quality of the soil. It covers the assessment of its physical conditions and the establishment of a management plan, as well as practical guidance on how soil quality can be improved by e.g. using organic amendments, on maintenance of soil structure and on drainage.	All farms
3.3 Nutrient management planning	This section deals with the management of nutrients in soil. It includes best practices on field nutrient budgeting, crop rotation, precision application of nutrients and selection of fertilisers with lower environmental impact.	All farms
3.4 Soil preparation and crop planning	This section focuses on selecting appropriate tillage operations, minimising soil disturbance, applying low impact tillage, implementing efficient crop rotations and establishing cover and catch crops.	All farms
3.5 Grass and grazing management	This section deals with maximising grass production and grazing uptake, managing grazing in high nature value areas, pasture renewal and clover incorporation as well as application of efficient silage production.	Livestock farms
3.6 Animal husbandry	This section outlines best practices related to animal husbandry. In particular, it presents practices related to appropriate breed selection, farm nutrient budgeting, dietary reduction of nitrogen excretion, improving feed conversion efficiency, green procurement of feed, animal health plans and herd/flock profile management.	Livestock farms
3.7 Manure management	This section covers best practices related to optimised manure management by reducing emissions and improving nutrient uptake. It includes the building of low emission housing systems, the implementation and optimisation of anaerobic digestion, the separation of slurry or digestate, and appropriate solid and liquid manure storage facilities, as well as techniques for the application of slurries and manure.	Livestock farms

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Section	Description	Target group
3.8 Irrigation management	This section deals with efficient irrigation strategies and provides guidance on agronomic methods, optimisation of irrigation delivery and efficient management of irrigation systems. The importance of the source of the water used for irrigation is also addressed.	Farms using irrigation
3.9 Crop protection	This section deals with sustainable crop protection practices in applying low pesticides input for pest management. The objectives are prevention of pest occurrence, reduction of dependency on chemical crop protection products, optimisation of the use of plant protection products and of pest resistance management strategies.	All farms
3.10 Protected horticulture	This section outlines best practices for protected horticulture. In particular, it deals with energy efficiency, water and waste management, and selection of growing media.	Protected horticulture farms

Table 2.2 presents the most relevant environmental aspects for farms, distinguishing between arable and horticultural production and livestock production. For each of them, the table outlines the related main possible environmental pressures and how these are addressed in this document. These environmental aspects were selected as the most commonly relevant in the sector. However, the environmental aspects to be managed by specific organisations should be assessed on a case by case basis.

Table 2.2

Most relevant environmental aspects for farms and how these are addressed in the SRD

Environmental aspects	Related main environmental pressures [1]	Relevant sections of the SRD
	Arable and horticultural production	
On-farm operations	Energy use	Section 3.1: Sustainable farm and land management, BEMP 3.1.5 Section 3.10: Protected horticulture, BEMP 3.10.1
Soil management	Soil degradation (erosion, compaction)	Section 3.2: Soil quality management, all BEMPs
Nutrients application	NH_3 and N_2O emissions Nutrient losses to water Biodiversity loss Heavy metal accumulation	Section 3.3: Nutrient management, all BEMPs
Tillage	Soil C and N loss Erosion Potential water sedimentation GHG emission	Section 3.4: Soil preparation and crop planning, BEMPs 3.4.1 — 3.4.3

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Environmental aspects	Related main environmental pressures ([1])	Relevant sections of the SRD
Grazing	NH_3 and N_2O emissions Soil erosion and compaction Nutrient losses to water Biodiversity loss Biomass C loss if land use has changed from forest	Section 3.4: Soil preparation and crop planning, all BEMPs Section 3.5: Grass and grazing management, all BEMPs
Crop protection	Eco-toxicity effects Biodiversity loss	Section 3.9: Crop protection, all BEMPs
Irrigation and other on-farm water use operations	Water stress Salinisation Nutrient losses	Section 3.1: Sustainable farm and land management, BEMP 3.1.5 Section 3.8: Irrigation, all BEMPs Section 3.10: Protected horticulture, BEMP 3.10.2
Protected horticulture	Plastic waste generation Biodiversity threat Energy and water use	Section 3.10: Protected horticulture, all BEMPs
	Livestock production	
Feed	CH_4 emissions from enteric fermentation	Section 3.6: Animal husbandry, all BEMPs
Animal housing	NH_3 and CH_4 emissions Nutrient losses Water use	Section 3.1: Sustainable farm and land management, BEMP 3.1.6 Section 3.7: Manure management, BEMP 3.7.1-3.7.3
Manure storage	CH_4, NH_3 and N_2O emissions	Section 3.7: Manure management, BEMP 3.7.4 and 3.7.5
Manure spreading	NH_3 and N_2O emissions	Section 3.7: Manure management, BEMPs 3.7.6 and 3.7.7
Grazing	NH_3 and N_2O emissions Soil erosion and compaction Nutrient losses to water Biodiversity loss (or potential biodiversity gain) Biomass C loss if land use has changed from forest	Section 3.5: Grass and grazing management, all BEMPs
On-farm medical treatment	Eco-toxicity effects Antibiotic resistance	Section 3.6: Animal husbandry, BEMP 3.6.6

([1]) Further information on the environmental pressures listed in this table is available in the 'Best Practice Report' published by the JRC and available online at: http://susproc.jrc.ec.europa.eu/activities/emas/documents/AgricultureBEMP.pdf

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Agriculture is a very diverse sector which includes a variety of produce and farm types, as well as intensity levels, ranging from large scale highly mechanised intensive farms to very small scale extensive agriculture farms. Whatever the farm type and business model, there is scope for substantial environmental improvement, although this may materialise in different sets of actions supporting different aims depending on the farm type and business model. In coherence with the spirit of the EMAS scheme, aimed at fostering continuous improvement in environmental performance whatever the starting point, this document covers best practices aimed at realising all those different improvement potentials. For instance, in the chapter on grass and grazing management, the document identifies a BEMP (section 3.5.1) on improving the efficiency of grass production and the nutrient uptake by livestock, as well as a BEMP (section 3.5.2) on matching grazing intensity to biodiversity needs in high nature value grassland. The first one is more relevant for farms with intensively managed grazing livestock and aims at improving the efficiency of the system; the second one is more relevant for extensively managed farms that prioritise the compatibility of the agricultural activity with the natural environment they are part of. In many cases, however, the best practices described are relevant, with due adjustment to the specific case, for all farms. For instance, in the chapter on soil preparation, there is a BEMP (section 3.4.2) on minimising soil preparation by implementing non-inversion tillage or specialist drills, which is beneficial whatever the level of intensity of the farming.

In each of the BEMPs presented in the document, a specific text indicates whether they are relevant for specific farm types and for intensive and/or extensive farming. Additionally, this information is summarised in Table 2.3 where the different BEMPs are mapped across 12 major farm types. Simplification is inevitably involved, and many farms may include features of multiple farm types (e.g. mix of intensive and extensive areas, mixed animal and crop production). This guidance is indicative and the actual relevance of individual BEMPs to a specific organisation should be assessed by the organisation itself on a case by case basis.

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Table 2.3

Relevance of the BEMPs described in this document for 12 major farm types (dark shading: very relevant; grey: likely to be relevant; white: not relevant or only partly relevant)

BEMP	Intensive dairy (*)	Extensive dairy	Intensive beef (*)	Extensive beef	Sheep	Intensive pigs (*)	Intensive poultry (*)	Extensive pig & poultry	Cereals and oils	Root crops	Field fruit & vegetables	Covered fruit & vegetables
3.1.1												
3.1.2												
3.1.3												
3.1.4												
3.1.5												

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BEMP	Intensive dairy (*)	Extensive dairy	Intensive beef (*)	Extensive beef	Sheep	Intensive pigs (*)	Intensive poultry (*)	Extensive pig & poultry	Cereals and oils	Root crops	Field fruit & vegetables	Covered fruit & vegetables
3.1.6												
3.1.7												
3.2.1												
3.2.2												
3.2.3												
3.2.4												
3.3.1												
3.3.2												
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3.6.6												
3.6.7												
3.7.1												
3.7.2												

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BEMP	Intensive dairy (*)	Extensive dairy	Intensive beef (*)	Extensive beef	Sheep	Intensive pigs (*)	Intensive poultry (*)	Extensive pig & poultry	Cereals and oils	Root crops	Field fruit & vegetables	Covered fruit & vegetables
3.7.3												
3.7.4												
3.7.5												
3.7.6												
3.7.7												
3.8.1												
3.8.2												
3.8.3												
3.8.4												
3.9.1												
3.9.2												
3.10.1												
3.10.2												
3.10.3												
3.10.4												

(*) Best practices for arable crop production may apply to areas of the farm for feed production, or to farms receiving pig and poultry manure in terms of slurry application.

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3. **BEST ENVIRONMENTAL MANAGEMENT PRACTICES, SECTOR ENVIRONMENTAL PERFORMANCE INDICATORS AND BENCHMARKS OF EXCELLENCE FOR THE AGRICULTURE SECTOR**

3.1. **Sustainable farm and land management**

This section is relevant for all farmers and farm advisors and all farm types. It deals with the high level planning and management of the farm, also in relation with the wider landscape context where the farm is located. It provides a framework for prioritising measures to achieve resource efficient and environmentally responsible farming. However, the specific measures to address the different environmental aspects are not given in this section, but presented in detail in the following sections (3.2 — 3.10).

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3.1.1. *Strategic farm management plan*

BEMP is to put in place a strategic farm management plan including the following elements:

— implementation of a strategic business plan for the farm that addresses market, regulatory, environmental and ethical considerations over a time period of at least five years;

— identification of, and progress towards attaining, accreditation by relevant sustainable farming or food certification schemes that add value to farm produce and demonstrate commitment to sustainable management;

— use of appropriate Life Cycle Assessment (LCA) or ecosystem service indicators, with appropriate metrics, to monitor and measure continuous improvement of farm environmental performance (see BEMP 3.1.2);

— collaboration with neighbouring farmers and public agencies to coordinate the delivery of priority ecosystem services at the landscape scale.

Applicability

This BEMP encompasses various elements that can be broadly applicable to all farm types addressed by this SRD. However, this BEMP is likely to be easier applicable in large farms due to the availability of more resources and potentially a better mapping of the operations carried out within the farms. Moreover, the collaboration with the adjacent farmers and public agencies, which actually set the priority of the actions to be taken at the landscape level, is an important element that influences the overall environmental performance of the farm and is more applicable to large farms.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i1) Strategic farm management plan in place (Y/N) (i2) Participation in existing accreditation schemes for sustainable farming or food certification schemes (Y/N)	(b1) The farm has in place a strategic management plan that: (i) considers a time period of at least five years; (ii) improves the sustainability performance of the farm in all three dimensions: economic, social and environmental; (iii) considers ecosystem services delivery in a local, regional and global context using appropriate and simple indicators

3.1.2. *Embed benchmarking in environmental management of farms*

BEMP is to embed benchmarking in the implementation of an environmental management system (EMS) for the farm. The objective is to benchmark the environmental performance of the farm against the best achievable performance, in order to allow farm managers and/or farm advisors to identify areas of excellence and areas where further improvement is needed. This can be implemented through systematic monitoring and reporting of the environmental

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performance of the farm at process level. Thanks to this, the EMS can focus more effectively on the areas with the poorest performance or the highest improvement potential. The main aspects of an EMS based on benchmarking are:

— systematic reporting at process level: regular data collection and reporting according to the different indicators included in this SRD;

— identification of areas to focus on based on comparing the performance measured with the available benchmarks, such as those included in this SRD;

— development of a clear protocol for major operations and for the areas of focus taking into account best available practices: farmers can be informed about of the new available best practices by other farmers, farm advisors and industry associations, as well as by consulting reference documents such as this SRD;

— use of decision support tools: use of appropriate tools to inform the implementation and assess the performance of specific best practices;

— staff training: all staff are appropriately trained on environmental management and explained the clear links between their individual actions and the related overall environmental performance.

Applicability

This BEMP is broadly applicable to all farm types. In large farms where extensive regular reporting is already in place, and which may have available resources to carry out the actions outlined (e.g. to afford the purchase of the equipment needed), it is likely that this BEMP may be more easily applicable. However, this BEMP is also applicable to small farms, subject to access of farmers to appropriate training and advice, and may eventually lead to greater environmental performance improvement on such farms, by encouraging systematic performance monitoring and optimisation.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i3) An EMS based on benchmarking for an appropriate selection of indicators is in place (Y/N) (i4) Environmental management training is provided to staff (Y/N)	(b2) Relevant indicators are applied to benchmark the performance of individual processes, and the entire farm system, against all relevant best practice benchmarks described in this SRD. (b3) Permanent staff participates in mandatory environmental management training programmes at regular intervals; temporary staff is provided information on environmental management objectives as well as training on relevant actions

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3.1.3. *Contributing to water quality management at river basin level*

BEMP is to implement catchment sensitive farming measures planned at the level of an entire catchment to minimise water pollution via nutrient, agrochemical, sediment and pathogen run-off.

This includes:

— establishing buffer strips, i.e. areas adjacent to watercourses without fertiliser applications and agrochemical operations; in particular, establishing buffer strips with trees or wild grasses to provide maximum biodiversity benefit and enhance run-off water interception;

— establishing integrated constructed wetlands at strategic catchment locations to intercept run-off water flow;

— setting up site-appropriate drainage systems taking into account the soil type and hydrological connectivity with water bodies;

— identifying signs of soil erosion and compaction by visual inspection of the field;

— contributing to setting up a catchment level management plan, including coordination of land management across farms.

Applicability

Catchment-sensitive farming is broadly applicable to all farm types. It is more easily applicable in smaller catchment areas typically involving fewer land owners. The practical implementation of this BEMP will also depend upon the governance structure for the river basin district where the farm may be located.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i5) Stream total nitrogen and/or nitrate concentration (mg N, NO_3/l) (i6) Stream suspended solid concentration (mg/l) (i7) Width of buffer strips (m)	(b4) Farmers work collaboratively with neighbouring farmers and river basin managers from relevant authorities to minimise risk of water pollution, for example through the establishment of strategically located integrated constructed wetlands. (b5) Buffer zones comprising of at least 10 m in width are established adjacent to all surface watercourses, in which no tillage or grazing operations are carried out.

3.1.4. *Landscape level biodiversity management*

BEMP is to devise and implement a biodiversity action plan that supports natural habitats and local biodiversity and includes measures such as:

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— applying integrated farm management that considers biodiversity at the farm and landscape level;

— developing habitat networks around and between farms contributing to the creation of 'biological corridors' that connect areas of significant biodiversity;

— taking marginal agricultural land out of production and encouraging the regeneration of natural habitats;

— reducing conversion of wild habitat to agriculture and protecting priority areas, such as watersheds, forest fragments, rivers and wetlands;

— taking special account of biodiversity in the management of high nature value grasslands, ponds, streams and ditches; for instance, avoiding the creation of new ponds in flower-rich wetland areas, reducing grazing on grassland when most of the plants are flowering (e.g. from May to June), preserving nesting habitats for farmland birds.

Applicability

The principles of this BEMP are applicable to all farm types, sizes and locations. Usually extensive farms (such as organic agriculture producers) give more prominence to these measures, but more intensive farms can also implement actions contributing to these objectives. In any case, the specific measures to be included in the action plan strongly depend on local circumstances, the labour costs as well as the business model and intensity level of the farm.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i8) Nutrient application rate (kg N/P/K/ha/year) (i9) Average livestock number per hectare (i10) Locally important species abundance ([1]) (No of key species/m^2)	(b6) A biodiversity action plan is implemented on the farm, to maintain and enhance the number and abundance of locally important species.

([1]) 'Locally important species' encompass locally endemic species and rare or threatened species. The farmer can refer to applicable national/regional biodiversity and habitat regulation, as well as to local NGOs, to determine key locally important species.

3.1.5. *Energy and water efficiency*

BEMP is to devise and implement appropriate plans to monitor and manage energy and water use within the farm. The key characteristics of such plans are summarised below, separately for energy and water.

Energy:

BEMP is to implement an energy management plan for the entire farm based on total energy use mapped across major energy-using processes, including indirect energy use, with targets for energy use reduction. Examples of measures that can be included in the plan are:

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— calculation of farm-level total energy use by hectare, livestock unit or tonne of produce and use of these energy intensity metrics for benchmarking;

— metering and recording energy use at the process level on at least a monthly basis for all major energy-using processes; using electricity sub-meters to individually measure processes such as milk cooling and lighting;

— estimation of the indirect energy use ([7]) of the farm, i.e. the energy used to manufacture inputs used on the farm (such as feed or fertilisers);

— application of green procurement principles to energy-using equipment and to the energy supply, such as purchase of energy-efficient equipment and certified renewable energy;

— use of heat exchange and heat recovery systems where feasible (e.g. milk chillers);

— integration of renewable energy generation in buildings and/or on land within the farm (e.g. installation of solar thermal systems, photovoltaic panels, wind turbines, boilers fuelled with sustainably harvested biomass).

Water:

BEMP is to implement a water management plan for the entire farm based on total water use mapped across major water-using processes, including indirect water consumption with targets for reducing abstracted water. Examples of measures that can be included in the plan are:

— calculation of the total water use from different sources (potable water, abstracted fresh water, reclaimed water ([8]), etc.) per hectare, livestock unit or tonne of produce and use of these metrics for benchmarking;

— separate metering and recording of water use for animal housing operation, animal watering and crop irrigation, by source, on at least a monthly basis via appropriate water sub-meters;

— estimation of the indirect water use on the farm, i.e. the water needed to produce the raw materials used on the farm (such as imported feed for live-stock);

— rainwater storage and use for animal watering, animal washing and/or irrigation.

([7]) Indirect energy use, also known as embodied energy, of fertilisers and/or animal feed refers to the energy that was used when these were produced (including raw material extraction, transport and manufacture).

([8]) Where available, the use of reclaimed water, or recycled water, i.e. water obtained from the processing of waste water, can allow reducing the use of fresh water.

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Applicability

The BEMP is broadly applicable to all farm types. However, the outlined actions (both for energy and water management) are likely to be more easily applicable to those farms, which are usually large farms, that already have in place monitoring systems and thus have the possibility to develop and implement more detailed plans.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i11) Final energy use within the farm (kWh or l_{diesel} per hectare) (i12) Farm water use efficiency (m^3 per hectare and year or per livestock unit or tonne of produce)	(b7) An energy management plan is implemented and revised every five years, including: (i) mapping of direct energy use across major energy-using processes; (ii) mapping of indirect energy use via fertiliser and animal feed consumption; (iii) benchmarking of energy use per hectare, livestock unit or tonne of produce; (iv) energy efficiency measures; (v) renewable energy measures. (b8) A water management plan is implemented and revised every five years, including: (i) mapping of direct water consumption by source across major processes; (ii) benchmarking of water consumption per hectare, livestock unit or tonne of produce; (iii) water efficiency measures; (iv) rainwater harvesting.

3.1.6. *Waste management*

BEMP is to implement in-house waste management practices ([9]) following the waste management hierarchy ([10]). These include:

— avoiding the generation of waste whenever possible;

— anaerobic digestion or composting of organic waste wherever possible;

— careful handling of hazardous chemicals and their packaging: fully emptying out packaging, segregation at source and correct storage of these hazardous wastes;

— careful handling and storage of manure and slurries.

([9]) A number of aspects of this BEMP are developed further in more specific BEMPs: see Section 3.7 on manure management, Section 3.9 on crop protection products and BEMP 3.10.3 on waste management in protected horticulture.

([10]) According to Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (the Waste Framework Directive) (OJ L 312, 22.11.2008, p. 3)), waste management practices should be prioritised in the following order: (a) prevention, (b) preparing for reuse, (c) recycling, (d) other recovery, e.g. energy recovery; and (e) disposal.

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Applicability

This BEMP is broadly applicable to all farm types and sizes. The distance between the farm and the anaerobic digestion or composting plant may be a limitation for the farms, especially the smaller ones (when the treatment of the organic waste takes place off-site); whereas space within the farm (for treatment on-site) is required. Plastic waste management is especially relevant to protected horticulture farms (as addressed in BEMP 3.10.3), as well as to farms producing silage bales.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i13) Waste generation by type (t/ha/year) (i14) Percentage of waste separated into recyclable fractions (%) (i15) Percentage of organic waste that is treated either anaerobically or aerobically (%)	(b9) Waste prevention, reuse, recycling and recovery is implemented so that no waste is sent to landfill.

3.1.7. *Engage consumers with responsible production and consumption*

BEMP is to engage with consumers, bringing them closer to food production and responsible farming practices and stimulating them to adopt responsible consumption by:

— participating in community supported agriculture;

— selling products directly from farm shops, local farmers' markets or vegetable box schemes;

— allowing gleaning (e.g. allowing people to come on the farm and harvest any leftover crops that could not be harvested for selling because of insufficient prices or not meeting certain requirements);

— establishing co-operation with local food processors, such as bakeries or dairies;

— hosting farm open days and guided tours for the public;

— using social media to communicate about the farm, organise events or to establish direct selling schemes for the public.

Applicability

All farms may decide to engage with consumers, e.g. by hosting open days for the public, establishing direct selling schemes or using social media to communicate about the farm (planting new crops, harvesting, type and timing of the operations carried out, information about the selling points etc.). However, this BEMP is particularly applicable to smaller extensive agriculture farms, such as small organic producers, serving a local market (including horticultural ones). Cooperation with local food processors is particularly relevant for cereal and livestock farmers.

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i16) Percentage of products sold to a defined (local) market ([1]) (%) (i17) Number of farm open days per year (No/year)	N/A

([1]) It represents the products sold directly from the farm either on-site or at local farmers' market and the products sold via vegetable box schemes or other forms of community supported agriculture.

3.2. **Soil quality management**

This section is relevant to mixed, arable and horticultural farms, and for both intensive and extensive farming. It deals with assessment and mitigation of the soil risks, planning actions to maintain or improve soil quality and monitoring soil conditions.

3.2.1. *Management plan for assessing and maintaining soil physical condition*

BEMP is to devise and implement a soil protection plan aimed at maintaining soil quality and functionality. The plan should include measures such as:

— Producing an annual report for signs of erosion, compaction and surface ponding based on visual field inspections, and calculating soil bulk density;

— Mapping the different soil types that exist on the farm to match the soils that are best suited to each land use type;

— Calculating soil organic matter balance at field level, as well as regularly checking soil nutrient reserves and pH values at field level according to the principles presented in BEMP 3.3.1;

— Implementing concrete actions that maintain the soil quality and the organic matter within the fields (these are detailed in the following BEMPs 3.2.2, 3.2.3 and 3.2.4).

Applicability

This BEMP is broadly applicable to all mixed, arable and horticultural farms, both practising intensive and extensive agriculture. Most of the measures included in the soil protection plan have relatively low investment costs and can yield significant benefits in terms of productivity, though possibly with some delay.

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i18) Soil infiltration capacity (mm/hour) (i19) Visual evaluation of soil structure for erosion and compaction signs across fields (Y/N) (i20) Soil bulk density (g/cm^3) (i21) Soil water holding capacity (m^3 water content/m^3 dry soil or g water content/100 g dry soil)	(b10) A soil management plan is implemented for the farm that incorporates: (i) an annual report for signs of erosion and compaction based on field inspections; (ii) soil bulk density and organic matter analyses at least every five years; (iii) implementation of concrete actions for maintenance of soil quality and organic matter

3.2.2. *Maintain/improve soil organic matter on cropland*

BEMP is to incorporate organic amendments to soil by importing high-quality organic materials that will contribute to improving soil structure. Organic matter may be imported to agricultural soils through:

— incorporation of crop residues and cover and catch crops e.g. legumes;

— decay of vegetative litter on non-tilled soils;

— application of manures (consult BEMP 3.7.6);

— establishing temporary grass leys (see also BEMP 3.4.4);

— application of alternative source of organic matter such as certified composted materials, digestate from anaerobic digestion plants and other organic waste.

Applicability

This BEMP is broadly applicable to arable farms, both for intensive and extensive systems, provided that all the added organic inputs are accounted for in the field nutrient management plan (see BEMP 3.3.1).

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i22) Organic dry matter application rate (t/ha/year) (i23) Soil organic carbon (% C) (i24) Carbon to Nitrogen ratio (C/N)	(b11) Ensure all arable soils on the farm receive organic matter inputs, e.g. from crop residues, manures, catch/cover crops, composts, or digestates, at least once every three years, and/or establish grass leys for one to three years.

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3.2.3. *Maintain soil structure and avoid erosion and compaction*

BEMP is to:

— apply timely and appropriate cultivations that preserve soil structure and minimise run-off and erosion due to both water and wind:

  — select a cultivation system that uses the minimum number of passes consistent with creating soil conditions suitable for the crop to be grown;

  — implement shallow cultivations to avoid raising subsoil or causing damage to drains;

  — consider direct drilling or reduced tillage systems and use furrow press if ploughing;

— maintain seedbed for water infiltration;

— apply aeration to avoid soil compaction;

— reduce the impact of machinery on the soil structure (e.g. flotation tyres can be used to minimise soil compaction).

Applicability

Techniques to control soil erosion and compaction and to maintain soil structure are broadly applicable to all farm types and in most locations. Water erosion is a common problem across Europe, while wind erosion is more of a problem in the drier south and east of Europe. In large farms, the BEMP seems more applicable because of potentially more available resources to carry out the actions outlined, afford the purchase of the equipment/machinery needed and/or acquire the competences/knowledge to implement successfully the actions above.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i19) Visual evaluation of soil structure for erosion and compaction signs across fields (Y/N) (i20) Soil bulk density (g/cm^3) (i25) Erosion losses (t/ha/year)	(b10) A soil management plan is implemented for the farm and it incorporates: (i) annual report for signs of erosion and compaction based on field inspections; (ii) soil bulk density and organic matter analysis at least every five years; (iii) implementation of concrete actions for soil quality and organic matter

3.2.4. *Soil drainage management*

BEMP is to manage soil drainage to maintain fertility and minimise nutrient losses by:

— mapping out drains in each field;

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— avoiding water saturation of soils by:

  — ensuring adequate infiltration of water;

  — minimising soil compaction according to the principles described in BEMP 3.2.3;

  — promoting natural drainage including through the planting of trees, deep-rooted crops and implementing crop rotation;

  — maintaining and where relevant, installing interception drains to divert water;

— engineering surface drainage systems to incorporate semi-natural features such as non-uniform cross-sectional profiles, meanders, riffles and pools and natural vegetation to increase the heterogeneity of depths and velocities while simultaneously improving natural habitats.

— minimising draining on peat soils and in areas vulnerable to nutrient losses; all un-drained land with peat or peaty soils should be left as natural or semi-natural areas, or as traditionally managed pasture.

Applicability

The applicability of this BEMP strongly depends to a great extent upon local parameters like the topography of the field (slope angle and length of the field, soil type and soil aggregate size, size of the area draining into the catchment area) and the cropping system. In particular, improved drainage practices are broadly applicable to most non-sandy and non-organic arable and grassland soils while drainage should be avoided or minimised in peat soils and wetlands.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i26) Installation of drains on grassland and arable land (Y/N) (i27) Production of field drain maps (Y/N) (i28) Minimisation of drainage on peat soils (Y/N)	(b12) Natural drainage is maximised through careful management of soil structure; the effectiveness of existing drains is maintained; new drains are installed where appropriate on mineral soils. (b13) Drainage is minimised on peat soils and soils where there is a high risk of increased nutrient transfer to water via drainage.

3.3. **Nutrient management**

This section is relevant for all farm types (including livestock farms). It deals with practices that ensure that the application of nutrients matches crop and animal needs, to optimise yield and obtain the maximum benefit from the nutrients applied while ensuring that the carrying capacity of the environment is fully respected.

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3.3.1. *Field nutrient budgeting*

BEMP is to ensure that crop nutrient requirements are met, while, at the same time, not applying nutrients in excess, through nutrient budgeting at the field level. The main aim of this BEMP is to achieve the 'economic optimum' crop yield and quality and to minimise input costs, as well as to protect soil and water and avoid air emissions. This can be achieved by:

— implementing systematic periodic soil testing to maintain soil pH within the optimum range (6,5–7,5) and appropriate levels of phosphorus (P) and potassium (K): it is recommended to test soils at least every three to five years for permanent pasture and every three years for crops and leys;

— accounting for all nutrient inputs to soils and nitrate residues in the root zone and applying nutrients (N, P and K) in correct amounts for optimum yield: the amount and plant availability of nutrients added as organic matter (according to BEMP 3.2.2) should be taken into account;

— calculating the nutrient surplus at the field level by calculating nutrients (N, P and K) imports and deducting nutrients (N, P and K) exports per hectare (high nutrient surpluses lead to risk of off-site pollution);

— calculating Nutrient Use Efficiency (NUE) at field or farm level: the NUE at farm level is the ratio of nutrients (N, P and K) contained in crop and livestock products exported from the farm to nutrient inputs to the farm (e.g. as fertiliser and feed). Relevant farm records can be used to calculate all nutrient inputs and outputs.

Applicability

This BEMP is broadly applicable to all farm types and is a key practice that strongly influences the environmental performance and the productivity of the farm. The measures enabling field nutrient budgeting have relatively low investment costs and can yield significant benefits in terms of production efficiency. An indicative cost range to compile a complete field nitrogen input-output budget is EUR 200 to EUR 500 per farm annually, depending on the size and type of farming system and on the level of external advice required.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i8) Nutrient application rate (kg N/P/K/ha/year) (i29) Field nutrient surplus (kg N/P/K/ha/year) (i30) NUE calculated for N/P/K (%) (i31) Gross Nitrogen Balance [1] (kg/ha)	(b14) The fertiliser nutrients applied do not exceed the amount required to achieve the 'economic optimum' crop yield. (b15) Nutrient surplus or nutrient use efficiency is estimated for nitrogen, phosphorus and potassium for individual crop — or grassland — management parcels.

[1] Gross nitrogen balance represents the surplus or reduction of nitrogen on agricultural land. It is calculated by subtracting the amount of nitrogen added to the farming system by the amount of nitrogen taken away from the system per hectare of agricultural land.

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3.3.2. *Crop rotation for efficient nutrient cycling*

BEMP is to optimise nitrogen cycling by incorporating legumes into crop rotation cycles ([11]). Legumes optimise the nitrogen input via biological nitrogen fixation and maximise the nitrogen transfer to subsequent crops with minimum nitrogen leaching losses. To make the most of biological nitrogen fixation, a crop rotation cycle should contain at least one legume crop and one break crop ([12]) (e.g. a grass clover ley grown as a main crop or as a catch crop ([13])) over a five-year period. The presence in crop rotation of plants fixing atmospheric nitrogen should be taken into account when determining overall nutrient inputs to soils and applying nutrients.

Applicability

Biological nitrogen fixation through legume crops is broadly applicable to all farming systems. It is particularly relevant for organic agriculture systems or low-fertiliser input systems and also highly important for arable land with a short supply of organic nutrients. However, this BEMP is not applicable to farming systems with peaty soils that have a low pH value because soil acidity adversely affects the mechanism of biological nitrogen fixation.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i31) Gross Nitrogen balance (kg/ha) (i32) Crop rotation cycles include legume and break crops (Y/N) (i33) Length of crop rotation cycles (years)	(b16) All grassland and crop rotations include at least one legume crop and one break crop over a five-year period.

3.3.3. *Precision nutrient application*

BEMP is to:

— synchronise the application of manures and (when necessary) fertilisers to coincide with crop requirements: for each nutrient (N, P and K), at the correct time and at rates that meet crop nutrient requirements ([14]);

— implement split applications when necessary, to maximise nutrient uptake and prevent losses: applying nutrients in more than one application reduces the total amount of nutrients that need to be applied and minimises nutrient leaching.

([11]) Crop rotation is the succession of humus-increasing and humus-demanding crops on a field throughout a cycle of several years, while taking into account regulatory and edaphic constraints. Crop rotation results in a great number of benefits. For instance, legumes, which are deep-rooting, N-fixing, humus- and soil fertility-building crops, are grown in combination with a balanced proportion of N- and humus-demanding crops such as cereals and root crops.

([12]) A break crop is a secondary crop that is cultivated in order to interrupt the repeated sowing of cereals as part of crop rotation.

([13]) A catch crop is a crop grown in the space between two main crops or at a time when no main crops are being grown.

([14]) The precision nutrient application should follow the principles known as the 4R stewardship: Right fertiliser, Right time, Right rate and Right method.

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— use GPS guidance systems for precision delivery of nutrients (N, P and K), including variable nutrient application rates within fields informed by crop canopy development and previous harvest data, and allowing accurate locational placement of fertilisers while keeping to tramlines.

— implement direct placement of nutrients (N, P and K) to seeds: the nutrient granules are placed directly in or alongside the rooting zone.

Applicability

This BEMP is broadly applicable to mixed, arable and horticultural farms. Split applications of nutrients are mainly used for cereals.

Precise application implies significant investment and operational costs, for equipment purchasing and labour costs (e.g. for acquisition of georeferenced data on nutrient needs, multiple GPS-guided nutrient applications) and is thus more applicable to large farms for which the payback time of the investment would be shorter. However, for small and medium size farms, or for those farms with limited investment capacity, it is often possible to rent the equipment needed to implement precision application or to outsource this task to a specialised company that owns and operates the necessary equipment.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i34) Use of precision farming tools such as GPS technology guidance to optimise nutrient delivery (Y/N) (i29) Field nutrient surplus (kg N/P/K / ha/year) (i30) NUE calculated for N/P/K (%)	N/A

3.3.4. *Selecting synthetic fertilisers with lower environmental impact*

Manufacture of mineral nitrogen requires large quantities of energy and gives rise to considerable greenhouse gas emissions (GHG) emissions, depending on the type of compounds, the efficiency of the manufacturing plants and the nitrous oxide (N_2O) abatement techniques applied ([15]). Therefore, whenever farmers need to use synthetic nitrate based fertilisers, BEMP is to select products with a documented lower carbon footprint ([16]).

Moreover, whenever a farmer selects urea-based fertilisers, BEMP is to select products, whose granules are coated with a nitrification inhibitor. The nitrification inhibitor slows down the rate of hydrolysis to ammonium and ammonia. Additionally, it allows precise nitrogen delivery to the crops, by slowing down nitrate production to a rate which more closely matches crop uptake.

([15]) The EU has compiled a Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals — Ammonia, Acids and Fertilisers — in the framework of Article 13(1) of the Industrial Emissions Directive (IED, 2010/75/EU). The Reference Document is available at: http://eippcb.jrc.ec.europa.eu/reference/BREF/lvic_aaf.pdf.

([16]) The carbon footprint of the nitrate based products must be provided in an openly reported calculation by the supplier.

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Applicability

This BEMP is broadly applicable to mixed arable and horticultural farms using mineral fertilisers.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i35) Carbon footprint of nitrogen fertilisers used (kg CO_2e/kg N) (i36) Synthetic fertilisers applied have low post application ammonia and GHG emissions (Y/N)	(b17) Mineral fertiliser used on the farm has not given rise to manufacturing emissions exceeding 3 kg CO_2e per kg N, which must be demonstrated in an openly reported calculation provided by the supplier. (b18) Synthetic fertilisers applied have low post-application ammonia emissions.

3.4. **Soil preparation and crop planning**

This section is relevant to mixed, arable and horticulture farms and deals with techniques and choices in soil preparation and crop planning that protect and enhance soil quality.

3.4.1. *Matching tillage operations to soil conditions*

BEMP is to match tillage operations to soil types and soil conditions in order to optimise crop establishment and protect the soil.

Selecting cultivation techniques such as minimum tillage and direct drilling reduces the cultivation intensity and the depth and extent of soil disturbance, and protects soils by avoiding:

— burial of organic matter and nutrients to soil depths beyond the major rooting zone;

— fragmentation of soil aggregates, resulting in mineralisation of organic matter (flushes of CO_2 and nitrate nitrogen (NO_3-N));

— disruption of the continuity of natural channels that allow water and oxygen infiltration.

Moreover, tillage and sowing operations need to be carefully timed with respect to soil moisture, soil type and weather conditions:

— weather conditions: establishment of autumn drilled crops in early autumn may enable nitrogen uptake before the onset of over-winter drainage and provide good vegetation cover (at least 25–30 %) over the winter months to protect the soil from rainfall-induced surface run-off and the associated erosion ([17]);

([17]) Wherever soil conditions allow, it is best practice to sow winter cereal crops early if a reduced cultivation intensity option is used; cover crops should be sown if cereals are not sown until spring.

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— soil moisture: avoiding working wet soils limits compaction and sediment and nutrient run-off, as well as erosion and problems with root development;

— soil type: sandy soils are easier to work when wet than clay soils.

The cultivation of peat soils should be avoided due to the high risk of nutrient leaching and carbon oxidation. Peat soils need to be kept covered with a long-term grass ley in order to maintain the organic matter content of the soil; tillage operations to reseed the ley should be limited to a maximum frequency of once every five years.

Applicability

This BEMP is broadly applicable to mixed, arable and horticultural farms.

The minimum tillage and direct drilling techniques are recommended for early winter sowing. Moreover they are recommended for clay loam soils and are not suitable for sandy or poorly structured soils.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i37) Percentage of winter soil coverage by vegetation (%) (i38) Percentage of peat soils cultivated (%) (i23) Soil organic carbon (% C) (i24) Carbon to Nitrogen ratio (C/N)	(b19) Fields with peat soils must be kept covered with long-term grass ley; soil tillage on peat soils to reseed the ley is carried out at a minimum interval of five years.

3.4.2. *Minimising soil preparation operations*

BEMP is to use non-inversion tillage operations or specialist drills for crop establishment rather than conventional ploughing. Soil preparation operations that can maintain and improve soil structure, porosity and microbial activity, are:

— direct drilling, where no soil inversion or tillage takes place and the crops are sown without any prior loosening of the soil;

— strip tillage, where soil preparation is limited to narrow strips of soil that are to contain the seed rows while residual cover of the soil is maintained between the rows;

— reduced or minimum tillage (chisel plough), where deep tillage happens without soil inversion; its approach is to loosen and aerate soils while leaving the crop residues at the surface of the soil.

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Applicability

The soil preparation operations listed in this BEMP are broadly applicable to arable farms. Direct drilling reduces soil losses, conserves soil moisture, increases water infiltration and reduces surface flows. It is best carried out on stable soil that maintains its structure throughout the growing season such as clays, silty clay loams and clay loams. However, it should be avoided on sandy soils, compacted soils, fields with serious weed problems and with crops that require specific tilth conditions (e.g. potatoes). Similarly, strip tillage should be avoided in wet soils because it can result in compaction. Reduced tillage runs the risk of weed infestation but can be properly managed by skilful crop rotation and practices like stale seedbeds. Additionally, the use of reduced tillage operations is not suitable for sandy soils.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i18) Soil infiltration capacity (mm/hour) (i20) Soil bulk density (g/cm^3) (i25) Erosion losses (kg/ha/year) (i39) Percentage of seeding area where direct drilling is applied (%) (i40) Percentage of area where non-inversion tillage operations for crop establishment are applied (%)	(b20) Inversion tillage is avoided through the use of e.g. direct seed drilling, strip tillage and reduced tillage (chisel plough).

3.4.3. *Mitigating tillage impacts*

BEMP is to carry out practices that mitigate the impacts of soil tillage operations and thus reduce the soil erosion potential and increase or maintain the soil organic carbon content: ([18])

— Cultivate and drill land across the slope (contour) to reduce the risk of developing surface run-off. The ridges created across the slope increase roughness and provide a barrier to surface run-off resulting in reduction of sediment losses.

— Create break slopes and plant hedges to intercept run-off and nutrients. Breaking up long slopes can be done by a ditch, hedge or grass strip (as wide as possible) on the contour. Hedges give a long term slope break and they are more effective whenever planted on a wide bank running along the contour to help retain sediment and prevent fine particles from reaching watercourses.

— Cultivate tramlines caused by machinery after tillage operations.

([18]) Additional relevant measures can be found in BEMP 3.2.3 on maintaining soil structure and avoiding erosion and compaction.

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— Use Controlled Traffic Farming (CTF) to limit all machinery loads to the smallest possible area, as permanent traffic lanes, using GPS guidance, to reduce soil compaction and crop damage.

— Create roughened seedbeds to increase available surface area available to rain drops and thus to reduce surface capping and run-off. By leaving the autumn seedbed rough improves water infiltration and reduces the risk of surface run-off and sediment losses.

Applicability

The measures of this BEMP are broadly applicable to mixed, arable and horticultural farms. However, when the practice of cultivation and drilling across the slope (contour) is chosen, crops requiring furrow cultivation may not be suitable.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i20) Soil bulk density (g/cm^3)	N/A
(i21) Soil water holding capacity (g water content/100 g dry soil or m^3 water content/m^3 dry soil)	
(i25) Soil erosion losses (kg/ha/year)	

3.4.4. *Crop rotation as a measure for soil protection*

This BEMP outlines the main design principles of crop rotation schemes for soil protection and enhancement. BEMP is to:

— select crop type and sequence within a crop rotation in order to:

(i) synchronise nitrogen supply with crop demands,

(ii) enhance soil organic matter,

(iii) provide phytosanitary benefits, and

(iv) prevent soil erosion;

— implement longer rotation cycles including for legumes (see also BEMP 3.3.2);

— select early maturing varieties of crops for the most susceptible land in order to harvest before the wet season and to facilitate the establishment of cover crops.

— create temporary grass leys on mixed farms: they are useful as a break crop to reduce the risk of erosion on arable land, while also enhancing soil fertility, especially by adding nitrogen;

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— incorporate weed management into rotation cycles to avoid weed infestation: e.g. alternate between leaf and straw crops, alternate between winter and spring crops, include root crops, use grazing and mowing to control perennial weeds and use cover crops;

— incorporate biofumigation crops (e.g. from the Brassicaceae family) into rotation cycles to reduce diseases: biofumigation consists of the use of specific crops that, during their decomposition, release into the soil volatile compounds that are toxic for some soil organisms and can help to control soil pathogens or pests.

Besides crop rotations over time, BEMP is to ensure spatial diversity within and beyond the farm. Adjacent fields within a farm or on different farms should contain different crops in order to avoid the propagation of pathogens and pests and reduce the risk of erosion.

Applicability

This BEMP is broadly applicable to mixed, arable and horticultural farms. The measures described are particularly effective when there is the potential to develop them over the long term.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i33) Length of rotation cycles (years) (i41) Number of break crops (ley, legume, oilseed) in the rotation cycles (number of crops/rotation cycle) (i42) Spatial diversity is considered in crop selection (Y/N) (i43) Selection of early maturing varieties of crops for the most susceptible land (Y/N)	(b21) On farms with a cereal-dominated crop rotation, break crops are planted for at least two years in a seven year crop rotation and for at least one year in a six-year or shorter crop rotation. (b22) Farms alternate crops cultivated in neighbouring fields to increase spatial diversity of cropping patterns at the landscape level. (b23) Early maturing varieties of crops are selected in order to harvest before the wet season and to facilitate the establishment of cover crops.

3.4.5. *Establishing cover crops and catch crops*

BEMP is to avoid leaving any cropland bare over the winter by establishing cover crops and catch crops. Catch crops retain nutrients in the root zone. Cover crops protect the soil against erosion and minimise the risk of surface run-off by improving the infiltration. Cover crops can sometimes act as a catch crop by mopping up the spring flush of nitrate nitrogen.

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It is BEMP to assess the potential to integrate catch/cover crops into cropping plans and to leave land bare during winter only when duly justified.

Applicability

Cover and catch crops are suited for use in any cropping system on tillage land, where bare soil is vulnerable to nutrient leaching, erosion or surface run-off in the period following main-crop harvest. Catch and cover crops can be sown under the previous main crop or immediately after its harvest. They are mainly used prior to spring-sown crops.

In some locations, farmers and regional water managers may want to avoid cover crops, due to the increase in evapotranspiration that they cause. More generally, they are effective in areas where there is a precipitation surplus during wintertime, and should be avoided in areas where planting cover crops may result in subsequent drought.

Furthermore, cover crops may cause structural damage when they are planted late or in wet conditions, resulting in poor utilisation of soil nitrogen by both the cover crop and the subsequent crops, and increased particulate phosphorus and sediment loss risks.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i5) Stream total nitrogen and/or nitrate concentration (mg N, NO_3/l) (i44) Percentage of land left as bare soil over winter (%) (i45) Percentage of land with catch/ cover crops planted (%)	(b24) The farm provides evidence of a full assessment of the potential to integrate cover/catch crops into cropping plans, providing justification for any land left bare over winter.

3.5. **Grass and grazing management**

This section deals with grassland management practices and is relevant to livestock farms, with best practices for both intensive and extensive farm types.

3.5.1. *Grass management*

BEMP is to make the best possible use of grass areas used for grazing on livestock farms by maximising pasture growth rate and pasture quality as well as its utilisation by livestock, while ensuring that average grass cover rates are achieved at critical times of the year. This encourages higher digestibility and nutritional value (and thus productivity) of feed while reducing purchased feed requirements, potentially reducing methane and ammonia emissions and avoiding upstream environmental impacts associated with feed production.

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The following measures can contribute to pursuing these objectives:

— grass height monitoring across all grazed fields;

— identifying optimum grazing times and implementing an extended grazing period (duration of the grazing day and number of grazing days per year) based on local circumstances and grass height monitoring;

— synchronising stocking rate to grass growth;

— implementing rotational and strip (or paddock) grazing: livestock is moved frequently through either a number of fields (rotational grazing), or a series of strips or paddocks (strip or paddock grazing), based on measured grass heights or grass covers to ensure that grazing occurs in synchrony with maximum grass availability and digestibility. These grazing strategies, and especially strip and paddock grazing, increase both grass uptake and digestibility.

Applicability

This BEMP is specifically relevant for farms with intensively managed grazing livestock, in particular beef, dairy and sheep farms. Strip grazing is suitable for beef and dairy cattle.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i46) Grazing days per year (No/year) (i47) Percentage of grass dry matter uptake by animals (%) ([1]) (i48) Average stocking rate, calculated as Livestock Units per hectare of Utilised Agricultural Area (LU/UAA)	(b25) 80 % grass dry matter uptake by grazing animals during the grazing period.

([1]) The uptake of the dry grass matter can be estimated by the farmer by taking regularly grass-height readings throughout the growing season. The grass height readings, before and after grazing, can give the amount of eaten grass by the animals during the grazing period.

3.5.2. *Managing high nature value grassland*

In areas of high natural value, BEMP is to keep low stocking rates to match grazing intensity to biodiversity needs and time mowing (for haylage) in consideration of biodiversity. Special software can be used to select appropriate grassland conservation measures including different mowing and/or grazing regimes. At the landscape level, the creation of a mosaic of different mowing regimes increases species diversity, since different mowing times suit different organisms, and, more generally, applying a low annual cutting frequency promotes wild plants and invertebrates.

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Applicability

This BEMP is relevant to extensively managed high natural value grassland such as alpine land, upland, moorland, coastal land, sites of specific scientific interest, Natura 2000 sites and special areas of conservation.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i10) Locally important species abundance ([1]) (No of key species/m^2)	N/A
(i48) Average stocking rate, calculated as Livestock Units per hectare of Utilised Agricultural Area (LU/UAA)	

([1]) 'Locally important species' encompass locally endemic species and rare or threatened species. The farmer can refer to applicable national / regional biodiversity and habitat regulation, as well as to local NGOs, to determine key locally important species.

3.5.3. *Pasture renovation and legume inclusion in permanent pasture and leys*

When required because of a drop in dry matter productivity or because of the need to improve pasture quality, BEMP is to apply over-seeding or, when needed, reseeding in order to maintain or recover high yields and to ensure good pasture quality (e.g. digestibility, measured by the D-value of pasture).

Over-seeding refers to a minimum-tillage approach whereby new seeds are planted directly on the original grassland, without damaging the existing grass or soil, improving pasture quality and productivity without sacrificing existing forage growth. It is facilitated by livestock trampling-in the seeds to improve soil-to-seed contact. Reseeding refers to ploughing out and seeding a whole new sward, which may be necessary to ensure good establishment in some conditions.

A key aspect of pasture renovation is the selection of the most suitable varieties. Legumes play a key fertilising role by fixing nitrogen. For maximum productivity, ryegrasses with higher yields and good nitrogen use efficiency are considered the ideal companion to legumes, converting nitrates produced by clover into digestible biomass yield. Particularly palatable and digestible varieties, such as high-sugar grasses, can significantly increase the dry matter intake by livestock and support higher feed conversion ratio. Growing a mix of four species (a fast-establishing non-nitrogen fixing grass such as ryegrass, a fast-establishing nitrogen-fixing legume such as red clover, a temporally persistent non-fixing flowering grass such as cocksfoot and a temporally persistent nitrogen-fixing legume such as white clover) results in greater yields compared to monocultures regardless of soil type, soil fertility and climate.

Applicability

The BEMP is primarily aimed at intensive systems. Pasture renovation is rarely undertaken in extensively grazed and mown areas, which are not managed to maximise productivity.

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i49) Percentage of field cover as legume (%) (i50) D-value of pasture	(b26) Pasture renovation (e.g. over-seeding) is employed to maximise forage production, maintain high legume coverage and introduce other flowering species.

3.5.4. *Efficient silage production*

BEMP is to maximise output from silage by applying good growing conditions, harvesting at the right time, and using the best preservation and storage techniques. This is achieved by the following measures:

— Maintaining swards in optimum condition as outlined in BEMP 3.5.3.

— Maximising silage quality by timing harvest to optimise nutritional quality and yield, i.e. harvest grass at the correct maturity and dry matter content. The first cut should happen at high D-values ([19]) (around late May when the grass is rich in energy and produces leaves instead of seeds). Well-fermented grass silage can significantly reduce the need for concentrate feed.

— Undertaking laboratory analysis of silage to estimate Dry Matter (DM), crude protein and pH value.

— Storing silage correctly to avoid dry matter losses: packing silage to a proper density eliminates air and thus undesirable aerobic organisms. Big bales need to be carefully wrapped with multiple layers, whilst clamps need to be adequately compacted and sealed, with minimum face-areas exposed during feeding.

— Wrapping silage: selecting a high-quality balewrap with good mechanical properties, a high level of tack (stickiness) and UV protection; four to six balewrap layers are necessary for a good oxygen barrier and to minimise dry matter losses and leachates.

Applicability

This BEMP is specifically relevant for intensive farms producing mainly grass silage but some aspects are also applicable to livestock farms producing other types of silage.

([19]) Harvesting for maximum D-values may mean sacrificing some yield, and needs to be evaluated by considering total feed requirements throughout the desired feeding period. It may be preferable to produce a higher yield of a lower quality silage, balancing it with concentrates.

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i51) Feed conversion ratio [1] (kg of animal feed DM uptake/kg of output meat or l of milk) (i52) Percentage of dry matter loss post ensiling (%)	N/A

[1] Feed Conversion Ratio is the ability of livestock to turn feed mass into body mass or other output (e.g. milk for dairy livestock).

3.6. **Animal husbandry**

This section is relevant to livestock farms and focuses on ruminants. Best practices for non-ruminants are covered in the Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs (IRPP BREF) ([20]). This section addresses both extensive and intensive livestock systems.

3.6.1. *Locally adapted breeds*

BEMP is to select the appropriate ([21]) animal breeds or strains according to the farm type and adapted to the local conditions. Different objectives can be pursued:

— Selecting locally adapted breeds that have a greater ability to convert locally available low-quality forage into meat or milk or to be tolerant to specific climates.

— Rearing local breeds and especially rare local breeds, where appropriate. Local and traditional breeds represent an important biodiversity heritage as well as a unique genetic resource for improving health and performance traits in the future. Genetic diversity also ensures better resistance to diseases or health problems and that the animals cope better with potential extreme conditions.

— Selecting and developing more resource-efficient breeds. This can be achieved using genetic indices that attempt to disentangle the effects of genes, the environment and management factors in order to select animals that have high genetic merit, and perform well under regional conditions and 'typical' management practices. Productive breeds generally result in higher yields with lower GHG intensities.

Applicability

Selecting locally adapted breeds is broadly applicable to livestock farms, and particularly relevant for grazing of marginal land or farms in harsh climates.

([20]) The IRPP BREF contains Best Available Techniques for Intensive Rearing of Poultry and Pigs in large industrial installations. However, some of the techniques described may prove relevant also for livestock production at smaller scale. The document is available online at: http://eippcb.jrc.ec.europa.eu/reference/irpp.html.

([21]) Traits are considered for inclusion in a breeding objective because either economically (e.g. productivity), socially (e.g. animal welfare) or environmentally (e.g. biodiversity) important.

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Local, rare and traditional breeds are more relevant for extensively managed livestock farms where biodiversity protection and conservation of the grassland environment may be the priorities. This is because, under good production conditions, local, rare and traditional breeds tend to be less productive than those breeds that are selected owing to high productivity and resource efficiency.

Selecting and developing more resource-efficient breeds is, by contrast, more relevant for intensive livestock systems aiming at maximum yield.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i53) Percentage of animals that are of rare genetic origin (%) (i54) Percentage of animals that are of locally adapted breeds (%) (i51) Feed conversion ratio (kg of animal feed DM uptake/kg of output meat or l of milk)	(b27) The livestock population of the farm consists of at least 50 % locally adapted breeds and at least 5 % rare breeds.

3.6.2. *Nutrient budgeting on livestock farms*

BEMP is to monitor the nutrient flows at farm level and optimise the nutrient surpluses by accounting for all nutrient inputs (nitrogen (N), phosphorus (P) and potassium (K)) to the farm and nutrient outputs exported in livestock products, and calculating the nutrient surplus and nutrient use efficiency (NUE) at farm level ([22]). Farm level NUE enables farm systems to be compared in terms of the overall efficiency of production.

Applicability

All livestock farms can implement, and benefit from, farm level nutrient budgeting, and this is most relevant for mixed farming systems and intensive livestock farms. The costs for implementing farm-level nutrient budgeting on livestock farms are relatively low.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i55) Farm level nutrient surplus (kg N, P /ha/year) (i56) Farm level NUE calculated for N and P (%)	(b28) The farm-level nitrogen surplus is, at the most, 10 % of farm nitrogen requirements. (b29) The farm-level phosphorus surplus is, at the most, 10 % of farm phosphorus requirements.

([22]) Definitions of nutrient surplus and NUE are outlined in BEMP 3.3.1. However, BEMP 3.3.1 is about nutrient budgeting at field level while this BEMP deals with nutrient budgeting for livestock farms at the level of the overall farm, i.e. taking into account inputs and outputs via the farm gate.

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3.6.3. *Dietary reduction of nitrogen excretion*

BEMP is to reduce nitrogen excretion by implementing nutritional measures:

— Using high-sugar grasses and/or maize silage for ruminants: high-sugar grasses are high in water-soluble carbohydrates that increase the carbon to nitrogen (C/N) ratio ([23]) of substrate for rumen microflora, leading to improved immobilisation and utilisation of nitrogen, thereby resulting in enhanced nitrogen use efficiency, improved microbial protein synthesis and reduced nitrogen excretion;

— Applying phase feeding, in which the nutrient composition of the diet is modified over time in order to fulfil the nutrient requirements of the animal. For instance, the levels of urea-nitrogen in milk can be used as an indicator to regulate the nutrient composition of dairy cows diets.

— Using low-protein feeds, such as low-dry-matter alfalfa silage, which improve nitrogen use efficiency and reduces ammonia emissions ([24]).

Applicability

This BEMP is broadly applicable to both ruminants and monogastric livestock and is mostly relevant to intensive farming systems. Some measures, such as the adoption of low-protein feed, are only applicable to housed animals, and may entail the risk of reduced productivity.

The costs associated with implementing this BEMP are usually limited. For instance, if maize silage grown on the farm is preferred over starchy concentrates, this BEMP results in reduced costs because of the reduced need for importing feeds to the farm.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i57) Dairy urea nitrogen in milk (mg/100 g)	N/A
(i51) Feed conversion ratio (kg of animal feed DM uptake/kg of output meat or l of milk)	

3.6.4. *Dietary reduction of enteric methane in ruminants*

BEMP is to apply a diet that reduces methane emissions from enteric fermentation of ruminants by increasing forage digestibility and digestible forage intake; for instance, this can be implemented by substituting grass with legume silage, which is lower in fibre and stimulates higher dry matter intake and an increased rate of rumen passage ([25]).

([23]) The efficiency of dietary nitrogen use in ruminants is mostly determined by the ratio of energy to protein in the rumen. Intensively managed pasture is high in nitrogen and also has high rumen degradability, particularly when abundant amounts of nitrogen from fertilisers are applied. If high nitrogen grass is not balanced with energy, it results in poor nitrogen utilisation by the ruminants.

([24]) For pigs and poultry, the low protein diets should be balanced with digestible amino-acids at the correct ratio as well.

([25]) High fibre, high rumen pH and a slow rate for rumen passage all favour methanogenesis.

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Applicability

This BEMP is only relevant to ruminants. The introduction of legume silage production in warm climates may be effective although low persistence and a need for long establishment periods are important agronomic constraints.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i58) Enteric methane emissions per kg meat or l milk (i51) Feed conversion ratio (kg of animal feed DM uptake/kg of output meat or l of milk)	N/A

3.6.5. *Green procurement of feed*

BEMP is to:

— select feeds with low upstream impacts, including indirect land use change; for instance, soya- and palm-oil-based feeds are minimised;

— when purchasing feeds with large potential upstream impacts, select feeds that are sustainably sourced and certified by a recognised body (e.g. Round Table on Responsible Soy — RTRS) as being from areas not recently converted from natural habitats.

Applicability

Green procurement of feed is broadly applicable to all livestock farms. However, the availability of certified feeds may sometimes be limited. Additionally there is often a small price premium associated with certified feeds.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i59) Percentage of procured feed that is sustainability certified (%) (i60) Feed related kg CO_2e per kg feed or per kg meat or l of milk	(b30) Imports of soy- and palm-based feeds are minimised, and where used, 100 % of such feeds are certified not to originate from areas of recent land use change.

3.6.6. *Maintain animal health*

BEMP is to implement practices in order to maintain animal health, reduce the need for veterinary treatments and minimise stock morbidity and mortality:

— producing a preventive healthcare programme, including routine preventive inspections (at least one preventative visit per year) by a veterinarian responsible for the animals and considering epidemiological data of the region; the inspections (and treatments, when required) can be jointly organised by neighbouring farms;

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— responsible use of medicines, such as reducing frequency of use to the minimum required and rotation of veterinary products to avoid resistance of pathogens;

— ensuring good nutrition of all animals;

— avoiding the mixing of unrelated and unfamiliar animals of different ages on the same pasture: young animals are more susceptible to internal parasites and should be put onto clean ([26]) pasture;

— mixing or rotating grazing with other species e.g. cattle and lamb to better control internal parasites; following sheep with cattle and horses is considered best;

— establishing quarantine periods for animals brought on to the farm;

— excluding livestock from wet areas to break the liver fluke breeding cycle;

— ensuring easy access to water and checking the quality of waters (e.g. pH, total dissolved solids, key minerals, bacteria);

— maintaining the animal welfare based on the five freedoms principle ([27]) and following the national and European guidelines on good animal husbandry.

Applicability

Maintaining animal health is an important measure for all livestock farms. It also makes sense for economic reasons, as healthy animals are more productive.

In order to reduce costs and improve effectiveness, neighbouring farms can jointly devise a preventive healthcare programme and arrange for a joint provision of veterinary services.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i61) Weight gain of the animals in the farm (kg/head/time unit) (i62) Occurrences of veterinary treatment per head over a year (No/year) (i63) Preventative healthcare programme in place (Y/N)	(b31) The farm systematically monitors animal health and welfare and implements a preventative healthcare programme that includes at least one preventative visit per year by a veterinary surgeon.

([26]) Clean pasture refers to pasture with no previous grazing by the same species for a year or to a field that has been cultivated after being grazed by older animals.

([27]) The five freedoms principle for animal welfare consists of: freedom from hunger and thirst, freedom from discomfort; freedom from pain, injury or disease, freedom to express normal behaviour and freedom from fear and distress (see: http://www.oie.int/en/animal-welfare/animal-welfare-at-a-glance/). These can be assessed by observing the animal behaviour and, in particular, thanks to: (i) the assessment of environmental stressors, (ii) the assessment of the body condition, (iii) relevant physiological indicators/signs, (iv) the amount of water and feed consumed and (v) records of animal treatments.

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3.6.7. *Herd/flock profile management*

BEMP is to optimise herd/flock profile management in order to mitigate methane emissions from enteric fermentation and optimise resource efficiency by increasing productivity. This can be achieved by:

— optimising the cull age from growth curves based on daily weight gain versus enteric fermentation;

— increasing longevity of animals by improving animal health (see BEMP 3.6.6)

— optimising fertility rate: high fertility rates contribute to lower GHG emissions by reducing the number of replacement animals kept on farm and increasing the number of dairy-reared calves supporting beef production.

Applicability

Herd profile management is applicable to all livestock farming systems regardless the size. However, specialised staff, or time for the existing staff to acquire the relevant competences and knowledge, may be required and, in some cases, constitutes a barrier to its implementation by small farms.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i64) Age at slaughter time (months)	N/A
(i58) Enteric methane emissions per kg meat or l of milk	
(i61) Weight gain of the livestock in the farm (kg/livestock unit/time unit)	

3.7. **Manure management**

This section is relevant to livestock farms and particularly to intensive cattle farming systems. Best practices for manure management in intensive pig and poultry production are covered in the Best Available Techniques Reference Document for the Intensive Rearing of Pigs or Poultry (IRPP BREF) ([28]).

3.7.1. *Efficient housing*

This BEMP focuses on the reduction of ammonia emissions from cattle housing in the context of manure management while also reducing methane emissions from housing.

The main design criteria of an efficient housing system are to:

— minimise surface area fouled by manure, e.g. by installing a grooved floor and automated floor scrapers;

([28]) The IRPP BREF contains Best Available Techniques for Intensive Rearing of Poultry and Pigs in large industrial installations. However, some of the techniques described may also prove relevant also for livestock production at smaller scale. The document is available online at: http://eippcb.jrc.ec.europa.eu/reference/irpp.html.

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— maintain the temperature and air velocity above manures and/or surfaces fouled with excreta as low as possible by installing roof insulation and automatically controlled natural ventilation; avoiding openings exposed to the prevailing wind direction;

— keep all areas inside and outside the animal housing clean and dry;

— rapidly remove excreta and separate faeces and urine as quickly as possible;

— in large confinement systems, remove ammonia emissions from exhaust air using acid scrubbers or biotrickling filters.

Applicability

The BEMP is broadly applicable to cattle farms. It can be implemented very cost-effectively when building new housing, or during renovation of existing housing systems. High capital cost measures such as chemical scrubbing may be applicable in large confined dairy systems, but not in typical dairy and beef systems.

An efficient cattle housing system should balance any possible trade-offs between reduction of environmental impacts and animal welfare.

In some cases, the best performance in reducing ammonia and methane emissions can be achieved by firstly minimising the amount of time animals spend indoors, before improving housing design.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i65) Installation of grooved floors and automated floor scrapers (Y/N) (i66) Ammonia emissions generated in animal housing system per livestock unit per year (kg NH_3/livestock unit/year)	(b32) Installation of a grooved floor, roof insulation and automatically controlled natural ventilation systems to animal housing.

3.7.2. *Anaerobic digestion*

BEMP is to treat slurries and manures in an on-farm anaerobic digestion system or at an adjacent anaerobic digestion plant to produce biogas that can be captured and used to generate heat and electricity or upgraded to biomethane, displacing fossil fuels. Anaerobic digestion also converts organic nitrogen into forms that are more readily available for plant uptake, thus enhancing the fertiliser replacement value of slurries and manures.

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Supplementing slurries and manures, with other organic residues ([29]) generated on the farm can compensate for reduced feedstock availability during the grazing season, ensuring operational stability and maintaining constant production of biogas.

The best environmental performance from anaerobic digestion systems is achieved by avoiding storage losses of methane and ammonia through gas-tight digestate storage.

The following options can be considered by livestock farms:

— on-farm anaerobic digestion of slurries and manures generated within the livestock farm;

— on-farm anaerobic digestion of slurries and manures imported from multiple livestock farms;

— on-farm anaerobic digestion of organic waste from the farm as well as other sources;

— sending the farm's organic waste (including slurries and manure) for treatment in an adjacent centralised anaerobic digestion plants, provided that the digestate can later be used efficiently as a fertiliser on agricultural land.

Applicability

This BEMP is broadly applicable to livestock farms and specifically relevant for mixed farms with large areas of (carbon-depleted) soils, used for arable or horticultural crops, which would benefit from digestate application. Slurries are better suited to anaerobic digestion than solid manures, which may be composted, although it is possible to feed manures into anaerobic digestion plants as a minority feedstock. The implementation scale and the capacity of the plant are the key elements that influence the economic viability of on-farm anaerobic digestion. Therefore cooperation with neighbouring farms or local waste management organisations may be an essential condition for the implementation of this BEMP.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i67) Percentage of slurries/manure generated on farm treated in an anaerobic digestion system from which digestate is returned to agricultural land (%) (i68) Amount of digestate that returns on the agricultural land of the farm as a fertiliser (kg/year)	(b33) 100 % of the slurry generated on the farm is treated in an anaerobic digestion system with gas-tight digestate storage, from which digestate is returned to agricultural land

([29]) Organic residues appropriate to supplement slurries and manures in the feedstock mixture for on-farm anaerobic digestion are: food, feed and crop residues. The growing of crops for anaerobic digestion is by contrast, in many cases, associated with poor life cycle environmental performance and, as such, is not best practice.

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3.7.3. *Slurry/digestate separation*

BEMP is to separate the on-farm generated slurries or the digestate from on-farm anaerobic digestion into solid and liquid fractions prior to storage and application to agricultural land. This separation allows more precise management of nutrients contained in the slurry/digestate because more of the nitrogen is in the liquid fraction and more of the phosphorus is in the solid fraction. Indeed, slurries and digestate deliver relatively high loads of plant-available phosphorus compared with nitrogen loads. Separation can help to avoid over-loading soils with phosphorus, and to distribute organic matter and phosphorus in the solid fraction to fields further away from the animal housing.

Several separation techniques exist. Decanter centrifugation is one of the most efficient at retaining phosphorus and producing a drier solid fraction.

The separation efficiency can be improved by using additives such as brown coal, bentonite, zeolite, crystals and efficient microorganisms and/or applying pre-treatments like flocculation, coagulation and precipitation.

Applicability

This BEMP is broadly applicable to livestock farms. Farms with limited availability for slurry storage may find it particularly beneficial because of the reduction in slurry volume, while the possibility to apply nitrogen independently from phosphorus is very valuable for farms in nitrate-vulnerable zones.

However, this BEMP is not applicable to farms where most manure is managed in solid manure systems, such as deep-bedding ones (many beef cattle and sheep farms) and it may not be economically viable for small farms.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i69) Percentage of on-farm slurry generated on dairy, pig and poultry farms that is separated prior to storage (%) (i70) Percentage of digestate from an on-farm anaerobic digestion system that is separated prior to storage (%) (i71) Targeted application of liquid and solid fraction in accordance with crop nutrient and soil organic matter requirements (Y/N)	(b34) Slurry or digestate arising on dairy, pig and poultry farms is separated as needed into liquid and solid fractions that are applied to soils in accordance with crop nutrient requirements and soil organic matter requirements.

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3.7.4. *Appropriate slurry processing and storage systems for slurry or digestate*

When there is no opportunity for anaerobic digestion of slurries ([30]), BEMP is to employ techniques that reduce the ammonia (NH_3) emissions and in parallel maintain a high nutrient value of manure, in view of their application on agricultural land. This is achieved by the following measures:

— Applying slurry acidification: the pH value of the slurry is lowered via the use of an acidic reagent, e.g. sulphuric acid (H_2SO_4). The lower pH value contributes to both the reduction of the pathogens and lower ammonia emission levels.

— Cooling slurry: cooling lowers the ammonia evaporation in the animal housing, and thus the ammonia emissions, contributing also to improved animal welfare.

— Appropriate slurry storage systems: decreasing the surface area where emissions can take place by placing artificial or natural covers on slurry stores and/or increasing the depth of the storage tanks. New-build slurry storage tanks are built as tall tanks (> 3 m in height) with a tight lid or tent cover; existing storage tanks are fitted with a tight lid or tent cover where possible, or a floating cover (such as a plastic-sheeting-type cover or a LECA (lightweight expanded clay aggregate) cover) otherwise; existing lagoon slurry stores are fitted with a floating cover (such as a plastic-sheeting-type cover or a LECA cover).

— Installing adequate slurry storage capacity to enable optimised timing of slurry application with respect to soil conditions and nutrient management planning. For instance, all farms should ensure that the slurry storage capacity is sufficient to comply with national nitrate-vulnerable zone requirements, whether in a nitrate-vulnerable zone or not.

Best practice for slurry storage systems is also best practice for anaerobic digestate storage tanks.

Applicability

This BEMP is broadly applicable to large pig, poultry and dairy farms where animals are housed for a large proportion of the year.

In some Member States, there are concerns about the potential hazards of the acids used for slurry acidification. Additionally, the use of sulphuric acid may impact the durability of some types of concrete used to build the storage tanks because of a sulphate reaction, but these impacts can be mitigated by appropriate concrete selection.

([30]) As described in BEMP 3.7.2

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i72) Capacity of liquid storage tanks for slurries (m^3) (i73) Implementation of slurry acidification or slurry cooling (Y/N) (i74) Liquid slurry storage tanks and anaerobic digestate store tanks are covered (Y/N)	(b35) New-build slurry stores, and anaerobic digestate stores, are built as tall tanks (> 3 m in height) with a tight lid or tent cover. (b36) Existing storage tanks are fitted with a tight lid or tent cover where possible, or a floating cover otherwise; existing lagoon slurry stores are fitted with a floating cover. (b37) Total liquid slurry storage capacity is at least equal to that required by relevant national nitrate-vulnerable zone regulations, whether or not the farm is in a nitrate-vulnerable zone, and is sufficient to ensure that the timing of slurry application can always be optimised with respect to farm nutrient management planning.

3.7.5. *Appropriate solid manure storage*

BEMP is to compost or batch store all the solid fractions arising from manure management systems. Batch storage is the storage of solid manure for at least 90 days before spreading on fields, during which time no fresh manure is added to the heap. The stored manure heap needs to be covered and located away from watercourses; any potential run-off needs to be collected and diverted into either an on-site liquid slurry system or back onto the manure heap.

Applicability

The BEMP is broadly applicable to livestock farms, and specifically for farms located in areas where there is a high risk of pathogen transfer to water systems. However, it is not relevant for farms in areas where fresh manure can be directly incorporated into soils (e.g. nearby tilled soils) during spring, as this option can lead to a better overall environmental performance.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i75) Percentage of solid manure fractions stored (%) (i76) Location and management of solid manure stores avoids contamination of surface watercourses (Y/N)	(b38) Solid manure fractions are composted or stored for at least three months in batches with no fresh manure additions. (b39) Solid manure stores are covered and located away from surface watercourses, with leachate collected and recycled through the farm manure management system.

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3.7.6. *Injection slurry application and manure incorporation*

Ammonia emissions from soils occur immediately following slurry or manure application, and can be largely avoided by the injection of slurry below the soil surface or incorporation of manures below the soil surface by inversion ploughing or alternative techniques.

Therefore BEMP is to:

— employ shallow injection of slurries close to crop roots, reducing losses of nitrogen from ammonia volatilisation and optimising the placement of nutrients for crop uptake;

— incorporate solid manure into arable soils as soon as possible after spreading; immediate incorporation by inversion ploughing results in the highest ammonia emissions abatement; however, non-inversion incorporation as well as delayed incorporation (e.g. after 4 to 24 hours) also offer significant abatement.

Applicability

Shallow injection of slurries works best for slurries with a low dry matter content, ideally lower than 6 %, and is best suited to the separated liquid fractions of slurries or digestates. Injection application enables precise dosing and placement of slurries but is not possible on steeply sloping, stony, clay, peaty or shallow soils, in which case other techniques such as trailing shoe or banded application may be preferable (see BEMP 3.7.7).

— Incorporation of manures is only applicable on arable soils. Additionally, it should be avoided in periods that are too dry and windy, or when soils are very wet. Optimum conditions to minimise ammonia emissions volatilisation are cool and humid conditions before or during light rain.

— The application of slurries or manures should always respect the principles of nutrient budgeting (BEMP 3.3.1) and precise nutrient application (BEMP 3.3.3).

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i77) Incorporation of manure into arable soils within two hours of spreading (Y/N) (i78) Use of shallow injection for slurries application (Y/N)	(b40) In accordance with nutrient requirements of the crops, 100 % of the slurries applied to land are applied via shallow injection, trailing shoe or banded application, and 100 % of the high ammonium manures applied to bare arable land are incorporated into the soil as soon as possible and in any case within two hours.

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3.7.7. *Slurry application to grassland*

BEMP is to apply slurries to grassland via shallow injection (see BEMP 3.7.6). When this is not possible, BEMP is to apply:

— banded spreading: it reduces the surface area of slurry exposed to the air by placing slurry in narrow bands directly on the ground under the crop canopy;

— trailing shoe: a metal shoe parts the herbage and slurry is deposited in bands on the soil surface, with minimum herbage contamination; it reduces nitrogen losses from ammonia volatilisation and results in less contamination of grass for grazing and/or silage-making.

Applicability

Banded spreading and trailing shoe applications are broadly applicable to livestock farms. If a farm does not own the necessary equipment, it can appoint a contractor to provide this service.

One potentially limiting factor for the trailing shoe application is the slurry 'thickness' (i.e. high solids content), especially when using umbilical systems.

The application of slurries to grassland should always to be implemented respecting the nutrient budgeting principles outlined in BEMP 3.3.1.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i78) Use of shallow injection for slurries application (Y/N) (i79) Use of banded spreading or trailing shoe for slurries application (Y/N) (i80) Percentage of slurry applied to grassland via shallow injection, or trailing shoe or banded application (%)	(b41) In accordance with the nutrient requirement of the crops, 100 % of the slurries applied to grassland are applied via shallow injection, trailing shoe or banded application.

3.8. **Irrigation**

This section is relevant for all farms using irrigation, and especially for farms located in areas of water scarcity. It relates to efficient irrigation techniques that minimise water use and/or maximise water use efficiency (WUE ([31])).

([31]) WUE is defined as crop yield (e.g. kg) per volume unit (e.g. m^3) of irrigation water applied. Practices that improve the yield per 'water drop' improve the WUE. Thus, WUE is enhanced by increasing crop production and/or reducing seasonal water application. In order to ensure high crop yields, the capture and storage of rainfall in the soil and the ability of the crop to utilise soil moisture must be maximised, whilst the severity of water deficits during key stages of crop development should be minimised.

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3.8.1. *Agronomic methods for optimising irrigation demand*

BEMP is to optimise irrigation demand by the following measures:

— Soil management: soil physicochemical properties highly influence water requirements and irrigation scheduling. Key soil parameters include depth, moisture holding capacity and infiltration rate. Soil moisture holding capacity depends on texture and organic matter content, which can be increased by appropriate crop rotations and through the addition of organic matter amendments, manures, etc. The effective soil depth is increased by penetrating the compacted soil layers with planting pits, thus offering the roots of the plants accessibility to a larger volume of soil water. The evaporation rate of water from soil can be reduced by applying reduced tillage (e.g. inter-row tillage) or by organic or plastic mulching.

— Selection of crop species and varieties according to water use efficiency (WUE): selection of genotypes resistant to water stress or salinity, and better suitable to water deficit irrigation.

— Determination of crop water requirements: precise calculation of crop water requirements based on crop evapotranspiration (ET), in relation to plant growth stage and weather conditions.

— Assessment of water quality: the physical and chemical parameters of the water should be monitored in order to ensure high-quality water available for the plants. In terms of the physical parameters, water should be delivered at ambient temperature and sufficiently clean (e.g. particles and/or suspended solids can cause blockages in the irrigation equipment). In terms of the chemical parameters, a high soluble salt concentration is responsible for clogging the irrigation distribution equipment and may require extra amounts of water to avoid salt accumulation in the root zone. Additionally, a high concentration of some elements, e.g. sulphur (S) and chlorine (Cl), can cause toxicity problems to the plants and should thus be carefully monitored.

— Precise irrigation scheduling to match crop ET with water supply. This can be implemented using the water balance method ([32]) and/or soil moisture sensors ([33]).

Applicability

This BEMP is broadly applicable to all farms using irrigation and especially for farms located in arid areas. Some measures may require investment and operational costs which may be a barrier for small farms. However, these costs may be outbalanced by the savings resulting from the reduced use of water, and, in some cases, by increased profits due to higher yields.

([32]) The water balance method consists of three basic steps: (i) estimating the available water (AW) in the root zone from soil texture and rooting depth, (ii) selecting the allowable water deficit (AWD) depending on crop species, growth stage, soil water capacity and the irrigation system's pumping capacity and (iii) estimating the crop evapotranspiration (ET). With this method, irrigation is applied whenever the ET exceeds the AWD.

([33]) Soil moisture sensors are used to set the frequency and the amount of irrigation. The amount is calculated through the changes of the soil moisture content between two irrigation events, assuming that evapotranspiration (ET) between the two equals the soil moisture change between the two occasions. Alternatively, it is calculated by measuring the soil tension before application of irrigation and using the allowable water deficit (AWD) to estimate the amount of water to be supplied.

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i81) WUE, expressed as kg/m^3 (i82) Percentage change in irrigation demand (%)	N/A

3.8.2. *Optimisation of irrigation delivery*

BEMP is to select the most efficient irrigation system that optimises the irrigation delivery in the cultivated area:

— Drip irrigation for intensive cropping systems (row crops).

— Low-pressure sprinkler for row crops and fruit trees, with water sprayed under the crop canopy. When designing such a system, the operating pressure, the nozzle type and diameter, the spacing layout and the wind speed need to be carefully examined to achieve high uniformity of irrigation.

Applicability

This BEMP is broadly applicable to both arid and humid areas, to most soil types and mainly for crops planted in rows, e.g. alfalfa, cotton, corn.

Drip irrigation on clay soils must be applied slowly in order to avoid surface water ponding and run-off. On sandy soils, higher emitter discharge rates are needed to ensure adequate lateral wetting of the soil. For crops planted on slopes, the target is to minimise changes in emitter discharge rates as a result of land elevation changes.

In low-pressure sprinkler systems, the operating pressure should be adjusted to achieve the appropriate irrigation rate based on the soil's physical characteristics. For crops planted on slopes, low-pressure sprinklers can be used provided that the lateral pipes supplying water to the sprinklers are laid out along the land contour whenever possible, so that pressure is minimised and sprinklers provide a uniform irrigation.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i83) Drip irrigation installed (Y/N) (i84) Low pressure sprinklers installed (Y/N) (i85) Irrigation efficiency [1] at crop level (%)	N/A

[1] Irrigation efficiency represents the applied water that is actually available to the plants. This indicator is calculated by multiplying the conveyance efficiency, which is the efficiency of the transfer of water to the field, e.g. through canals, by the field application efficiency.

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3.8.3. *Management of irrigation systems*

BEMP is to efficiently operate and control irrigation systems, to avoid water losses and high run-off rates, and to avoid over- and/or under-irrigation incidents. Water meters are important to determine the exact amount of water used for irrigation and to detect water losses. Diversion ditches can collect run-off from sloping surfaces to minimise damage to crops.

Applicability

This BEMP is broadly applicable to all farms using irrigation and especially for farms located in arid areas.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i86) Irrigation efficiency at farm level (%)	N/A

3.8.4. *Efficient and controlled irrigation strategies*

Optimal irrigation can be achieved with appropriate strategies aimed at avoiding over-irrigation or water deficit.

In regions where water resources are very limited, BEMP is the application of water deficit irrigation: in this strategy, the crop is exposed, during some growth stages or during the whole growing season, to a specific level of water stress that results in limited or no yield reduction.

An example of deficit irrigation is Partial Root Drying (PRD): it consists of alternately watering one side or the other of crops planted in a row, so that only parts of the roots are exposed to water stress.

Applicability

Deficit irrigation is specifically applicable in very arid areas where it makes sense for a farmer to maximise the net income per unit of water used rather than per unit of land. However, it cannot be used over extended time periods.

Before its application, it is essential to assess the impact of specific deficit irrigation strategies by running multi-year open-field experiments for each given crop in relevant agro-climatic zones.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i81) WUE, expressed as kg/m^3	N/A

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3.9. **Crop protection**

This section is relevant for all farms. This section presents best practices on how farmers can implement a full set of actions to apply sustainable crop protection strategies to prevent pests occurrence, optimise and reduce the use of crop protection products, and, when these are needed, choose those products which have the lowest environmental impact and are the most compatible with the rest of the strategy. It is best practice for farmers to implement these actions going beyond the legal requirements and namely the provisions of Directive 2009/128/EC of the European Parliament and of the Council ([34]) and Regulation (EC) No 1107/2009 of the European Parliament and of the Council ([35]) which provide for the application of general principles of integrated pest management in Europe.

3.9.1. *Sustainable crop protection*

BEMP is to control pest populations by adopting a dynamic crop protection management plan, which incorporates a preventive approach and key aspects of integrated pest management. The main elements of an effective dynamic crop protection management plan are as follows:

— Crop rotation that prevents the development of populations of pests in arable crops, vegetables and mixed farming systems thanks to the creation of a discontinuity over time and space that blocks specific pest species from reproducing further. Crop rotation also avoids problems with accumulation of soil-borne pathogens and contributes to maintain fertility (as explained in BEMP 3.3.2).

— Use of resistant/tolerant crop cultivars

— Application of agronomical and hygiene practices to reduce occurrence/ pressure of pests e.g. choice of sowing period, regular cleansing of machinery, tools, etc.

— Monitoring and early diagnosis system to define if and when necessity to intervene

— Biological pest control, where pests are controlled by using biological plant protection products, beneficial organisms or natural enemies. These can be ones already occurring in the farm and/or introduced ([36]). Maintaining the population of beneficial organisms or natural enemies requires avoiding adverse agricultural practices (e.g. reducing the mowing frequency) and preserving or developing a natural habitat within the farm, such as natural strips (e.g. with a width of 5 m) with spontaneous or sown flora.

([34]) Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides (OJ L 309, 24.11.2009, p. 71).

([35]) Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC (OJ L 309, 24.11.2009, p. 1).

([36]) Biological pest control can be implemented by: importation, augmentation and conservation. Importation is based on determining the relevant pests to be controlled, identifying the associated natural enemies and importing them to the field. Augmentation consists of the supplemental release of natural enemies already present on site, boosting the naturally occurring population. Conservation of existing natural enemies consists of ensuring that the conditions allow naturally occurring populations of natural enemies to persist. The latter is the simplest method to implement, given that natural enemies are already adapted to the habitat and to the target pests.

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— Prioritising whenever feasible non chemical techniques such as soil solarisation or catch crops for soil disinfection. For the use crop protection products (only when proved to be needed e.g. on the basis of the results of the monitoring) selection as much as possible of low risk plant protection products, having specific target action and presenting the least side effects. Applying them with precise application, which contributes to reducing the use of pesticides as well as increasing the application efficiency. In particular, efficient application can be achieved through compulsory calibration of machinery, but also through precision farming techniques such as use of sensors applications and GPS guidance in order to apply precisely the crop protection products only in the necessary amounts required and where the crops have pest problems within the farm. Finally keeping detailed records regarding the conditions of the plants and the treatments applied.

— Operators/farmers training on effective application of crop protection products, personal safety, and the maximum level of environmental protection throughout all aspects from buying and using the crop protection products to proper handling (storage) and disposal of the products and of their packaging. In particular, the training programme need to cover the use of safety equipment and clothing, the need to respect the local weather conditions, the environmental regulations in place, how to look for potential entry points of crop protection products into water, how to check the operational parameters for application, how to ensure the cleaning of the machinery, the correct disposal of crop protection products residues and the proper storage of products.

— Periodical review of the effectiveness of the crop protection strategy applied, based on the collected data, to improve the decision-making and the future development of the strategy.

Applicability

This BEMP includes a large spectrum of techniques, which can be implemented individually or together and which need to be tailored to the crop and specific conditions of each region, farm and field. The definition and implementation of a dynamic crop protection management plan is broadly applicable, provided that the measures that it contains are well adapted to the specific case. For instance, biological pest control and crop rotation would be particularly relevant to an organic farm or a conventional extensive farming system.

Biological pest control is easily implemented in protected horticulture and orchards, where controlled conditions facilitate the quick development of high populations of introduced beneficials and prevent their migration out of the growing area. Meanwhile, it is more difficult to implement in open fields and especially in production systems with short crop cycles. More generally, the prevention measures and biological control are more effective when pest population levels are not too high when and where natural enemies are released; otherwise they may prove insufficient to protect the crops. Particular care is needed regarding the release of natural enemies: as a general rule, the release takes place when the temperature is relatively low, e.g. early in the morning or late in the afternoon/evening, under favourable weather conditions and in the best season for the specific organism.

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i87) A dynamic crop protection plan for sustainable crop protection is in place that includes: (i) crop rotation aimed at pest prevention, (ii) biological pest control, (iii) precision application of plant protection products (if their use is needed), (iv) appropriate training on crop protection, (v) periodical review and improvement of the plan (Y/N)	N/A

3.9.2. *Crop protection products selection*

BEMP is to select crop protection products in compliance with the provisions of Directive 2009/128/EC as specific as possible for the target pest and with the lowest environmental impact ([37]) and lowest risk to human health. Farmers can achieve these objectives by consulting the labels of these products as well as by referring to publicly available databases that provide indications mainly on the toxicity of the pesticides to human health and/or to fauna and flora at a given use rate. The aim is to select products with the least toxicity, and which are as selective as possible towards the pest species to be tackled, while not interfering with the implemented biological control measures (e.g. natural enemies). The risk of pest resistance shall also be considered and a strategy put in place when needed. The specific characteristics of the crop and field to be treated (in particular proximity to water sources, soil characteristics, crop growing system, etc.) must also be taken into account in order to determine the suitability of a specific crop protection product.

Applicability

This BEMP is applicable for all farmers that need to use crop protection products.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i89) Selected crop protection products have the least toxicity and are compatible with the overall crop protection strategy (Y/N)	N/A

3.10. **Protected horticulture**

This section is relevant to farms that grow covered fruit and vegetables crops (e.g. in greenhouses).

3.10.1. *Energy efficiency measures in protected horticulture*

It is BEMP to reduce the energy demand of closed greenhouses and meet it with on-site renewable energy generation where feasible:

([37]) At the manufacturing and use stages.

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— apply a dynamic control of climatic parameters within the greenhouse which adapts the internal conditions taking into account the external weather conditions in order to reduce energy use;

— select appropriate covering materials, such as glass or plastic double glazing, to improve the 'building' (greenhouse) envelope;

— consider the orientation and the position of windows in new facilities or during major retrofits;

— install cooling measures in greenhouses located in dry and warm climates; in particular, apply natural ventilation, whitewashing measures that reduce solar radiation entering the greenhouse and/or install evaporative techniques such as cooling pads and fogging ([38]);

— when possible, install a geothermal heating system for greenhouses located in cool climates that need heating; geothermal wells can supply water at a temperature appreciably higher than ambient air temperature directly to the heat delivery equipment in the greenhouse or to a wide range of heating systems;

— install suitable lighting equipment considering local climatic conditions and the influence of the lighting equipment on the indoor temperature.

Applicability

This BEMP is broadly applicable to protected horticulture farms.

The application of geothermal energy is limited, for instance because of the specificities of the temperature profile of the aquifer and the required investment.

The evaporative techniques involve the use of fresh water and thus the water availability needs to be taken into account. Moreover, the amount of water to be used must avoid increasing the humidity levels inside the greenhouse above its optimum (usually 65–70 %) and thus affecting the transpiration of the plants. This is specifically relevant for fogging techniques and in areas with a high level of atmospheric humidity.

Fogging techniques may also require large investments, because of the water distribution system needed.

Cooling pad systems are efficient only when the width of the greenhouse is more than 50m, but have the advantage that they can also run on seawater.

([38]) In cooling pads, fans are placed in one wall and a wet pad in the opposite wall so that air from outdoor is sucked into the greenhouse through the wet pad decreasing its temperature. Fogging is based on the supply of water in very small drops that evaporates, thereby reducing the temperature in the greenhouse.

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i90) Energy use for lighting in the greenhouse (kWh/m^2/year) (i91) Total energy use in the greenhouse (kWh/yield) (i92) Share of the greenhouse energy use for heating, cooling, lighting and manufacture of carbon dioxide (if applicable) met by on-site renewable energy generation on an annual basis (%)	(b42) The combined energy use of the protected horticulture system for heating, cooling, lighting and manufacture of carbon dioxide (if applicable) is met by at least 80 % of on-site renewable energy generation, on an annual basis.

3.10.2. *Water management in protected horticulture*

BEMP is to maximise the irrigation efficiency of vegetable crops in closed greenhouses, which are located in arid areas by implementing the following actions:

— determine precisely the crop water requirements ([39]), according to the principles described in BEMP 3.8.1.

— put in place an irrigation scheduling system (according to the principles discussed in BEMP 3.8.1) that considers the crop water demand and availability of water in the root zone for crops grown in soil or substrates. Especially for crops grown in substrate, implementing irrigation scheduling based on moisture sensors allows more frequent irrigation with small volumes of water thus ensuring adequate supplies of water and nutrients.

— apply irrigation practices that maximise the water use efficiency (WUE) ([40]) rates such as micro-irrigation for crops grown in substrates and a closed (or semi-closed) loop system for crops grown either in soil or in substrates. Both micro-irrigation and closed loop systems also enable the possibility to implement fertigation.

Applicability

This BEMP is broadly applicable to all protected horticulture farms and very relevant to arid areas.

Closed loop systems are technically effective but are financially viable only in areas with good water quality or where high-value crops are cultivated that offset the costs of ensuring good water quality e.g. rain collection and/or desalinisation.

Micro-irrigation systems provide a high uniformity of distribution and high efficiency of application provided that proper dimensioning and design is ensured.

([39]) For protected horticulture activities the net crop water requirements are considered equal to crop evapotranspiration (ETc) because rainfall does not enter the greenhouse and little moisture depletion occurs.

([40]) The definition of the WUE is given in BEMP 3.8.1.

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Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i81) WUE, expressed as kg/m^3	N/A

3.10.3. *Waste management in protected horticulture*

BEMP is to segregate correctly the different fractions of waste arising within the protected horticulture system and to:

— compost the residual biomass or send it to an adjacent anaerobic digestion plant;

— make use of bio-based plastics, whenever feasible, for mulching films that can be fully biodegraded and nursery pots that can be composted on site or sent to an adjacent anaerobic digestion plant;

— separate and store properly the residues and the packaging of crop protection products in order to avoid leaching incidents and indirect contact with soil, plants and water;

— send all contaminated materials for appropriate treatment by a specialised licensed company;

— send all uncontaminated plastics for recycling.

Applicability

The elements of this BEMP are broadly applicable to all closed greenhouses and are also relevant for most other farms.

The bio-based plastic materials to be used should fulfil the following criteria:

— complete biodegradation (not simply disintegration) higher than 90 %;

— durability compatible with the specific application;

— no remains of heavy metals or other harmful chemical elements.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i93) All biomass waste is composted or sent to anaerobic digestion (Y/N) (i94) Use of fully biodegradable bio-based plastic materials for nursery pots and mulching films (Y/N) (i95) Percentage of non-contaminated plastic waste that is sent for recycling (%)	(b43) All waste is collected, separated and properly treated, the organic fraction is composted and no waste is sent to landfill. In particular: — Any mulching material is 100 % biodegradable, unless it is a plastic film that is physically removed — 100 % of waste is segregated at source — 100 % of the residual biomass generated is composted or sent to an adjacent anaerobic digestion plant

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3.10.4. *Selection of growing media*

BEMP is to either purchase environmentally certified growing media (e.g. EU Ecolabel) or define one's own environmental criteria for the purchasing of the growing media (e.g. based on the criteria set in Commission Decision 2015/2099 ([41])).

Applicability

This BEMP is broadly applicable to protected horticulture farms that purchase growing media.

Associated environmental performance indicators and benchmarks of excellence

Environmental performance indicators	Benchmarks of excellence
(i96) Use of environmentally certified growing media (e.g. EU Ecolabel) (Y/N)	N/A

([41]) Commission Decision (EU) 2015/2099 of 18 November 2015, establishing the ecological criteria for the award of the EU Ecolabel for growing media, soil improvers and mulch (OJ L 303, 20.11.2015, p. 75).

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4. RECOMMENDED SECTOR-SPECIFIC KEY ENVIRONMENTAL PERFORMANCE INDICATORS

The following table lists a selection of key environmental performance indicators for the agriculture sector, together with the related benchmarks and reference to the relevant BEMPs. These are a subset of all the indicators mentioned in section 3.

Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator (1)	Related benchmark of excellence	Related BEMP (2)
Sustainable farm and land management							
Strategic farm management plan in place	Y/N	All farms	An integrated management plan for the entire farm is in place that addresses market, regulatory, environmental and ethical considerations over a time period of at least five years	Per farm	Material efficiency Energy efficiency Emissions Biodiversity Water Waste	The farm has in place a strategic management plan that: (i) considers a time period of at least five years; (ii) improves the sustainability performance of the farm in all three dimensions: economic, social and environmental; (iii) considers ecosystem services delivery in a local, regional and global context using appropriate and simple indicators.	3.1.1
Participation in existing accreditation schemes for sustainable farming or food certification schemes	Y/N	All farms	The farm participates in accreditation schemes that add value to farm produce and ensure sustainable management	Per farm	Material efficiency	—	3.1.1
An EMS based on benchmarking for an appropriate selection of indicators is in place	Y/N	All farms	The EMS in place uses relevant indicators to benchmark the environmental performance of individual processes and at the entire farm level.	Per farm	Material efficiency Energy efficiency Emissions Biodiversity Water Waste	Relevant indicators are applied to benchmark the performance of individual processes, and the entire farm system, against all relevant best practice benchmarks described in this SRD	3.1.2

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Environmental management training is provided to staff	Y/N	All farms	Training on environmental aspects is given to all staff of the farm (temporary and permanent) at regular intervals.	Per farm	Material efficiency Energy efficiency Emissions Biodiversity Water Waste	Permanent staff participates in mandatory training environmental management programmes at regular intervals; temporary staff is provided information on environmental management objectives as well as training on relevant actions	
Width of buffer strips	m	All farms	Width of the strips of land along watercourses that are maintained in permanent vegetation and where tillage and grazing are not carried out	Per field	Water	Buffer zones of at least 10 m in width are established adjacent to all surface watercourses, in which no tillage or grazing operations are carried out	3.1.3
Stream total nitrogen and/or nitrate concentration	Mg NO_3/l, Mg N/l	All farms	The nitrogen or nitrate concentration should be measured in all watercourses adjacent or passing through the farm	Per farm or per field	Material efficiency Biodiversity Water	Farmers work collaboratively with neighbouring farmers and river basin managers from relevant authorities to minimise risks of water pollution, for example through the establishment of strategically located integrated constructed wetlands	3.1.3, 3.4.5
Locally important species abundance	number of key species/m^2	All farms	Measurement of the presence of selected species to monitor changes in the local biodiversity	Per farm or per field	Biodiversity	A biodiversity action plan is implemented on the farm, to maintain and enhance the number and abundance of locally important species.	3.1.4, 3.1.1, 3.4.4 3.5.2

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Final energy used within the farm	kWh/ha l_{diesel}/ha	All farms	Direct energy use (e.g. solid fuels, oil, gas, electricity, renewables) within the farm per hectare in terms of final energy. Different units can be used as appropriate for different energy carriers. Energy used for specific processes (e.g. diesel use in tractors) should be reported separately whenever possible.	Per farm or per process	Energy	An energy management plan is implemented and revised every five years, including: (i) mapping of direct energy use across major energy-using processes; (ii) mapping of indirect energy use via fertiliser and animal feed consumption; (iii) benchmarking of energy use per hectare, livestock unit or tonne of produce; (iv) energy efficiency measures; (v) renewable energy measures	3.1.5
Farm water use efficiency	m^3/ha/year m^3/tonne of produce m^3/livestock unit	All farms	Water used within farms per hectare and year or tonne of produce or per livestock unit. It needs to distinguish by source (e.g. water from wells, from municipal water supply, from surface watercourses, harvested rainwater, reclaimed water). Water used for specific processes should be reported separately whenever possible.	Per farm or per process	Water	A water management plan must be implemented and revised every five years, including: (i) mapping of direct water consumption by source across major processes; (ii) benchmarking of water consumption per hectare, livestock unit or tonne of produce; (iii) water efficiency measures; (iv) rainwater harvesting	3.1.5, 3.8.1
Percentage of waste separated into recyclable fractions	%	All farms	Amount of waste separated into recyclable fractions divided by the total amount generated within the farm	Per farm	Waste	Waste prevention, reuse, recycling and recovery is implemented so that no waste is sent to landfill	3.1.6, 3.10.3

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator (1)	Related benchmark of excellence	Related BEMP (2)
			Soil quality management				
Visual evaluation of soil structure for erosion and compaction signs across fields	Y/N	All farms	This indicator monitors whether the farmer inspects the fields in his farm in order to identify signs of erosion and compaction	Per field	Material efficiency	A soil management plan is implemented for the farm that incorporates: (i) an annual report for signs of erosion and compaction based on field inspections; (ii) soil bulk density and organic matter analyses at least every five years; (iii) implementation of concrete actions for maintenance of soil quality and organic matter	3.2.1
Soil bulk density	g/cm^3	All farms	Weight of dry soil divided by the total soil volume. The value of this indicator is obtained by laboratory testing.	Per field	Material efficiency	A soil management plan is implemented for the farm that incorporates: (i) an annual report for signs of erosion and compaction based on field inspections; (ii) soil bulk density and organic matter analyses at least every five years; (iii) implementation of concrete actions for maintenance of soil quality and organic matter	3.2.1, 3.2.3
Organic dry matter application rate	t/ha/year	All farms	Amount of organic matter applied in the field per hectare per year, expressed as dry matter	Per field	Material efficiency	Ensure all arable soils on the farm receive organic matter inputs, e.g. from crop residues, manures, catch/cover crops, composts, or digestates, at least once every three years, and/or establish grass leys for one to three years	3.2.2

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Erosion losses	Tonnes of soil/ha/year	All farms	Loss of the topsoil of a field caused either by water (run-offs) or wind, expressed by the amount of the soil lost per hectare per year	Per field	Material efficiency	A soil management plan is implemented for the farm that incorporates: (i) an annual report for signs of erosion and compaction based on field inspections; (ii) soil bulk density and organic matter analyses at least every five years; (iii) implementation of concrete actions for soil quality and organic matter	3.2.3
Production of field drain maps	Y/N	All farms	This indicator monitors whether drains are systematically mapped across fields in order to enable their management	Per field/per farm	Material efficiency Water	Natural drainage is maximised through careful management of soil structure; the effectiveness of existing drains is maintained; new drains are installed where appropriate on mineral soils	3.2.4, 3.4.3
Minimisation of drainage on peat soils	Y/N	All farms	Drainage is avoided in the fields with peat soils.	Per field	Material efficiency Water	Drainage is minimised on peat soils and soils where there is a high risk of increased nutrient transfer to water via drainage	3.2.4
			Nutrient management				
NUE calculated for N/P/K	%	All farms	Ratio between the amount of fertiliser removed from the field by the crop and the amount of fertiliser applied. The amount of fertiliser removed from the field by the crop is calculated by multiplying the crop yield by the average nitrogen content.	Per field	Material efficiency	The fertiliser nutrients applied do not exceed the amount required to achieve the 'economic optimum' crop yield. Nutrient surplus or nutrient use efficiency is estimated for nitrogen, phosphorus and potassium for individual crop — or grassland — management parcels.	3.3.1, 3.3.3, 3.5.3

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Gross Nitrogen Balance	kg/ha	All farms	This indicator represents the surplus or reduction of nitrogen on agricultural land. It is calculated by subtracting the amount of nitrogen added to the farming system by the amount of nitrogen taken away from the system per hectare of agricultural land.	Per field/per farm	Material efficiency	The fertiliser nutrients applied do not exceed the amount required to achieve the 'economic optimum' crop yield. Nutrient surplus or nutrient use efficiency is estimated for nitrogen, phosphorus and potassium for individual crop — or grassland — management parcels.	3.3.2, 3.3.1
Crop rotation cycles include legume and break crops	Y/N	All farms	This indicator refers to the incorporation of legume and break crops in the crop rotation cycles. The duration of the cycle should be reported too.	Per field/per farm	Material efficiency	All grassland and crop rotations include at least one legume crop and one break crop over a five-year period	3.3.2
Use of precision farming tools such as GPS technology guidance to optimise nutrient delivery	Y/N	All farms	This indicator refers to whether geolocation tools are used to define precisely the amount of nutrients to be applied in each specific location within the field/farm.	Per field	Material efficiency Emissions	—	3.3.3
Carbon footprint of nitrogen fertilisers used	kg CO_2e/kg N	All farms	This indicator refers to the manufacturing emissions of the nitrogen fertilisers used in the farm, expressed as kg CO_2e/kg N; the values are provided by the supplier of the fertilisers and must be based on an openly reported calculation.	Per farm	Emissions	Mineral fertiliser used on the farm has not given rise to manufacturing emissions exceeding 3 kg CO_2e per kg N, which must be demonstrated in an openly reported calculation provided by the supplier	3.3.4

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Synthetic fertilisers applied have low post application ammonia and GHG emissions	Y/N	All farms	This indicator monitors whether the synthetic fertilisers applied have specific characteristics (such as nitrification inhibitor coating) to limit post application emissions	Per farm	Emissions	Synthetic fertilisers applied have low post application ammonia emissions	3.3.4
			Soil preparation and crop planning				
Percentage of peat soils cultivated	%	All farms	Surface of the cultivated land with peat soils divided by the total surface of the land with peat soils in the farm	Per field/per farm	Material efficiency	Fields with peat soils must be kept covered with long-terms grass ley; soil tillage on peat soils to reseed the ley is carried out at a minimum interval of five years	3.4.1, 3.2.4
Percentage of winter soil coverage by vegetation	%	All farms	Surface of the land covered over winter by vegetation divided by the total surface of the field or the farm	Per field/per farm	Material efficiency	—	3.4.1
Percentage of area where non-inversion tillage operations for crop establishment are applied	%	All farms	Surface of the land where non-inversion tillage (e.g. direct seed drilling, strip tillage and reduced tillage) operations are implemented divided by the total surface of the field or farm	Per field/per farm	Material efficiency	Inversion tillage is avoided through the use of e.g. direct seed drilling, strip tillage and reduced tillage (chisel plough)	3.4.2
Number of break crops (ley, legume, oilseed) in the rotation cycles	No of crops/ rotation cycle	All farms	This indicator refers to the number of break crops in the rotation cycle.	Per field/per farm	Material efficiency	On farms with a cereal-dominated crop rotation, break crops are planted for at least two years in a seven year crop rotation and for at least one year in a six-year or shorter crop rotation	3.4.4, 3.3.2

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Length of rotation cycles	Years	All farms	Length of the applied rotation cycles.	Per field	Material efficiency	On farms with a cereal-dominated crop rotation, break crops are planted for at least two years in a seven year crop rotation and for at least one year in a six-year or shorter crop rotation	3.4.4, 3.3.2
Spatial diversity is considered in crop selection	Y/N	All farms	This indicator monitors whether, when designing crop rotation cycles, the farmer ensures the alternation of crops in neighbouring fields within the farm.	Per field	Material efficiency Biodiversity	Farms alternate crops cultivated in neighbouring fields to increase spatial diversity of cropping patterns at the landscape level	3.4.4
Selection of early maturing varieties of crops for the most susceptible land	Y/N	All farms	This indicator refers to whether the farmer avoids that the most susceptible land is left bare during the wet season by selecting early maturing varieties and facilitating the establishment of cover crops before the beginning of the wet season	Per farm	Biodiversity Material efficiency	Early maturing varieties of crops are selected in order to harvest before the wet season and to facilitate the establishment of cover crops	3.4.4
Percentage of land left as bare soil over winter	%	All farms	Surface of the land left as bare soil over winter divided by the total surface of the farm	Per farm	Water	The farm provides evidence of a full assessment of the potential to integrate cover/catch crops into cropping plans, providing justification for any land left bare over winter	3.4.5

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
			Grass and grazing management				
Percentage of grass dry matter uptake by animals	%	Livestock farms	Quantity of grass dry matter eaten by grazing animals over the grazing period out of the total grass dry matter available in the field. Grass height readings are taken throughout the growing period, which are then used to estimate the offtake amount of grass by the animals	Per field	Material efficiency	80 % grass dry matter uptake by grazing animals during the grazing period	3.5.1
D-value of pasture	No	Livestock farms	This indicator represents the digestibility rate of pasture by livestock; it can be improved thanks to pasture renovation	Per field	Material efficiency Biodiversity	Pasture renovation (e.g. over-seeding) is employed to maximise forage production, maintain high legume coverage and introduce other flowering species	3.5.3
Feed conversion ratio	kg of animal feed dry matter uptake/kg of output meat or l of milk	Livestock farms	Ratio between the amount of the feed (in terms of dry matter) eaten by the animals divided by the amount of farm produce, such as kg of output meat or litres of milk	Per field	Material efficiency Emissions	—	3.5.4, 3.6.1, 3.6.3, 3.6.4
			Animal husbandry				
Percentage of animals that are of rare genetic origin	%	Livestock farms	Ratio between the number rare breeds livestock units and the total number of livestock units within the farm	Per farm	Biodiversity	The livestock population of the farm consists of at least 50 % locally adapted breeds and at least 5 % rare breeds	3.6.1

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Percentage of animals that are of locally adapted breeds	%	Livestock farms	Ratio between the number of locally adapted breeds livestock units and the total number of livestock units within the farm	Per farm	Material efficiency	The livestock population of the farm consists of at least 50 % locally adapted breeds and at least 5 % rare breeds	3.6.1
Farm level nutrient surplus	kg N/ha/year kg P/ha/year	Livestock farms	This indicator refers to the difference between the nutrient input and output at farm level.	Per farm	Material efficiency Emissions	The farm-level nitrogen surplus is, at the most, 10 % of farm nitrogen requirements The farm-level phosphorus surplus is, at the most, 10 % of farm phosphorus requirements	3.6.2, 3.6.3
Farm level NUE calculated for N and P	%	Livestock farms	Ratio between the nutrient (nitrogen and phosphorus) inputs, ([3]) and the nutrient outputs (nutrient contained in crop and animals products sold and in exported livestock manure).	Per farm	Material efficiency Emissions	The farm-level nitrogen surplus is, at the most, 10 % of farm nitrogen requirements The farm-level phosphorus surplus is, at the most, 10 % of farm phosphorus requirements	3.6.2, 3.6.3
Dairy urea nitrogen in milk	mg/100 g	Livestock farms	Urea concentration in milk is obtained by performing laboratory tests	Per farm	Material efficiency	—	3.6.3
Enteric methane emissions	kg CH_4 per kg meat or l milk	Livestock farms	Calculation of the enteric methane emissions from the fermentation of feed per produce outcome	Per farm	Emissions	—	3.6.4, 3.6.7

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Percentage of procured feed that is sustainability certified	%	Livestock farms	Ratio between the weight of purchased feed that is sustainability certified and the total procured feed. This indicator can be broken down per different types of feeds and is specifically relevant for soy- and palm-based feeds.	Per farm	Material efficiency	Imports of soy- and palm-based feeds are minimised, and where used, 100 % of such feeds are certified not to originate from areas of recent land use change	3.6.5
Preventative healthcare programme in place	Y/N	Livestock farms	This indicator monitors whether the farm has a pro-active preventative healthcare programme for the livestock.	Per farm	Biodiversity	The farm systematically monitors animal health and implements a preventative healthcare programme that includes at least one preventative visit per year by a veterinary surgeon	3.6.6
Occurrences of veterinary treatment per head over the year	No/year	Livestock farms	Number of the health treatments with medicines (e.g. antibiotics) per livestock unit per year	Per farm	Biodiversity	—	3.6.6
Weight gain of the livestock in the farm	kg/livestock unit/time unit	Livestock farms	This indicator refers to the average measured increase in weight of livestock on the farm over an appropriate time unit (e.g. daily weight gain)	Per farm	Biodiversity	—	3.6.6
			Manure management				
Ammonia emissions generated in animal housing system per livestock unit per year	kg NH_3 per livestock unit per year	Livestock farms	Generation of ammonia emissions from animal housing, before excreta reach storage areas, per livestock unit per year	Per animal housing system	Emissions	Installation of a grooved floor, roof insulation and automatically controlled natural ventilation systems to animal housing	3.7.1

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Percentage of slurries/ manure generated on farm treated in an anaerobic digestion system from which digestate is returned to agricultural land	%	Livestock farms	Amount of slurries/manure treated in an anaerobic digestion system divided by the total amount of slurries generated in the farm	Per farm	Waste	100 % of slurry generated on farm is treated in an anaerobic digestion system with gas-tight digestate storage, from which digestate is returned to agricultural land	3.7.2
Percentage of on-farm slurry generated on dairy, pig and poultry farms that is separated prior to storage	%	Livestock farms	Ratio between the slurry separated into liquid and solid fraction prior to storage and application and the total amount of slurries generated in the farm	Per farm	Waste	Slurry or digestate arising on dairy, pig and poultry farms is separated as needed into liquid and solid fractions that are applied to soils in accordance with crop nutrient requirements and soil organic matter requirements	3.7.3
Liquid slurry store tanks and anaerobic digestate store tanks are covered	Y/N	Livestock farms	This indicator refers to taking appropriate actions to minimise emissions from slurry or digestate stores: for new build tanks, these should be covered with tight lid or tent cover and built as tall tanks; for existing tanks, when is not possible to use tight lid or tent cover, plastic-sheeting-type, clay ball or floating systems can be used.	Per farm or per animal housing system	Emissions	New-build slurry stores, and anaerobic digestate stores, are built as tall tanks (> 3 m in height) with a tight lid or tent cover. Existing storage tanks are fitted with a tight lid or tent cover where possible, or a floating cover otherwise; existing lagoon slurry stores are fitted with a floating cover	3.7.4

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Capacity of liquid storage tanks for slurries	m^3	Livestock farms	Volume of the tank for the slurry storage. This can be compared against the minimum required capacity value in order to apply nutrients according to the farm nutrient management plan.	Per farm	Emissions Waste	Total liquid slurry storage capacity is at least equal to that required by relevant national nitrate-vulnerable zone regulations, whether or not the farm is in a nitrate-vulnerable zone, and is sufficient to ensure that the timing of slurry application can always be optimised with respect to farm nutrient management planning	3.7.4
Implementation of slurry acidification or slurry cooling	Y/N	Livestock farms	This indicator refers to the implementation of slurry processing techniques such as acidification or cooling	Per farm	Waste Emissions	—	3.7.4
Percentage of solid manure fractions stored	%	Livestock farms	Amount of solid manure stored divided by the total generation of solid manures	Per farm	Waste Emissions	Solid manure fractions are composted or stored for at least three months in batches with no fresh manure additions	3.7.5
Location and management of solid manure stores avoids contamination of surface watercourses	Y/N	Livestock farms	This indicator monitors whether the farm has selected the location for solid manure stores away from surface watercourses and whether leachates are collected and recycled through the farm manure management system.	Per farm or per animal housing system	Waste Emissions	Solid manure stores are covered and located away from surface watercourses, with leachate collected and recycled through the farm manure management system	3.7.5

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Incorporation of manure into arable soils within two hours of spreading	Y/N	Livestock farms	This indicator refers to the immediate incorporation of the manure into arable soils	Per farm	Waste Emissions	In accordance with nutrient requirements of the crops, 100 % of the slurries applied to land are applied via shallow injection, trailing shoe or banded application, and 100 % of the high ammonium manures applied to bare arable land are incorporated into the soil as soon as possible and in any case within two hours	3.7.6
Percentage of slurry applied to grassland via shallow injection, or trailing shoe or banded application	%	Livestock farms	Amount of slurries applied to grassland via banded spreading or trailing shoe application or shallow injection techniques divided by the total amount of slurries applied to grassland	Per farm	Waste	In accordance with the nutrient requirement of the crops, 100 % of the slurries applied to grassland are applied via shallow injection, trailing shoe or banded application	3.7.7
			Irrigation				
Water Use Efficiency	kg/m^3	Farms using irrigation	Crop yield per irrigation water applied in the farm	Per farm	Water	—	3.8.1-3.8.4, 3.10.2
Irrigation efficiency at crop level	%	Farms using irrigation	It is calculated by multiplying the conveyance efficiency of the water to the field by the field application efficiency.	Per field	Water	—	3.8.2

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
			Crop protection				
A dynamic crop protection plan for sustainable crop protection is in place that includes: (i) crop rotation aimed at pest prevention, (ii) biological pest control,(iii) precision application of crop protection products (if their use is needed), (iv) appropriate training on plant protection, (v) periodical review and improvement of the plan	Y/N	All farms	This indicator refers to the implementation and periodical review of a dynamic crop protection plan, which incorporates key aspects of integrated pest management.	Per farm	Material efficiency Biodiversity Water	—	3.9.1
Selected crop protection products have the least toxicity and are compatible with the overall crop protection strategy	Y/N	All farms	This indicator refers to the selection of crop protection products which are compatible with the overall crop protection strategy and have the least toxicity.	Per field or farm	Biodiversity Water		3.9.2
			Protected horticulture				
Total energy use in the greenhouse	kWh/yield	Protected horticulture farms	Total energy use supplied to the protected horticulture system per yield	Per protected horticulture facility	Energy efficiency	—	3.10.1

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Share of the greenhouse energy use for heating, cooling, lighting and manufacture of carbon dioxide (if applicable) met by on-site renewable energy generation on an annual basis	%	Protected horticulture farms	Ratio between the use of renewable energy generated on-site and the total energy use over the year	Per protected horticulture facility	Energy efficiency	The combined energy use of the protected horticulture system for heating, cooling, lighting and manufacture of carbon dioxide (if applicable) is met by at least 80 % of on-site renewable energy generation, on an annual basis	3.10.1
All biomass waste is composted or sent to anaerobic digestion	Y/N	Protected horticulture farms	This indicator refers to the composting or anaerobic digestion of all biomass waste produced in the protected horticulture system. Anaerobic digestion can take place off-site	Per protected horticulture system	Waste	All waste is collected, separated and properly treated, the organic fraction is composted and no waste is sent to landfill. In particular: — Any mulching material is 100 % biodegradable, unless it is a plastic film that is physically removed — 100 % of waste is segregated at source — 100 % of the residual biomass generated is composted or sent to an adjacent anaerobic digestion plant	3.10.3

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Indicator	Units	Target group	Short description	Recommended minimum level of monitoring	Related EMAS core indicator ([1])	Related benchmark of excellence	Related BEMP ([2])
Use of fully biodegradable bio-based plastic materials for nursery pots and mulching films	Y/N	Protected horticulture farms	This indicator monitors the use of biodegradable plastics for pots, mulching, coverings, etc.	Per protected horticulture facility	Waste	All waste must be collected, separated and properly disposed, organic fraction composted and no waste to landfill. In particular: — Any mulching material is 100 % biodegradable, unless it is a plastic film that can be physically removed, — 100 % of waste is segregated at source — 100 % of the residual biomass generated is composted or sent to an adjacent anaerobic digestion plant	3.10.3

([1]) EMAS core indicators are listed in Annex IV to Regulation (EC) No 1221/2009 (Section C.2)
([2]) The numbers refer to the sections in this document.
([3]) Inputs include imports of mineral fertilisers, animal feed, bedding, animal manure, livestock and seed, as well as biological nitrogen fixation and atmospheric nitrogen deposition