This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727482 (DiverIMPACTS)

DiverIMPACTS
Diversification through Rotation, Intercropping, Multiple cropping, Promoted with Actors and value-Chains Towards Sustainability

D3.2 Open-access database on field experiments

Planned delivery date (as in DoA): Month 11

Actual submission date: Month 12, 30 May 2018

Work package: WP3

Work package leader: Guénaëlle Hellou (ESA Angers), Erik Steen Jensen (SLU) as deputy leader

Task leader T3.1: Clotilde Toqué (Acta)

Version: 1.0

This deliverable is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727482.	
Dissemination Level	
PU Public	PU
CI Classified, as referred to Commission Decision 2001/844/EC	
CO Confidential, only for members of the consortium (including the Commission Services)	

Research and Innovation action: GA no. 727482

Start date of the project: June 1st, 2017

Contents

1. Context and objectives

DiverIMPACTS will produce data that include data from measurements carried oud in a network of 10 field experiments. This network was built across Europe (7 countries) covering a range of pedo-climatic conditions and different farming systems: arable and vegetable systems both under conventional and organic management. Each field experiment will test one or several diversified cropping systems combining three strategies of diversification with low input practices compared to a reference system less diversified and more dependent on external inputs. The three strategies of crop diversification (Figure 1) are a) rotation, b) multiple-cropping (growing different crop species on the same land within a growing season) and c) intercropping (growing different species in proximity in the same field.

The WP3 database must give an access to information that could help diversification initiatives by the demonstration of the multiple benefits of different strategies of diversification (in time and space) at the cropping system level and the decision rules for their design and their management in different contexts (Figure 2).

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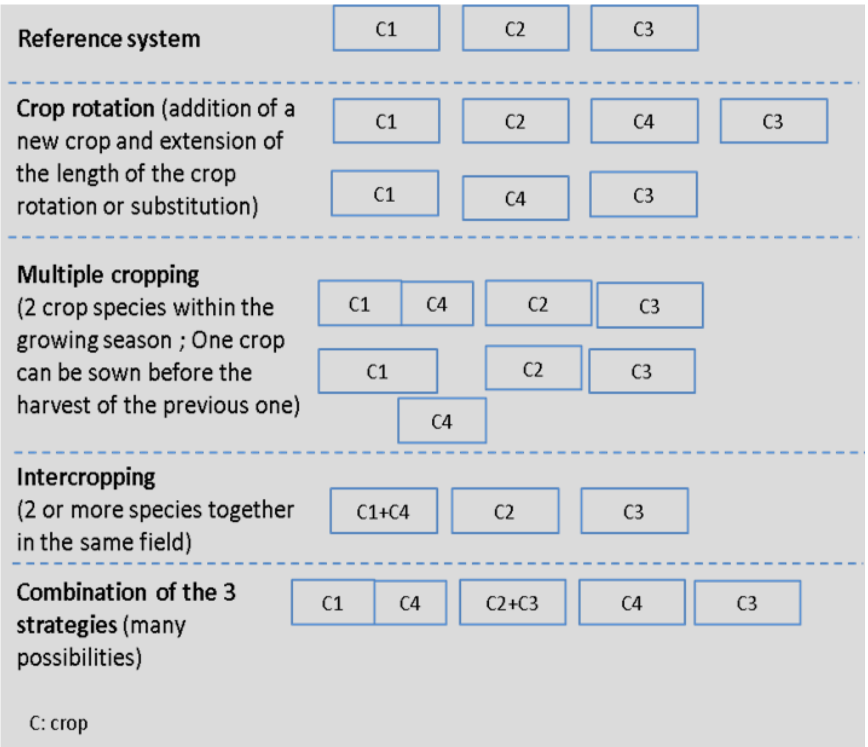

Figure 1. Strategies of crop diversification tested in DiverIMPACTS

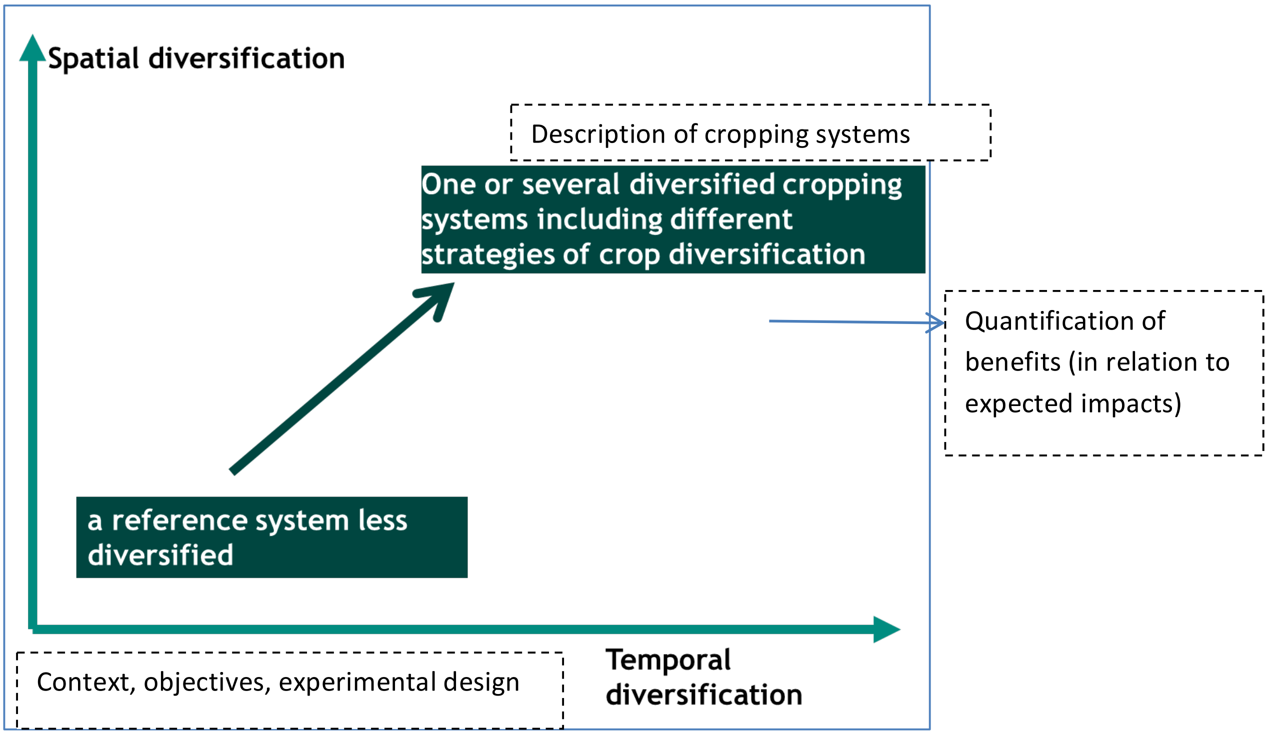

Figure 2. Categories of data collected in field experiments

The WP3 database will be used by partners during the project and after the project finishes to produce:

- annual synthesis of key results shared among partners and presented at the annual meetings;
- practice abstracts for dissemination and supports for training and education;
- scientific papers in relation to several hypotheses of the effects of crop diversification in time and space and the interest to combine spatial and temporal diversification strategies;
- oral communications and posters in national and international conferences.

This document explains:

- the type of data and metadata collected in this network
- the structure of the data base and tools
- the structure of the field experiment data base.

2. Data and metadata

Different data and metadata will be collected in the network (Figure 2 and Figure 3).

Data:

- The main data concern the quantification of **the benefits of the cropping systems** tested in relation to expected impacts.
- **The description of the cropping system** and their level of crop diversification both in time and space will be carefully done. It will help to assess the benefits in relation with the nature and the intensity of diversification. **The practices and decision rules** will be also recorded for each crop of the crop sequence.

Metadata: Other types of information which can be considered as metadata will be also collected to facilitate the multi-site analysis and the transfer of results for other initiatives of crop diversification:

- **The context** will be described at different levels: pedo-climatic conditions but also technical, socio-economic and environmental context. The description of this context will also help the interactions with other initiatives in the project (Case studies) and with other WPs dedicated to the identification of barriers and leverages.
- **The objectives** in relation to the expected impacts will be defined at the beginning of the project.
- **The experimental design** will be described: location, number of treatments, spatial replications, temporal replications.

- **Identification:** codification taken into account the different levels studied: site, cropping system, year, crop (see 4.1).

These categories of data were detailed in the handbook of methods (see D3.1) but are summarized in section 6.

3. Structure of the data base and tools

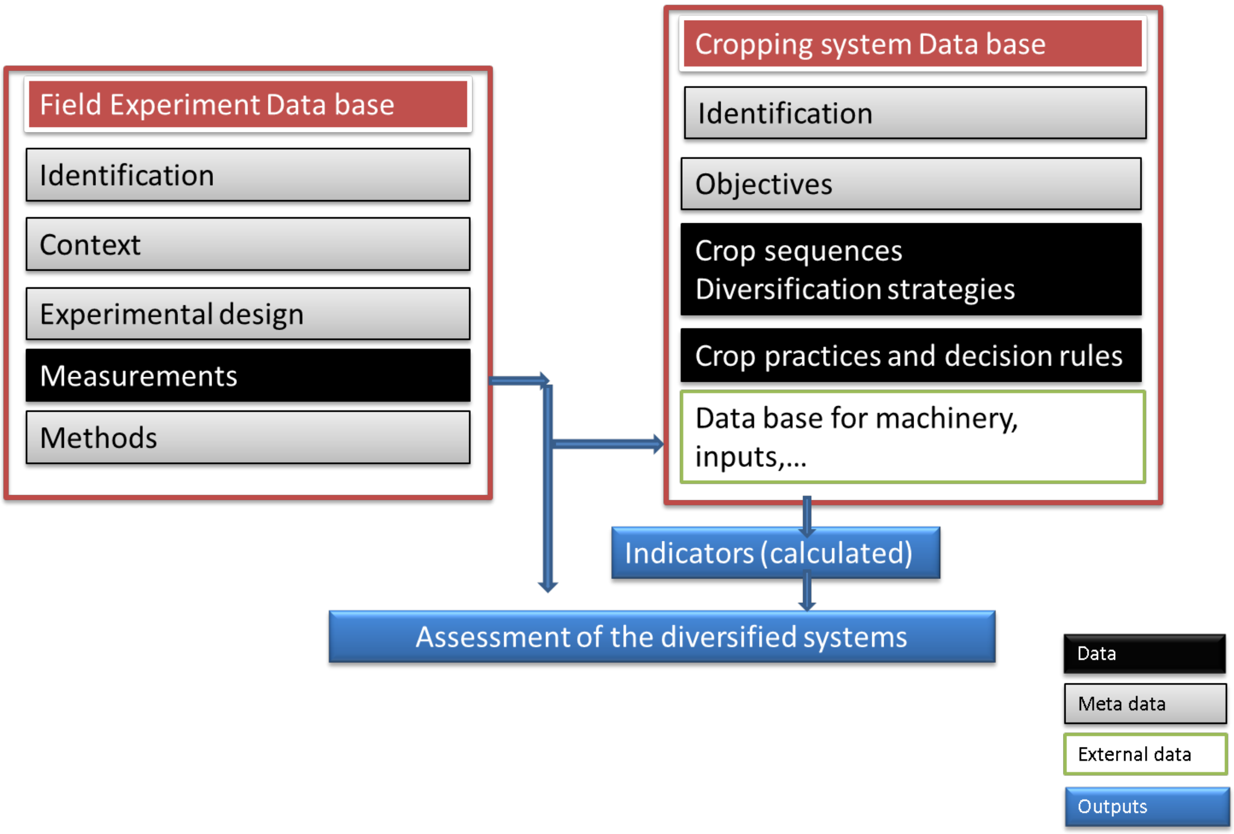

Figure 3. Organisation of the data collected in the network of field experiments

Key points of the data base

- **The structure described in Figure 3 should allow taking into account both the measurements** collected in the field experiments and the **accurate description of the cropping system**. It will allow **linking diversification strategies, crop management and their effects**.

- Special attention is paid to the description of the practices and the decision rules and a specific data base will be dedicated to this objective.
- Great importance is given to **metadata** for an in-depth transversal analysis of the systems tested.
- Great importance is given to the **identification** of the cropping system taken into account the different levels for data collection and analysis (see 4.1). A same codification will be used for the two parts of the data base: field experiment data base and cropping system data base.
- The tools will allow a **transparency** for the methods used for the measurements and the calculations.
- **Flexibility** of the tools: The systems tested are very different within the network (species, strategies, start of the experiment,..). There is a common set of criteria but also optional measurements. The structure of the data base chosen will be able to take into account this diversity and the different levels of complexity of the system tested.
- **The structure of the field experiment data** (excel format) is explained below (4.) and relies on the description of the methods found in the **handbook** (D3.1).
- **For the cropping system data base, an existing tool** (Systerre®) is proposed and will be presented to all partners for its validation. Decisions will be taken concerning the entry of data (centralisation by one partner or done by field experiment leaders themselves). This tool has already been successfully used in several previous French projects for such system experiments and for the assessment of innovative cropping system. Using this tool will facilitate the continuity of the network and the use of the results after the end of DiverIMPACTS. The tool offers the ability to calculate a wide range of criteria to assess the systems Thus it is not required to use several other tools which would make difficult the analysis process. It offers also the ability to make quick comparisons among systems and among sites. The tool has existing data bases with references concerning machinery, inputs as well as for the calculation of economic, social and environmental criteria. These data bases can be adapted with National set of references. Exports of data and results of the assessment are easy to do. This tool has not yet been provided to partners. The process of data collection, adaptations, and the links to field measurements will be discussed during the first annual meeting.

4. Structure of the field experiment data base

4.1 Scales and identification

The data base of field measurements takes into account the different temporal and spatial levels needed for data collection and their analysis (Figure 4).

Site information resides at the top level of this structure, system and year at the next levels, while information collected for each crop resides at the lowest level of the hierarchy.

One site contains different systems (minimum: two systems, one reference and one diversified system). One cropping system is a crop sequence with different years and one year can contain several crops (in the case of multiple cropping and intercropping).

The raw data will be collected mainly at the crop level.

The year level and the system level will integrate information recorded at lower levels.

The analysis will be mainly at the system level.

The excel file has a sheet per level.

All field experiments will use the same codification taken into account these different levels.

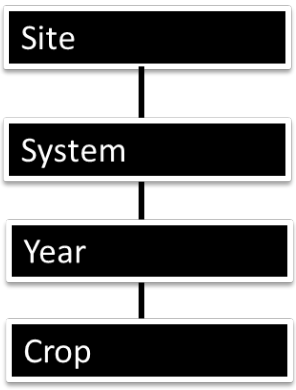

Figure 4. Different levels of data collection and analysis

4.2 Variables

One column represents a variable. The description of each variable (rationale, description, method) is defined in the handbook. The **unit** of each variable is given. Each variable will be coded. The **methods** used by each partner to collect each variable will be recorded. The **date** of measurement of each variable will be also recorded. Additional columns for comments will be used to give explanations of the year context, unexpected situations and problems which could help the analysis. **A colour code** is used to identify the **level of importance of each variable**: green means "essential", blue means "useful", orange means "optional, selected sites". It is the same colour code used in the handbook. The criteria are reminded in section 6. with this colour code.

4.3 Illustrations of the structure with two examples

The following examples are excerpts of the Excel file used to record data and will help understand the structure and to check the ability of the tool to take into account a diversity of situations of diversified systems (Table 1 and 2).

Example 1: Field experiment 6 will test two systems in Sweden (partner SLU) in an organic arable situation.

The crop sequence of the reference system is: winter rye - oat+undersown red clover - red clover - winter wheat - spring pea - winter oilseed rape

The second system is more diversified including catch crops and intercrops:

Winter rye - oat+lupin+red clover - red clover - winter wheat

Field experiment number	system number	year	temporal replication	spatial replication	rank of the crop	crop name
-	-	-		-	-	-
6	1	2018	A	1	1	winter rye
6	1	2019	A	1	1	spring oat
6	1	2019	A	1	1	red clover
6	1	2020	A	1	1	red clover
6	1	2021	A	1	1	winter wheat
6	1	2022	A	1	1	spring pea
6	1	2023	A	1	1	winter oilseed
6	2	2019	A	1	2	spring oat
6	2	2019	A	1	2	lupin
6	2	2019	A	1	2	red clover
6	2	2020	A	1	1	red clover
6	2	2021	A	1	1	wheat
6	2	2022	A	1	1	ray-grass
6	2	2022	A	1	1	vetch
6	2	2022	A	1	1	oil radish
6	2	2022	A	1	2	spring pea
6	2	2022	A	1	2	spring barley

Table 1. Different levels of hierarchy to structure the description of data in the field experiment data base. Example 1. Two cropping systems are described. In this site, there are temporal replications (not described here). The rows will be replicated for 6 temporal replications (A to F)

Field experiment number: each experiment has a number (1 to 10).
Each system tested has a number.
Year is the year of harvest.
Rank of the crop with the year: in the case of multiple cropping, the ranks 1 and 2 (and more of needed) indicate that two (or more) species are harvested in the same year. For intercrops, two lines are created (one for each crop) having the same rank and harvested the same year. Standardization for the crop names will be proposed.
Temporal replications: In several sites, each crop of the rotation is present each year. Thus the rotation could be replicated x times with x= number of the crops of the rotation. A letter indicates the different spatial replications. **Spatial replications** are replications of the system tested in space (e.g. with different blocks).

Example 2: Field experiment 1 will test 8 systems in Netherlands in conventional situation. The first one is monoculture of maize. The second and third rotations add grass in the rotation (1:1 or 1:3). Systems 4-6 relies on multiple cropping (addition of fodder crops (3 situations depending on the species) and use of short season maize to have two harvests the same year) and systems 7-8 relies on intercropping (maize is intercropping with sorghum or grass).

Table 2. Different levels of hierarchy to structure the description of data in the field experiment data base. Example 2. Eight cropping systems are described.

Field experiment number	system number	year	temporal replication	spatial replication	rank of the crop	crop name
1	1	2017	A	1	1	maize
1	1	2018	A	1	1	maize
1	1	2019	A	1	1	maize
1	1	2020	A	1	1	maize
1	1	2021	A	1	1	maize
1	1	2022	A	1	1	maize
1	2	2017	A	1	1	maize
1	2	2018	A	1	1	ray-grass
1	2	2019	A	1	1	maize
1	2	2020	A	1	1	ray-grass
1	2	2021	A	1	1	maize
1	2	2022	A	1	1	ray-grass
1	3	2017	A	1	1	maize
1	3	2018	A	1	1	ray-grass
1	3	2019	A	1	1	ray-grass
1	3	2020	A	1	1	maize
1	3	2021	A	1	1	ray-grass
1	3	2022	A	1	1	ray-grass
1	4	2017	A	1	1	rye
1	4	2017	A	1	2	maize
1	4	2018	A	1	1	rye
1	4	2018	A	1	2	maize
1	4	2019	A	1	1	rye
1	4	2019	A	1	2	maize
1	4	2020	A	1	1	rye
1	4	2020	A	1	2	maize
1	4	2021	A	1	1	rye
1	4	2021	A	1	2	maize
1	4	2022	A	1	1	rye
1	4	2022	A	1	2	maize
1	5	2017	A	1	1	rye
1	5	2017	A	1	1	winter pea
1	5	2017	A	1	2	maize
1	5	2018	A	1	1	rye
1	5	2018	A	1	1	winter pea
1	5	2018	A	1	2	maize
1	5	2019	A	1	1	rye
1	5	2019	A	1	1	winter pea
1	5	2019	A	1	2	maize
1	5	2020	A	1	1	rye
1	5	2020	A	1	1	winter pea
1	5	2020	A	1	2	maize
1	5	2021	A	1	1	rye
1	5	2021	A	1	1	winter pea
1	5	2021	A	1	2	maize
1	5	2022	A	1	1	rye
1	5	2022	A	1	1	winter pea
1	5	2022	A	1	2	maize
1	6	2017	A	1	1	ray grass
1	6	2017	A	1	2	maize
1	6	2018	A	1	1	ray grass
1	6	2018	A	1	2	maize
1	6	2019	A	1	1	ray grass
1	6	2019	A	1	2	maize
1	6	2020	A	1	1	ray grass
1	6	2020	A	1	2	maize
1	6	2021	A	1	1	ray grass
1	6	2021	A	1	2	maize
1	6	2022	A	1	1	ray grass
1	7	2022	A	1	2	maize
1	7	2017	A	1	1	maize
1	7	2017	A	1	1	sorghum
1	7	2018	A	1	1	maize
1	7	2018	A	1	1	sorghum
1	7	2019	A	1	1	maize
1	7	2019	A	1	1	sorghum
1	7	2020	A	1	1	maize
1	7	2020	A	1	1	sorghum
1	7	2021	A	1	1	maize
1	7	2021	A	1	1	sorghum
1	7	2022	A	1	1	maize
1	7	2022	A	1	1	sorghum
1	8	2022	A	1	2	maize
1	8	2017	A	1	1	maize
1	8	2017	A	1	1	ray grass
1	8	2018	A	1	1	maize
1	8	2018	A	1	1	ray grass
1	8	2019	A	1	1	maize
1	8	2019	A	1	1	ray grass
1	8	2020	A	1	1	maize
1	8	2020	A	1	1	ray grass
1	8	2021	A	1	1	maize
1	8	2021	A	1	1	ray grass
1	8	2022	A	1	1	maize
1	8	2022	A	1	1	ray grass

5. Data entry, checking and management

Date entry

Field experiment leaders are responsible for the data entry in the field experiment data base for their sites.

Data checking

The objective is that the data to be analysed should be of as high a quality as possible. Therefore the process of data checking begins at the data collection stage and continues until, and during, the analysis. Data checking is first done by field experiment leaders for their own data and by WP leaders for the common data base.

Data management

The Data Management Plan guides the way to manage data produced in WP3.

According to the data management plan of DiverIMPACTS data produced in the project have to be **publicly available**. Main rules are the following ones (data management plan V0.3 1 October 2017):

- As DiverIMPACTS adheres to the Open Research Policy, there is no restriction to data sharing once any publication derived from data is public.
- All datasets used during the project will be made publicly available, after anonymization, at the latest one year after the end of the project in order to allow, in a first step, the publication of the documents mobilizing them.

Data produced by WP3 will be shared, managed and stored through the collaborative workspace that DiverIMPACTS set up. The collaborative workspace is a secured extranet dedicated to the project and only accessible to DiverIMPACTS members. It is designed to share and archive information, to enable collaboration between partners and to ensure traceability during the construction of DiverIMPACTS outputs and to disseminate results within the DiverIMPACTS community.

Datasets will be stored in WP3 folder (within a specific sub-folder). Names of files will include: the reference of the dataset, the uploading date, the name of version, the creator.

Each partner has been given a login and password to get access to the collaborative workspace.

Data flow for field experiment: each FE leader provide each year the data concerning his experiment directly on the collaborative workspace and after verification by task leader and WP leaders, these data are put in the common dataset.

The dataset will be **publicly available in the Zenodo repository at the end of the project when all the data will be available and once any publication derived from data is public**.

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In principle, the datasets will remain accessible on Zenodo after the lifetime of the project. Some datasets may be destroyed if deemed irrelevant. Datasets from WP3 might be updated after DiverIMPACTS is over.

The description of all field experiments is also available on **DiverIMPACTS website** with metadata (partner, contact, location, design, strategies tested, rationale, issues, objectives and potential links with case studies). This description is regularly updated.

6. Description of the data collected

6.1 Criteria and measurements used to assess the benefits of crop diversification

The list of criteria for each expected impact to be measured and calculated each year in the network is given in Table 3. The choice of these criteria and the description of the measurements are detailed in the handbook of methods (D3.1).

Table 3. Criteria for the assessment of the benefits of crop diversification

Impacts	Criteria
Higher arable land productivity	**Yield** (t/ha/crop, t/ha/year, t/ha/system, (M)
	Quality of harvested products (% protein, %oil, sanitary and organoleptic qualities for some vegetables) *(M)*
	Aboveground biomass of harvested and not harvested products (cover crops) (M)
	LER for intercrops (M)
	Variability: min Yield, maxYield during the rotation ; number of crops with a yield lower than ….(to be defined) (M)
Diversification and increase of farmers revenues	**Gross margins** (/crop, year, system)
	Input costs (/crop, year, system)
	Mechanization costs (/crop, year, system)
	Species sorting costs (for intercropping)
	Production value(/crop, year, system)
	Economic efficiency *(Production value/production costs)*
	Sensibility of economic performances to the volatility of prices
	Diversity of type of products (food, feed,

	Number of species with a high added value (value higher than…(to be defined)
Lower environmental impact of diversified cropping systems with reduced use of pesticides, chemical fertilisers, energy and water	**Water use** (/crop, year, system) **Pesticide use** (active ingredients g/ha/crop, year, system ; treatment frequency index) **Energy use** (/crop, year, system) **N use** (/crop, year, system)from organic or inorganic fertilisers and from N2 (M) **N fertilizer efficiency** **Yield/water use, /pesticide use, /energy use, fertiliser use**
	N balance (/crop, year, system) (M) **Risk of N leaching** - soil N at harvest (M) **GHG emissions** (/crop, year, system) (M)
Improved delivery of ecosystem services (other than production)	**Soil biodiversity :** Quantification of microbial populations, incl. bacteria, archaea and fungi ; Quantification of functional genes involved in the nitrogen cycle ; Prokariot diversity, fungal diversity (M)
	Earthworm abundance and diversity (M) Decomposition of organic matter (litter bag) (M)
	Natural enemy diversity, abundance and biocontrol potential (Weed seed predation rates, Insect prey predation rates on ground and vegetation, habitat provision and habitat quality) (M)
	Arthropod abundance and diversity(M) **N2 fixation :** Quantity of N2 fixed/legume/ha,/year, /system (M) % of time with legumes during the rotation (M) Aboveground Biomass of legumes (M)
	Weeds, pest and disease control Weed biomass (M)
	Weed diversity (M)
	Pests and diseases (intensity) (M)
	C sequestration (C inputs and soil organic carbon) (M)
	Soil cover Vegetation cover during nitrate leaching period (M)
	N capture by catch crops (M) Risk of erosion
Feasibility - adoption	**Workforce** **Complexity of implementation** **Machinery challenges** **Value-chain challenges**

	Legal issues **Access to equipment, inputs, market, knowledge** **Involvement of actors (contribution to the design, access to results, perception,..**

A colour code is used: Green is for essential criteria. It will be assessed in all sites. Blue is for useful measurements but not necessarily assessed in all sites. Orange is for measurements done only on selected sites. "M" is for measurement: these criteria will be assessed with a measurement.

6.2 Experimental design

The objective is to know the conditions in which the diversification schemes are tested. Information collected are:

- Start and duration of the experiment
- Number of Cropping systems tested (reference system + diversified system)
- Size of plots
- Temporal and spatial replications

6.3 Description of the cropping systems

The objective is to describe the main crops sequences and to collect information on crop management in the beginning of the experiments ("expected"), during the project ("adaptation") and at the end ("realised").

Description of the diversification schemes:

Crop sequences tested can be diversified in time and/or in space with rotation, multiple cropping and intercropping. The strategies are combined in the same cropping system. The WP3 database must show how the three strategies of diversification are combined in the innovated systems tested in 10 Field Experiments of the network. The description should allow assessing the nature and the level of diversification in the different sites. Some criteria will be used to characterize diversification (table 4) (see also D3.1).

Table 4. Criteria for the description of the cropping systems

Diversification	Description
Level of diversification	Length of the crop rotation Number of species per rotation Number of families per rotation Number of strategies of diversification (new crops, multiple cropping, intercropping) (Spatial diversification: % of time with two or more species in the same field Time with catch crops (absolute and % of duration of rotation) % of time with bare soil (absolute and % of duration of rotation) % of spring crops % of legumes (in sole crop only and including intercrops) % of cereals (in sole crop)
Rotation	Crop sequence including catch crops (species with date of sowing and harvest (or destruction) Rationale of the crop sequence (new crops with added value, pre-crop effects, ecosystem services…), expected impacts
Multiple cropping	Description of the crop sequence at year level and rationale Rationale of the crop sequence (two crops with added value, pre-crop effects, ecosystem services…), expected impacts
Intercropping	Species intercropped Which is the main crop? Which species are harvested? Additive or substitutive design Mixed, row, strip (width) Density of each species at sowing Rationale: expected benefits, main objectives

Description of crop management:

- Tillage
- Fertilization
- Weed control
- Pest control
- Diseases control
- Lodging control
- Water management
- Machinery

We remind that crop management should differ according to the modalities (diversified systems and reference system) tested because the objective (as written in the call) is to demonstrate the benefits of crop diversification "allowing low-input agronomic practices". Decision rules are needed to understand how the amount of inputs (for example) has been decided for each modality.

Management of ecological processes:

The management of diversified cropping systems should probably be more based on the management of ecological processes (nutrient cycling, nitrogen fixation, regulation of pests and diseases, species interactions…) than on the management of external inputs and with a systemic approach than only annual crop management. Therefore a focus should be made on the decision rules concerning the design of crop sequences and spatial diversification strategies to favour ecological processes.

Description of the decision rules:

Decision rules or usual practices regarding the choice of crop sequence and combination of the strategies of crop diversification in relation to expected impacts have to be described, as well as decision rules for crop management.

The objective is to know the conditions in which the diversification schemes are tested: to have the validity domain of the results and to make the potential connexions with other experiments and the WP2 case studies.

6.4 Context

The context (Table 5) will be characterized at different levels: pedo-climatic conditions but also technical, socio-economic and environmental context. The description of this context will also help the interactions with other initiatives in the project (Case studies) and with other WPs dedicated to the identification of barriers and leverages.

Table 5. Criteria for the description of the context

Context	Criteria
Climate	Mean annual temperature Mean annual precipitation Positive aspects and constraints (drought, high temperatures…)of the site
Soil	Soil texture Soil depth pH(water) Maximum water holding capacity Bulk density

Technical context	Organic/conventional Type of agricultural systems (arable, vegetable) Interactions with livestock (fodder, manure…) Access to irrigation Access to specific equipment (sowing, harvest, mechanical weeding, sorting equipment)
Socio-economic context	Access to markets (new market, ability of existing value-chain to accept diversification strategies) Regulations, incentive measures (opportunities, constraints for some diversification strategies) Involvement of actors (farmers, advisers, collectors to the design,..)
Environmental context	Environmental issues (regulations, incentive measures..) Landscape (ecological infrastructures around the experiment)

6.5 Objectives of the cropping systems tested

The objective is to know expected results from the innovative cropping system tested in FEs. Objectives must be consistent with DiverIMPACTS expected impacts of crop diversification:

- To increase yields, arable land productivity, and land-equivalent ratio
- To increase farmer revenues through access to new markets and to reduce economic risk
- To reduce the use of inputs : *of pesticides, chemical fertilisers, energy and water*
- To reduce environmental impacts
- To enhance ecosystem services : including biodiversity, soil fertility, pest and disease control, groundwater and surface water quality and carbon sequestration
- To increase resilience to environmental stresses

The objectives of the innovative cropping systems tested have to be defined by each experiment leader early in the project.

Each cropping system will be evaluated in relation to these initial objectives.

7. Data entry, checking and management

Date entry

Field experiment leaders are responsible for the data entry in the field experiment data base for their sites.

Data checking

The objective is that the data to be analysed should be of as high a quality as possible. Therefore the process of data checking begins at the data collection stage and continues until, and during, the analysis. Data checking is first done by field experiment leaders and WP leaders.

Data management

The Data Management Plan guides the way to manage data produced in WP3.

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Datasets will be stored in WP3 folder (within a specific sub-folder). Names of files will include: the reference of the DMP dataset, the uploading date, the name of version, the creator.

Each partner has been given a login and password to get access to the collaborative workspace.

Data flow for field experiment: each FE leader provide each year the data concerning his experiment directly on the collaborative workspace and after verification by task leader and WP leaders, these data are put in the common dataset.

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In principle, the datasets will remain accessible on Zenodo after the lifetime of the project. Some datasets may be destroyed if deemed irrelevant. Datasets from WP3 might be updated after DiverIMPACTS is over.

8. Calendar for the use of the data base by experiment leaders

The data of the field experiment data base can already be recorded in the excel file. Some adaptations will be made based on feedbacks on field experiment leaders after the entry of the first data collected.

The cropping system data base: As indicated above, the Systerre® tool has not yet been provided to partners. The process of data entry, some adaptations, and the links with measurements will be discussed during the annual meeting. The objective is to start the entry of data just after the end of the first cropping season.