

## CONSOLE

CONtract Solutions for Effective and lasting delivery of agri-environmental-climate public goods by EU agriculture and forestry  
Research and Innovation action: H2020 - GA 817949

# D4.5. Report on integrated solutions, upscaling and lessons learned

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## 1 Summary

D4.5 develops tools to contribute to explore some key questions in CONSOLE: (a) What is the impact of agri-environmental contracts for the delivery of public goods on the landscape? (b) What could be the effects of specific contracts' results for promoting environmentally friendly land use? (c) Can the models provide information to the new common agricultural policy?

The evaluation component of CONSOLE it is implemented by developing models that evaluate the design and performance of the contract solutions. D4.5 addresses upscaling issues at the regional level, intended as the possibility/desirability to provide a wide regional uptake of what are often very local initiatives and implications for benefit calculation and design. The modelling approach includes implications for marginal social costs of delivering marginal agri-environmental and climate public goods. The contracts and performance parameters selected are those that provide information that is more tractable and may have a higher learning potential from numerical modelling and/or that cannot be treated based on ex-post information.

The main public good selected for analysis in in D4.5 is greenhouse gas mitigation, since: (a) it has a common value that can be compared across regions, (b) is was analysed with the individual models in Tasks 4.2-4.4, (c) is linked to objectives of the CAP and the Green Deal, and (d) it is included in many of the empirical case studies in WP2.

The selection of the Pilot Modelling Exercises is based on four criteria: (a) information of the CONSOLE Case Studies, (b) linkages to other modes in Tasks 4.2 to 4.5, (c) relevance to common agricultural policy and to the Green Deal ambition; and (d) adequacy to extent the results of the marginal environmental gains to large areas.

As a result of the implementation of a contract solution, the behaviour of land managers is modified to improve the provision of AECPGs. The aim of the upscaling model is to estimate the potential environmental gain that could be obtained from a set of proposed contract solutions if they were widely adopted across Europe. The environmental gain that could be potentially achieved is the result of multiple factors that are quantified through the successive phases of the upscaling model.

The methodological approach followed in the analysis is based on the concept of the Marginal Abatement Cost Curve (MACC) to relate the cost of contract solutions with the amount of environmental gain obtained through their implementation. A schematic example of a MACC is show in Figure 1, where the contract solutions (bars) are ranked in order of decreasing cost-effectiveness from left to right. The MACC plots the environmental gain that could be achieved by contract solutions that generate negative implementation cost values (i.e., incur cost-savings) and practices that generate positive implementation cost

values (i.e., incur a positive cost). This approach may also include cost-effectiveness analyses to combine the costs and effects (outcomes) of different contract solutions. The effect is measured as a quantitative environmental gain. The cost is estimated through a qualitative indicator related to the complexity of the implementation of the contract solution.

## 2 Introduction

### 2.1 Scope of D4.5

WP4 is part of the evaluation component of CONSOLE and it is implemented by developing models that evaluate the design and performance of the contract solutions. **The design** of models is based on the indicators designed in WP1 to ensure internal consistency, the empirical data of the Case Studies in WP2. **The performance** aims to the quantitative assessment based on empirical models as an outcome.

D4.5 addresses **upscaling** issues at the regional level, intended as the possibility/desirability to **provide a wide regional uptake** of what are often very local initiatives and implications for benefit calculation (offset/spillover) and design.

Attention is given to assessing implications for economic viability and ecosystem services, **developing tools for integration across the space and evaluating performance**.

In this deliverable, the term land manager is used. This term refers to farmers and forest owners who make the land-use decisions on the land they manage. Land managers can be either landowners or act as tenants on the land they have rented.

### 2.2 Outline of D4.5

D4.5 deliverable includes the following sections:

1. Section 1 is the **summary**.
2. Section 2 in the **introduction**.
3. Section 3 describes the **integration into the CONSOLE framework**. This section defines how D4.5 is integrated into the conceptual framework (WP1), the Case Studies (WP2) and the different modelling aspects of individual models (WP4, D4.2-4.4).
4. Section 4 reports on **tool development**.
5. Section 5 reports on the simulations of the **Pilot Modelling Exercises**.
6. Section 6 elaborates on **lessons learned**.

## 3 Integration into the CONSOLE framework

### 3.1 Selection of contract and performance parameters

The selection of contract and performance parameters is guided by the results WP1, WP2, WP3 and WP4. The contracts and performance parameters selected are those that provide information that is more tractable and may have a higher learning potential from numerical modelling and/or that cannot be treated based on ex-post information.

D4.5 develops tools to contribute to explore some key questions in CONSOLE:

What is the impact of agri-environmental contracts for the delivery of public goods on the landscape?

What could be the effects of specific contracts' results for promoting environmentally friendly land use?

Can the models provide information to the new common agricultural policy?

### 3.2 Selection of performance indicators and environmental variables

To identify the most interesting model specifications/parameters and scenarios variables to be modelled and analysed, D4.5 analyses how the work in WPs1-4 could be linked to numerical modelling that upscaled **performance**. This is done by systematically reviewing the outcome of the activities and collectively assessing the use of variables by the WP4 teams. Based on presentations of the potential performance variables, discussion in the general assembly and specific modeling meetings, D4.5 focuses on effectiveness (i.e., achievement of target objective in terms of provision of ecosystem services), efficiency (i.e., cost-effectiveness of solutions); and enhanced targeting (i.e., location, agglomeration, and spatial distribution to better achieve the expected impact).

The main public good selected for analysis in D4.5 is **greenhouse gas mitigation**, since: (a) it has a common value that can be compared across regions, (b) it was analysed with the individual models in Tasks 4.2-4.4, (c) it is linked to objectives of the CAP and the Green Deal, and (d) it is included in many of the empirical case studies in WP2.

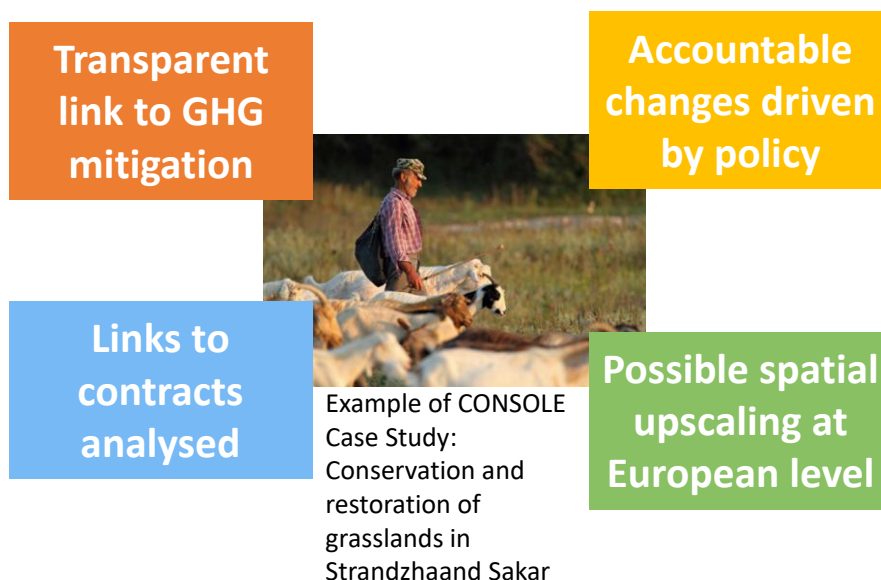
### 3.3 Linking the empirical Case Studies to the Pilot Modelling Exercises

#### 3.3.1 Approach

The selection of the Pilot Modelling Exercises is based on four criteria (Figure 1): (a) information of the CONSOLE Case Studies, (b) linkages to other modes in Tasks 4.2 to 4.5, (c) relevance to common agricultural policy and to the Green Deal

ambition; and (d) adequacy to extent the results of the marginal environmental gains to large areas. Additional information is included in Section 4.

## Selection of Pilot Modelling Exercises



*Figure 1: Criteria for selecting the Pilot Modelling Exercises*

### 3.3.2 Database of contracts in the Case Studies

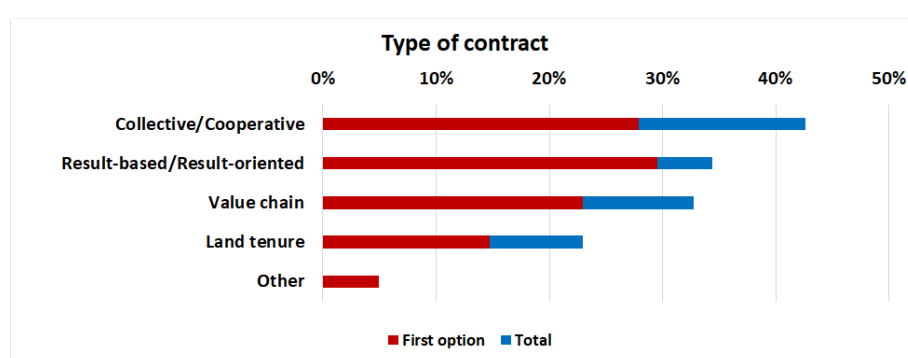
The activities carried out in WP2 have produced abundant information on implemented contract solutions for the improved delivery of AECPGs in Europe. This information was compiled as a collection of factsheets that provide a description of each case study, contract information and facts, context features and analysis of success.

This information is relevant to the work presented in this deliverable because it covers a wide range of cases that can be used to build a quantitative model to assess performance of contract solutions across Europe. The information contained in the factsheets was reviewed and structured in a database that summarized all the data relevant for the modelling exercise. The database included the following fields:

- Geographical location
- Type of contract solution: land tenure, collective, results-based and value chain. Many contracts were found to correspond to more than one typical contract type
- Main AECPGs promoted: biodiversity, soil conservation, agricultural landscapes, climate, etc. Many contracts were found to promote more than one AECPG.

- Number of land managers that joined the initiative
- Estimated average farm size in ha
- Main type of agriculture (grassland, permanent crops, arable land, etc.) or forestry (continuous cover forestry, drained peatlands, etc.) involved
- Main type of management actions that were promoted in the contract (ecological management, organic farming, protection of natural resources, landscape management, awareness, etc.
- Payment information, when available
- Timeframe: beginning and final year
- Final outcome (success, undecided or non-success)

An overall summary of the relevant information contained in the database is presented in the following figures. The distribution of contract types in the case studies analysed is presented on Figure 2. The figure shows the fraction of contracts that fall in each category, both as first option and as all options. All contract types are well represented. Cooperative and collective actions are the most represented, in 43% of case studies. The representation is very similar for result-based and value chain (34%-33%), with a little less incidence of land tenure contracts (23%).



*Figure 2: Distribution of contract types in the case studies*

The distribution of AECPGs promoted in the contracts analysed in the case studies is shown on Figure 3. The figure shows the distribution of AECPGs types that are mentioned in the factsheets as targets for the contracts, both for the first option and all options. An average of four AECPGs are mentioned for each contract. The distribution is highly irregular. The largest proportion corresponds to biodiversity, mentioned in 79% of the case studies (46% as first option), and landscape of scenery, selected as main target in 61% of the case studies (28% as first option). Rural viability and vitality is targeted in 48% of the contracts, but never as a first option. The next group is concerned with water and soil quality (38%-30%). Cultural heritage, resilience to natural hazards and carbon storage are targeted in more than 20% of the contracts analysed in the case studies.

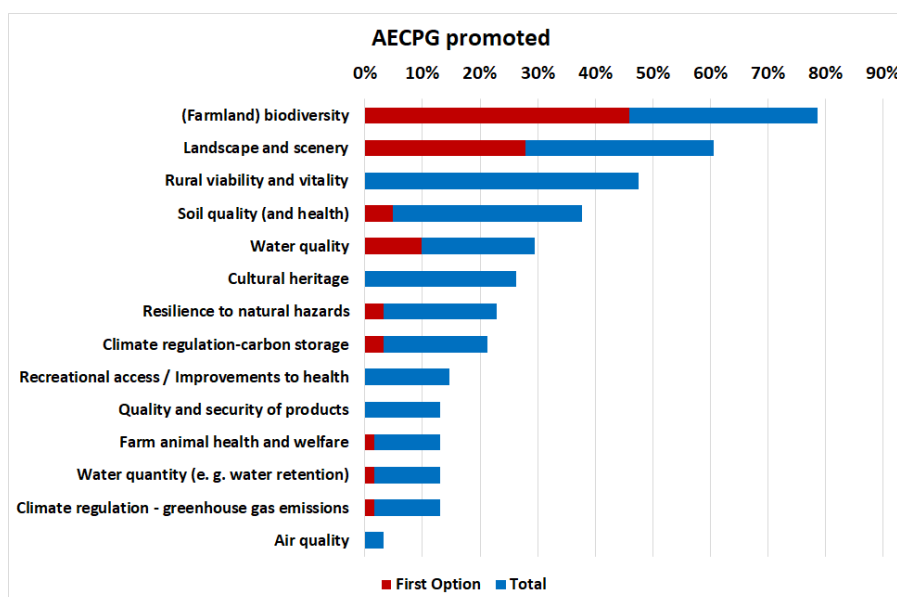


Figure 3: Distribution of AECPGs promoted in the case studies

The analysis of the nature of the contracts analysed in the case studies is presented on Figure 4. The left part of the figure shows the distribution of farm types that are targeted by the contracts and the right part of the figure shows the distribution of management actions induced by the contracts. The most frequent farm types correspond to general categories, such as grassland (17%), all farms (15%) and forest (15%). Livestock and arable are also targeted by at least 10% of the case studies analysed. 14% of the contracts are targeted on very specific farm categories. The dominant management actions induced by contracts are ecological management (18%), ecological restoration (12%) and organic farming (10%). 20% of the contracts are focused on specific management actions that do not appear in other contracts.

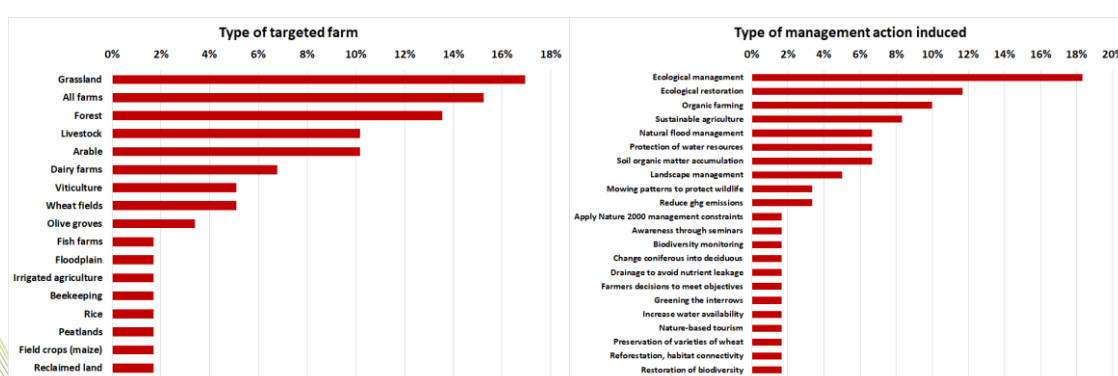
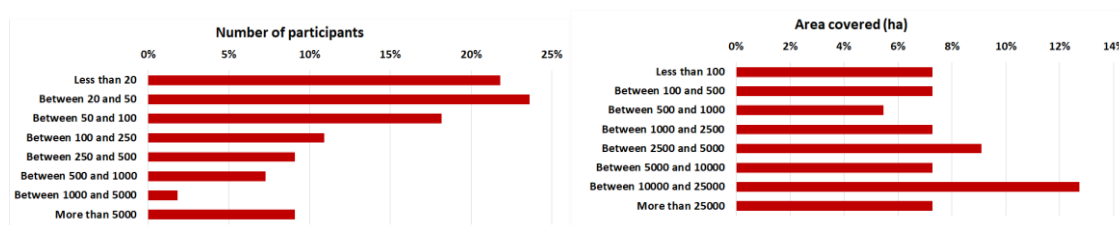


Figure 4: Distribution of targeted farms (left) and management action induced (right) in the case studies

The analysis of the participation in the contracts is presented on Figure 5. The distribution of the number of participants recruited in the contracts is shown on the left and the distribution of the area covered by the contracts is shown on the right. Most of the contracts (64%) involve less than 100 participants, with 24% involving between 20 and 50 participants. The average number of participants is 1,770 per contract, but this figure is misleading because there are a few contracts that involve a very large number of participants: 5 contracts involve more than

5,000 participants. The average number of participants in contracts involving less than 1,000 land managers is 125. The distribution of covered area is very uniform. The most frequent range is between 10,000 and 25,000 ha (13% of the contracts). The mean area covered by contracts affecting less than 10,000 ha (69% of the total) is 2,360 ha. The mean area covered by contracts affecting more than 10,000 ha (31% of the total) is 75,000 ha.



*Figure 5: Distribution of number of participants (left) and area covered (right) in the case studies*

The analysis carried out shows that typical contracts target the promotion of biodiversity, landscape and rural vitality in land covered by generic activities, such as grassland, forest or agriculture, promote ecological management and restoration and organic farming in a hundred farms covering an area of 2,500 ha (Table 1) and case studies with a link to GHG mitigation (Table 2).

*Table 1: Case studies from WP2 analysed for their contribution to the upscaling model*

| N  | Country | ID  | Title   | Contract 1 | Contract 2 |
|----|---------|-----|---|------------|------------|
| 1  | AT      | AT1 | ALMO - alpine oxen meat from Austria  | VC         |            |
| 2  | AT      | AT2 | Biodiversity monitoring   | RB         |            |
| 3  | AT      | AT3 | Result-based Nature conservation Plan (RNP)   | RB         |            |
| 4  | AT      | AT4 | The Humus Program of the Ökoregion Kaindorf   | RB         |            |
| 5  | BE      | BE1 | Participation of private landowners to the ecological restoration of the Pond area Midden-Limburg through a close participation of private and public landowners and a triple E-approach in the 3watEr project. | CO         | RB         |
| 6  | BE      | BE2 | FLANDERS – Flemish Forest Group   | CO         |            |
| 7  | BE      | BE3 | Wildlife Estates Label in Flanders  | RB         | CO         |
| 8  | BE      | BE4 | Flemish Nature Management Plan  | RB         | CO         |
| 9  | BG      | BG1 | Conservation of grasslands and meadows of high natural value through support for local livelihoods  | LT         |            |
| 10 | BG      | BG2 | Organic honey from Stara Planina mountain sites   | VC         |            |
| 11 | BG      | BG3 | "The Wild Farm" organic farmers.  | VC         |            |
| 12 | BG      | BG4 | Conservation and restoration of grasslands in Strandzha and Sakra   | LT         |            |

|    |     |       |   |    |    |
|----|-----|-------|---|----|----|
|    |     |       | mountains for restoring local biodiversity and endangered bird species  |    |    |
| 13 | DE  | DE1   | Viticulture on steep slopes creates diversity in the Moselle valley (Steillagenweinbau schafft Vielfalt – Das Moselprojekt) | RB |    |
| 14 | DE  | DE2   | Organic farming for biodiversity (Landwirtschaft für Artenvielfalt)   | RB | VC |
| 15 | DE  | DE3   | Collaboration for sustainability between institutional land owners and tenants farmers (Greifswalder Agrarinitiative)       | LT |    |
| 16 | DE  | DE4   | Agro-ecological transition pathways in arable farming   | CO | RB |
| 17 | DE  | DE5   | Water protection bread (Wasserschutzbrot)   | VC |    |
| 18 | DE  | DE6   | Forest conversion from coniferous to deciduous stands - an eco-account case   | CO |    |
| 19 | ES  | ES1   | Cooperative rice production in coastal wetlands in Southern Spain   | VC |    |
| 20 | ES  | ES2   | Organic wine in Rueda, Spain (Rueda)  | VC |    |
| 21 | ES  | ES3   | Beneficial practices monitoring in Olive crops in the framework of the new eco-schemes                                      | OT |    |
| 22 | ES  | ES4   | Integrated production in olive groves   | VC |    |
| 23 | FI  | FI1** | Forest Bank (a forest conservation program in Indiana and Virginia, US)   | LT | VC |
| 24 | FI  | FI2   | Protected areas of private forests as tourism destination in Kuusamo  | RB | LT |
| 25 | FI  | FI3   | Carbon Market (Hillipörssi) – a marketplace for the restoration of ditched peatlands  | VC | CO |
| 26 | FI  | FI4   | Pasture bank - a platform for pasture leasing   | LT |    |
| 27 | FI  | FI5   | Green jointly owned forest - TUOHI  | LT | VC |
| 28 | FI  | FI6   | Nature value bargaining (Luonnonarvokauppa)   | RB |    |
| 29 | FR  | FR1   | Eco-grazing - Grazing for ecological grasslands maintenance in the green areas of Brest Metropole                           | LT |    |
| 30 | FR  | FR2   | Terres de Sources - Public food order in Brittany, France   | RB | VC |
| 31 | FR  | FR3** | Esprit Parc National - Food and services in the national park of Guadeloupe   | VC |    |
| 32 | FR  | FR4   | ECO-METHANE – Rewarding dairy farmers for low GHG emissions in France   | RB |    |
| 33 | FR  | FR5   | HAMSTER – Collective AECM to restore habitats of the European Hamster in Alsace   | CO | RB |
| 34 | IRL | IRL1  | BurrenLife Project  | RB | CO |
| 35 | IRL | IRL2  | RBAPS - The Results-based Agri-Environment Payment Scheme (RBAPS) Pilot in Ireland  | RB |    |

|    |     |      |   |    |    |
|----|-----|------|---|----|----|
| 36 | IRL | IRL3 | BRIDE - Biodiversity Regeneration in a Dairying Environment   | RB | CO |
| 37 | IRL | IRL4 | Carbery Greener Dairy Farms™ CGDF   | OT |    |
| 38 | IT  | IT1  | Incentives for collective reservoirs  | CO |    |
| 39 | IT  | IT2  | Cooperation in Natura 2000 area benefiting biodiversity   | CO |    |
| 40 | IT  | IT3  | Rewilding of detention basin in Massa Lombarda  | LT |    |
| 41 | IT  | IT4  | "Carta del Mulino" – Barilla  | VC |    |
| 42 | IT  | IT5  | Farmers as Custodian of a Territory   | RB |    |
| 43 | IT  | IT6  | TERRITORIAL INTEGRATED PROJECTS - (PIT) /territorial agreement  | CO |    |
| 44 | LV  | LV1  | NUTRINFLOW  | CO |    |
| 45 | LV  | LV2  | DVIETE LIFE   | LT |    |
| 46 | LV  | LV3  | Bauska Nature Park  | RB |    |
| 47 | LV  | LV4  | Forest Management   | OT |    |
| 48 | NL  | NL1  | Kromme Rijn Collective management   | CO |    |
| 49 | NL  | NL2  | Green Deal Dutch Soy  | VC | CO |
| 50 | NL  | NL3  | Biodiversity monitor for dairy farming  | RB | VC |
| 51 | NL  | NL4  | Biodiversity monitor for arable farming   | RB | VC |
| 52 | PL  | PL1  | Natural Grazing in Podkarpackie Region  | CO | LT |
| 53 | PL  | PL2  | Program "Sheep Plus" - Provincial Program of Economic Activation and Preservation of the Cultural Heritage of the Beskids and Kraków-Częstochowa Upland | CO | LT |
| 54 | PL  | PL3  | Program "Flowering meadows" - contracts for protection of biodiversity and water resources by regular mowing of meadow                                  | VC |    |
| 55 | PL  | PL4  | BioBabalscy - Organic Pasta Chain Preserving Old Varieties of Cereals   | VC |    |
| 56 | UK  | UK1  | Delivering multiple environmental benefits in the South Pennines  | CO |    |
| 57 | UK  | UK2  | Using natural flood management to achieve multiple environmental benefits in Wharfedale   | CO |    |
| 58 | UK  | UK3  | Building natural flood management knowledge and capacity in Wensleydale   | CO |    |
| 59 | UK  | UK4  | Natural Flood Management in the River Swale catchment in Yorkshire  | CO |    |
| 60 | UK  | UK5  | Environmental improvement across a whole catchment: Esk Valley  | CO |    |

*Table 2: Case studies from WP2 analysed with direct links to GHG mitigation*

| N  | Order | Direct Links to GHG mitigation | Indirect links to GHG mitigation | Farms  | Main Farming system | Management                           | Initial |
|----|-------|--------------------------------|----------------------------------|--------|---------------------|--------------------------------------|---------|
| 1  | AT1   |                                | yes                              | 400    | Grassland           | Landscape management                 | 1988    |
| 2  | AT2   |                                | yes                              | 700    | Grassland           | Biodiversity monitoring              | 2007    |
| 3  | AT3   |                                | yes                              | 143    | Arable, grass       | Farmers decisions to meet objectives | 2015    |
| 4  | AT4   | yes                            | yes                              | 300    | All farms           | Soil organic matter accumulation     | 2007    |
| 5  | BE1   |                                | yes                              | 10     | Fish farms          | Ecological restoration               | 2009    |
| 6  | BE2   | yes                            | yes                              | 13000  | Forest              | Reforestation, habitat connectivity  |         |
| 7  | BE3   |                                | yes                              | 27     | All farms           | Ecological management                | 2018    |
| 8  | BE4   |                                | yes                              |        | Forest              | Ecological management                | 2014    |
| 9  | BG1   |                                | yes                              | 54     | Grassland           | Mowing patterns to protect wildlife  | 2007    |
| 10 | BG2   |                                | yes                              | 4000 b | Beekeeping          | Organic farming                      | 2015    |
| 11 | BG3   |                                | yes                              | 4      | Livestock           | Organic farming                      | 2018    |
| 12 | BG4   |                                | yes                              | 20     | Grassland           | Ecological restoration               | 2015    |
| 13 | DE1   |                                | yes                              | 32     | Viticulture         | Greening the interrows               | 2015    |
| 14 | DE2   |                                | yes                              | 72     | All farms           | Organic farming                      | 2012    |
| 15 | DE3   |                                | yes                              | 54     | Arable              | Sustainable agriculture              | 2013    |
| 16 | DE4   |                                | yes                              | 9      | Arable              | Sustainable agriculture              | 2018    |
| 17 | DE5   |                                | yes                              | 32     | Wheat fields        | Protection of water resources        | 2014    |
| 18 | DE6   |                                | yes                              | 1      | Forest              | Change coniferous into deciduous     | 2019    |
| 19 | ES1   |                                | yes                              | 1100   | Rice                | Sustainable agriculture              | 2000    |
| 20 | ES2   | yes                            | yes                              | 100    | Viticulture         | Organic farming                      | 2010    |
| 21 | ES3   | yes                            | yes                              | 30     | Olive groves        | Soil organic matter accumulation     |         |
| 22 | ES4   | yes                            | yes                              | 55000  | Olive groves        | Soil organic matter accumulation     | 1995    |
| 23 | FI1** | yes                            | yes                              | 62     | Forest              | Ecological management                | 2002    |
| 24 | FI2   |                                | yes                              | 4      | Forest              | Nature-based tourism                 | 2018    |
| 25 | FI3   | yes                            | yes                              | 10     | Peatlands           | Soil organic matter accumulation     | 2018    |

|    |       |     |     |                |                       |  |      |
|----|-------|-----|-----|----------------|-----------------------|--|------|
| 26 | FI4   |     | yes | unknown        | Grassland             | Ecological management                    | 2005 |
| 27 | FI5   | yes | yes | 45             | Forest                | Ecological management                    |      |
| 28 | FI6   |     | yes | 365            | Forest                | Ecological management                    | 2002 |
| 29 | FR1   |     | yes | 1              | Grassland             | Mowing patterns to protect wildlife      | 2018 |
| 30 | FR2   |     | yes | 23             | All farms             | Protection of water resources            | 2015 |
| 31 | FR3** |     | yes | 939 products   | All farms             | Organic farming                          | 2015 |
| 32 | FR4   |     | yes | 616            | Dairy farms           | Reduce ghg emissions                     | 2011 |
| 33 | FR5   |     | yes | 137            | Field crops (maize)   | Ecological restoration                   | 2013 |
| 34 | IRL1  |     | yes | 328            | Grassland             | Ecological management                    | 2005 |
| 35 | IRL2  |     | yes | 35             | Grassland             | Ecological management                    | 2015 |
| 36 | IRL3  | yes | yes | 44             | Dairy farms           | Ecological management                    | 2018 |
| 37 | IRL4  |     | yes | 62             | Dairy farms           | Reduce ghg emissions                     | 2012 |
| 38 | IT1   |     | yes | 249            | Irrigated agriculture | Increase water availability              | 2007 |
| 39 | IT2   |     | yes | 0              | All farms             | Apply Nature 2000 management constraints | 2013 |
| 40 | IT3   |     | yes | 1              | Reclaimed land        | Ecological restoration                   | 1999 |
| 41 | IT4   |     | yes | 500            | Wheat fields          | Natural flood management                 | 2018 |
| 42 | IT5   |     | yes | 27             | All farms             | Sustainable agriculture                  | 2011 |
| 43 | IT6   |     | yes | 36             | Viticulture           | Ecological management                    | 2016 |
| 44 | LV1   |     | yes | 72             | Arable                | Drainage to avoid nutrient leakage       | 2016 |
| 45 | LV2   |     | yes | 27             | Floodplain            | Ecological restoration                   | 2010 |
| 46 | LV3   |     | yes | 2004 companies |                       | Landscape management                     | 2013 |
| 47 | LV4   |     | yes | 3              | Forest                | Awareness through seminars               | 2011 |
| 48 | NL1   |     | yes | 300            | All farms             | Landscape management                     | 2016 |
| 49 | NL2   | yes | yes |                | Arable                | Sustainable agriculture                  | 2016 |
| 50 | NL3   | yes | yes | 11000          | Dairy farms           | Organic farming                          | 2014 |
| 51 | NL4   |     | yes | 11000          | Arable                | Ecological management                    |      |
| 52 | PL1   |     | yes | 715            | Grassland             | Ecological restoration                   | 2012 |

|    |     |  |     |     |              |                                    |      |
|----|-----|--|-----|-----|--------------|------------------------------------|------|
| 53 | PL2 |  | yes | 100 | Grassland    | Restoration of biodiversity        | 2008 |
| 54 | PL3 |  | yes | 97  | All farms    | Protection of water resources      | 2011 |
| 55 | PL4 |  | yes | 90  | Wheat fields | Preservation of varieties of wheat | 1993 |
| 56 | UK1 |  | yes | 60  | Livestock    | Ecological restoration             | 2016 |
| 57 | UK2 |  | yes | 16  | Livestock    | Natural flood management           | 2017 |
| 58 | UK3 |  | yes | 34  | Livestock    | Natural flood management           | 2017 |
| 59 | UK4 |  | yes | 17  | Livestock    | Natural flood management           | 2017 |
| 60 | UK5 |  | yes | 59  | Livestock    | Protection of water resources      | 2017 |

### 3.3.3 Selection of the Pilot Modelling Exercises

Pilot modelling exercises were selected from the ensemble of case studies analysed in the project but imposing the additional constraint of suitability for a quantitative approach. The AEC PG selected for analysis is climate regulation-carbon storage because it can be easily measured with the same units for all kinds of agri-environmental environments. There is also a wealth of information on estimating the expected effect of management actions on carbon sequestration and reduction of greenhouse gas emissions.

The pilot modelling exercises were selected considering two main factors: management actions that can be induced by contracts and farm types that are targeted by the contracts. The following action categories were selected among the catalogue of management actions induced by contracts:

- Land use change, as in 18 (DE) Forest conversion from coniferous to deciduous stands - an eco-account case
- Crop substitution, as in 49 (NL) Green Deal Dutch Soy
- Improved environmental management, as in 4 (AT) The Humus Program of the Ökoregion Kaindorf
- Environmental restoration, as in 27 (FI) Green jointly owned forest - TUOHI

An additional action category was added, although it was not induced by the contracts analysed in the project: reforestation. This action category was selected because of its high potential for carbon sequestration.

The different types of farms that could be targeted by the contracts were considered to divide some of the categories in subcategories. The following types of farm were considered:

- Annual crops, as in 16 (DE) Agro-ecological transition pathways in arable farming

- Perennial tree crops, as in 21 (ES) Beneficial practices monitoring in Olive crops in the framework of the new eco-schemes
- Grassland, as in 9 (BG) Conservation of grasslands and meadows of high natural value through support for local livelihoods
- Rice crops, as in 19 (ES) Cooperative rice production in coastal wetlands in Southern Spain
- Peatlands, as in 25 (FI) Carbon Market (Hillipörssi) – a marketplace for the restoration of ditched peatlands

Table 3 presents the links of the selected Pilot Modelling Cases to policies that respond to the objective of mitigating GHG emissions and to specific CONSOLE case studies.

*Table 3: Links between the Pilot Modelling exercises and the empirical CONSOLE Case Studies*

| <b>Pilot Modelling Exercise</b>                             | <b>GHG mitigation objective (links to policy)</b>   | <b>Contract types (links to CONSOLE Case Studies)</b>  |
|---|---|--|
| 1a: Reforestation from annual crops                         | reduce carbon emissions by changing land use from existing annual crops to forest             | 6 (BE) FLANDERS – Flemish Forest Group   |
| 1b: Reforestation from perennial tree crops                 | reduce carbon emissions by changing land use from existing perennial tree crops to forests    | 6 (BE) FLANDERS – Flemish Forest Group   |
| 1c: Reforestation from grassland                            | reduce carbon emissions by changing land use from existing grassland to forests               | 6 (BE) FLANDERS – Flemish Forest Group   |
| 2a: Land Use Change from annual crop to perennial tree crop | reduce carbon emissions by change land use from existing annual crops to perennial tree crops | 6 (BE) FLANDERS – Flemish Forest Group   |
| 2b: Land Use Change from annual crop to grassland           | reduce carbon emissions by change land use from existing annual crops to perennial tree crops | 6 (BE) FLANDERS – Flemish Forest Group   |
| 3a: Substitution of annual crop by soybean                  | reduce carbon emissions by changing existing annual crop to soybean                           | 49 (NL) Green Deal Dutch Soy   |
| 4a: Improved management in perennial systems                | change the carbon sequestration of perennial systems through improved                         | 4 (AT) The Humus Program of the Ökoregion Kaindorf: 13 (DE) Viticulture on steep slopes creates diversity in the Moselle valley (Steillagenweinbau |

|  |   |  |
|--|---|--|
|  | management techniques   | schaftt Vielfalt – Das Moselprojekt); 20 (ES) Organic wine in Rueda, Spain (Rueda); 21 (ES) Beneficial practices monitoring in Olive crops in the framework of the new eco-schemes; 22 (ES) Integrated production in olive groves  |
| 4b: Improved management in rice                  | change the carbon sequestration of rice fields through improved management techniques | 19 (ES) Cooperative rice production in coastal wetlands in Southern Spain  |
| 5a: Grassland systems degradation and management | change the degradation state of grassland through improved management techniques      | 9 (BG) Conservation of grasslands and meadows of high natural value through support for local livelihoods; 12 (BG) Conservation and restoration of grasslands in Strandzha and Sakra mountains for restoring local biodiversity and endangered bird species; 29 (FR) Eco-grazing - Grazing for ecological grasslands maintenance in the green areas of Brest Metropole; 36 (IRL) BRIDE - Biodiversity Regeneration in a Dairying Environment; 50 (NL) Biodiversity monitor for dairy farming |
| 5b: Forest degradation and management            | change the degradation state of forests through improved management techniques        | 6 (BE) FLANDERS – Flemish Forest Group, 23 (US) Forest Bank (a forest conservation program in Indiana and Virginia, US), 24 (FI) Protected areas of private forests as tourism destination in Kuusamo; 27 (FI) Green jointly owned forest - TUOHI  |
| 5c: Restoration of drained peatland              | recover carbon stocks in drained peatlands  | 25 (FI) Carbon Market (Hiilipörssi) – a marketplace for the restoration of ditched peatlands   |

### 3.3.4 Lessons learned from the individual models in WP4

The modelling in D4.5 includes the key findings about effectiveness of the contracts taken from the results of the models reported in D4.1 to T4.4. The assumptions about the implementation, effectiveness and sources of uncertainty, are:

- (a) The implementation of the results and collective based contracts is guided by an Environmental Extension Service, to increase the impact in the performance of the scheme.
- (b) The value of information provided by the Environmental Extension Service is homogeneous in the geographical space and type of agri-environmental system.

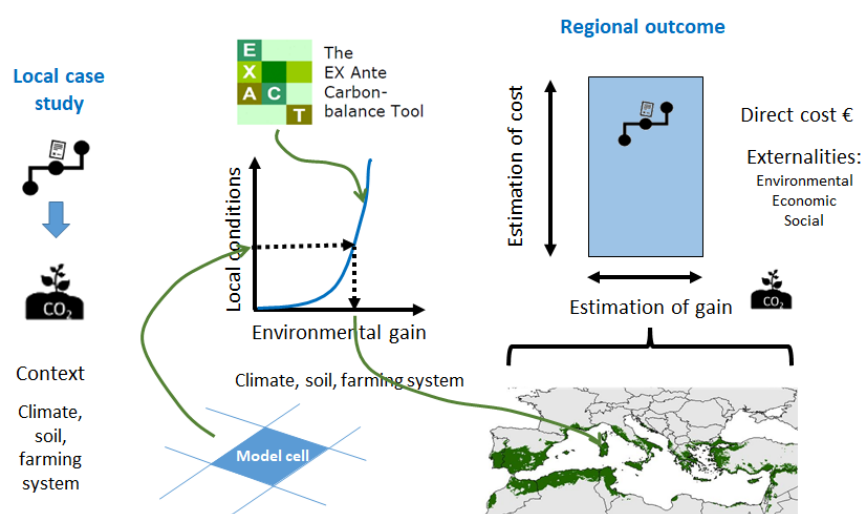
- (c) The effectiveness of the result and collective based schemes is higher than the effectiveness of a classic input-based scheme due to adequate payments that ensure the enrolment in the scheme.
- (d) Designing a result and collective based scheme where results are modelled (rather than monitored) is likely to be more effective than traditional input based schemes.
- (e) The farmers have clear evidence about the environmental results of the contract scheme.
- (f) The modelling does not consider the public transaction costs to design, implement, and monitor the measures or new incentives in the new CAP programming period.
- (g) The representation of the results of the contract in a real scenario is inaccurate due to variability in environmental conditions, agri-environmental systems, farmers' behaviour, local policy mixes, and prices of commodities.
- (h) The uncertainty of the upscaled results is higher in the case of biodiversity, since biodiversity gains are dependent on the entire landscape configuration, and therefore the agglomeration bonus is the most effective one.
- (i) The most effective contracts combine mixed instruments combining the lessons from collective instruments with the one from result-based schemes.

## 4 Tool development

### 4.1 Components of the upscaling models to estimate performance

The upscaling model to estimate performance intends to extend results of the analysis of contract solutions at the local level to a wider geographical context, to understand how the generalized application of contract solutions may lead to significant environmental gains. To perform this task, the model accounts for the basic processes that influence the provision of AECPGs as a result of changes in the behaviour of land managers induced by contract solutions. Some of these processes are extremely complex at the physical, chemical, biological, and socioeconomic levels, and therefore they need to be simplified to become manageable. The basic approach is illustrated in Figure 6, where the relevant processes are represented.

As a result of the implementation of a contract solution, the behaviour of land managers is modified to improve the provision of AECPGs. The aim of the upscaling model is to estimate the potential environmental gain that could be obtained from a set of proposed contract solutions if they were widely adopted across Europe. The environmental gain that could be potentially achieved is the result of multiple factors that are quantified through the successive phases of the upscaling model.



*Figure 6: Proposed analysis of each contract solution in the upscaling model*

### Step 1: Analysis of individual case studies

The upscaling model is based on the analysis of individual contract solutions to obtain information on how the specific contract produces the desired environmental gain. The required information may come from the models developed in WP4 or from the analysis of the local case studies compiled in CONSOLE.

### Step 2: Functional relation

Analysis of the functional relationship is performed with the EX Ante Carbon balance Tool (EXACT). EX-ACT is a decision support tool that quantifies the amount of greenhouse gas released or sequestered from agricultural production (Bockel et al. 2017). It covers a variety of landscapes: the agriculture, forestry and other land use sector, coastal and inland wetlands, fisheries and aquaculture, agricultural inputs, and infrastructure. The EX-ACT tool has been used to analyse local case studies and infer suitable functional relations for the spatial extension. The outcome of each individual case study is an EX-ACT model that provides a quantitative analysis of the amount of carbon sequestration obtained from the implementation of the contract solution. This model is then used to establish a functional relation between local conditions and the amount of environmental gain. Local conditions are described through a set of parameters related to natural factors (climate, soils) and management (land use, agricultural practices). The choice of parameters to describe local conditions depends on the context in which the contract solution will be applied and the nature of the management practices that produce the beneficial result.

### Step 3: Spatial extension

Spatial extension is the application of the contract solution to a representative fraction of sites located in the target area. The target area is the region where

the contract solution could potentially be implemented. It is delimited by identifying areas with a similar context to that of the local case study (i.e., forest, cereals, peatlands). The number of contract solutions implemented is determined from policy scenarios. The actual implementation sites are located through random sampling from the target area through a Monte Carlo method that accounts for the expected distributions of descriptive variables (number of participants and area). The extension is carried out by identifying local parameters in each potential site and applying the functional relation derived for the contract solution from the EX-ACT tool. This procedure is supported by a database of spatial information that includes the main parameters considered in the EX-ACT tool.

#### Step 4: Regional outcome

Regional outcome is the final input to represent the contract solution under consideration in the MACC. It includes an estimation of the potential environmental gain that could be obtained through the widespread adoption the solution, expressed in ton of sequestered CO<sub>2</sub> per year and an estimation of the estimation of cost, including direct cost and economic, environmental and social externalities.

The upscaling model has been applied to the following types of contract solutions inferred from the analysis of local case studies:

- Reforestation from annual crops
- Reforestation from perennial tree crops
- Reforestation from grassland
- Land use change from annual crop to perennial tree crop
- Land use change from annual crop to grassland
- Substitution of annual crop for soybean
- Improved management in perennial systems
- Improved management in rice
- Grassland systems degradation and management
- Forest degradation and management
- Restoration of drained peatland

The presentation of the upscaling model is structured as follows. The methodology of analysis with the EX-ACT tool and the data catalogue with the spatial information are presented in section 4.1. Then, the analysed contract solutions are presented, including the local case study and the EX-ACT model used to formulate the functional relation. Finally, some conclusions are drawn from the analyses performed.

## 4.2 Spatial extension

The spatial extension of the upscaling model consists of the repeated application of the EX-ACT tool of obtain the outcome of the contract on each individual land unit that participates in it. It is based on the EX-ACT spreadsheet prepared to

analyze the outcome of the contract on an individual land unit. The spatial extension follows four consecutive steps: (1) identification of target areas for the application of the contract; (2) random generation of contracts; (3) estimation of local variables in each land unit that joins each contract; and (4) application of the EX-ACT tool to obtain the outcome in each land unit.

A full description of this component of the model is included in Section 4.3.

#### 4.2.1 Identification of target areas

The identification of target areas is based on the scope of the contract solution. It may be focused on a particular ecological zone, land use type, crop category or a specific crop. For instance, a contract focusing on improving the management of forests to avoid degradation should have as target areas the CLC categories that describe forests: Broad-leaved forest, Coniferous forest and Mixed forest.

Target areas are identified by selecting the spatial units that match the description of the scope of the contract, formulated in terms of CLC categories.

#### 4.2.2 Random generation of contracts

The generation of contracts is achieved through a Monte Carlo simulation method. For each contract type, the following parameters are specified:

- Number of contract solutions to be generated,  $N$
- Region of influence of the contract solution: the area where individual participants may join the contract. This could be the size of a geometric shape delimiting the region of application, or an administrative unit, such as a country or region. The default option is a rectangular region of side  $L$  (in km).
- Number of participants joining the contract,  $n$ : this is described as a random variable determined by the parameters of the probability distribution function. The default is a normal distribution with known mean and standard deviation.
- Area of the land units joining the contract,  $s$ : this is described as a random variable determined by the parameters of the probability distribution function. The default is a gamma distribution with known mean and standard deviation.

The upscaling model identifies the target area for the type of contract and selects  $N$  random locations from the target area as centroid of the area of influence of each contract.

For each contract, it samples the number of participants from the corresponding probability distribution:

$$n = N^{-1}(p, \mu_n, \sigma_n)$$

where

$n$  is the number of participants in the contract

$N^{-1}$  is the inverse Gaussian distribution

$p$  is a random number in the interval (0,1)

$\mu_n$  is the mean of the probability distribution of the number of participants in the contract

$\sigma_n$  is the standard deviation of the probability distribution of the number of participants in the contract

The location of the  $n$  participants in each contract is randomly chosen among the land units in the target area that are within the region of influence of each contract. The region of influence may be specified as an administrative unit, if participation in the contract is limited to that particular region, or as a region of a given size. The default region of influence is a square of side  $L$  centered on the centroid of the area of influence.  $L$  is described as a random variable with normal distribution of known mean and standard deviation. The size of the region of influence is sampled from this probability distribution:

$$L = N^{-1}(p, \mu_L, \sigma_L)$$

where

$L$  is the size of the region of influence of the contract

$N^{-1}$  is the inverse Gaussian distribution

$p$  is a random number in the interval (0,1)

$\mu_L$  is the mean of the probability distribution of the size of the region of influence of the contract

$\sigma_L$  is the standard deviation of the probability distribution of the size of the region of influence of the contract

The area of the land unit corresponding to each participant of the contract is sampled from the corresponding probability distribution. The default is the Gamma distribution:

$$s = F_{\gamma}^{-1}(p, a, b)$$

where

$s$  is the area of the land unit that participates in the contract

$F_{\gamma}^{-1}$  is the inverse Gamma distribution

$p$  is a random number in the interval (0,1)

$a$  is the shape parameter of the Gamma distribution, taken as 3

$b$  is the shape parameter of the Gamma distribution, taken as  $\frac{\mu_s}{3}$ , where  $\mu_s$  is the mean area of the land units participating in the contract

The outcome of the random generation of contracts is a list of  $N$  realizations of the contract across Europe, each with  $n_i$  participants, randomly distributed over the region of influence of each contract. The region of influence of each contract is described as a square of side  $L_i$  centered in the centroid of the contract, of coordinates  $x_{Ci}, y_{Ci}$ , where  $x$  is longitude and  $y$  is latitude. The location of each participant is described by the coordinates  $x_{ij}, y_{ij}$ , where  $i = 1 \dots N$  and  $j = 1: \dots n_i$ .

### 4.3 Estimating marginal abatement costs and benefits of contracts

The methodological approach followed in the analysis is based on the concept of the Marginal Abatement Cost Curve (MACC) to relate the cost of contract solutions with the amount of environmental gain obtained through their implementation. A schematic example of a MACC is shown in Figure 7, where the contract solutions (bars) are ranked in order of decreasing cost-effectiveness from left to right. The MACC plots the environmental gain that could be achieved by contract solutions that generate negative implementation cost values (i.e., incur cost-savings) and practices that generate positive implementation cost values (i.e., incur a positive cost). This approach may also include cost-effectiveness analyses to combine the costs and effects (outcomes) of different contract solutions. The effect is measured as a quantitative environmental gain. The cost is estimated through a qualitative indicator related to the complexity of the implementation of the contract solution.

The MACC method has been proven valuable to communicate science results for mitigation policy. The MACCs have been derived to inform policy development for major economic sectors (McKinsey & Company 2009), for waste reduction strategies (Beaumont and Tinch 2004; Rehl and Müller 2013) and for agricultural greenhouse practices in some countries such as United Kingdom (MacLeod et al. 2010; Moran et al. 2011a), Ireland (O'Brien et al. 2014), France (Pellerin et al. 2013) and China (Wang et al. 2014). Further to the MACC approach, Pacala and Socolow (2004) created the concept of stabilisation wedges to clarify how mitigation options could help stabilize atmospheric CO<sub>2</sub>. This concept has been used widely as it provides a clear-cut way to link science to policy. The stabilisation wedges have been derived for the major carbon-emitting activities by means of decarbonisation of the supply of electricity and fuel, and also from biological carbon sequestration by forest and agricultural management (Pacala and Socolow 2004; Grosso and Cavigelli 2012).

The MACCs (Figure 7) have been derived to inform policy development for major economic sectors (McKinsey & Company, 2009), for waste reduction strategies (Beaumont and Tinch, 2004; Rehl and Müller, 2013) and for agricultural greenhouse practices in some countries such as United Kingdom (MacLeod et al., 2010; Moran et al., 2011a), Ireland (O'Brien et al., 2014), France (Pellerin et al., 2013) and China (Wang et al., 2014). Further to the MACC approach, Pacala

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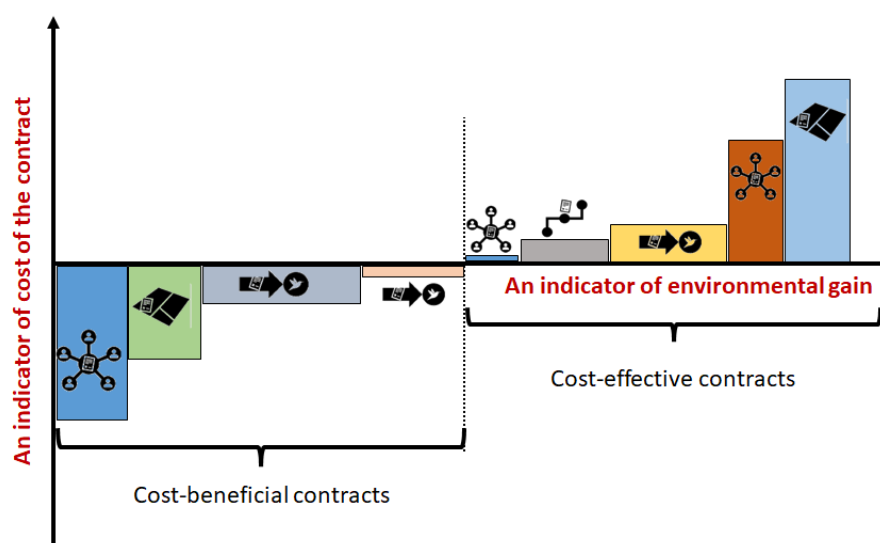


Figure 7: MACC concept

The quantitative analysis of environmental gain is focused on a particular category of AECPG: **reduction of GHG emissions to the atmosphere by sequestering soil organic carbon**. The reasons for this decision are: (1) soil carbon storage can be quantified and measured; (2) climate change mitigation through carbon storage is a key policy in EU and (3) there is good knowledge to estimate the effect of contract solutions on carbon storage.

#### 4.3.1 Estimating the marginal abatement benefits with the FAO the EX-ACT Carbon balance Tool

The EX-Ante Carbon-balance Tool (EX-ACT) is a tool developed to estimate and track the outcomes of agricultural interventions on GHG emissions. It is based on the Intergovernmental Panel on Climate Change (IPCC) methodology for greenhouse gas (GHG) emissions inventories.

EX-ACT is a land-based accounting system, estimating carbon stock changes (i.e. emissions or sinks of CO<sub>2</sub>) as well as GHG emissions per unit of land, expressed in equivalent tons of CO<sub>2</sub> per hectare and year. The tool helps project designers to estimate and prioritize project activities with the greatest economic benefit and potential for climate change mitigation. This GHG mitigation potential may also be used for economic analyses and for allocating additional project funds.

EX-ACT is a GHG accounting tool that covers the entire agricultural sector including Agriculture, Forestry and Other Land Use (AFOLU), inland and coastal wetlands, fisheries and aquaculture, agricultural inputs and infrastructure. EX-ACT consists of a set of eight linked Microsoft Excel sheets, covering different activity areas of the AFOLU sector. They allow users to specify information concerning

land-use change activities and agricultural management practices, and a few geographical, climatic and agro-ecological variables. The eight modules are:

1. General description of the project (Geographic area, climate and soil characteristics, duration of the project)
2. Land use change (Deforestation, afforestation/reforestation, non-forest LUC)
3. Crop production and management (Agronomic practices, tillage practices, water & nutrient management, manure application)
4. Grassland and livestock (Grassland management practices, livestock feeding practices)
5. Land degradation (Forest degradation, drainage of organic soils, peat extraction)
6. Coastal wetlands (Extraction/excavation, drainage and restoration in coastal wetlands)
7. Inputs and further investments (Fertilizers and agro-chemical use, fuel consumption, electricity use, infrastructure establishment)
8. Fishery & aquaculture (Marine capture and associated fuel consumption, ice production, aquaculture production and emissions from feed)

The wide coverage of these eight modules ensures that EX-ACT is capable of analyzing a wide range of agricultural, forestry and fishery development projects, including:

- Livestock and aquaculture development
- Crop production intensification
- Food security
- Forest and coastal wetlands protection and management
- Watershed development
- Land and coastal wetlands rehabilitation
- Climate change mitigation (forestry, etc.)
- Management activities within coastal wetlands
- Fishery management

Ex-ante project evaluation compares the impacts of a planned intervention to the business-as-usual scenario. Thus, for each of the variables identified as relevant to the project, data is required for the following three situations:

- The baseline situation
- The With-Project scenario
- The Without-Project scenario (business-as-usual)

Figure 8 illustrates the application of EX-ACT:

$x_0$  denotes the initial situation of land use and management practices in the project area, (e.g. the amount of cropland managed under improved nutrient management). Intervention due to the project (With-Project scenario) will result in an increase in the area that benefits from improved management, to  $x_2$ . In the absence of project intervention (Without-Project scenario) this increase will likely

be smaller – only  $x_1$  hectares will benefit from improved management (see Baseline scenario building).

EX-ACT differentiates between two time periods. The first is the implementation phase which defines the time period in which active project activities are carried out. This phase runs from  $t_0$  until  $t_1$ . The period covered by the analysis does not necessarily end with the termination of the active project intervention. Once an equilibrium in land use and agricultural practices is reached at  $t_1$ , further changes may occur due to the prior intervention, for instance in soil carbon content or in biomass. This period is defined as the capitalization phase and lasts from  $t_1$  until  $t_2$ .

The difference in activity data between the With- and Without-Project scenarios serves as the input data for calculating the carbon-balance of the project.

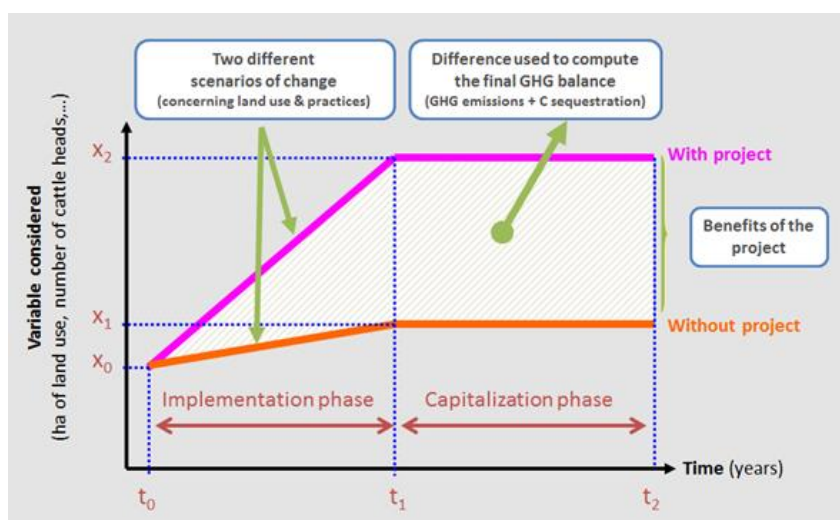


Figure 8: Development scenarios used in EX-ACT (Source: FAO Ex-ACT Quick Guidance)

The EX-ACT tool is used to obtain an estimate of the effectiveness of a contract solution to reduce GHG emissions through increased carbon storage.

#### 4.3.2 Applying FAO EX-ACT to the Pilot Modelling Exercises

The local model is based on the analysis of the measures or agricultural practices incentivized by the contract. These measures or practices are formulated using the vocabulary of available actions in the EX-ACT tool, which provides the analysis of carbon stocks that result from the intervention. Interventions are grouped by categories following the classification of EX-ACT: land use change, change of crops, improved management, restoration, etc. The model computes the carbon stock changes (i.e. emissions or sinks of CO<sub>2</sub>) expressed in equivalent tons of CO<sub>2</sub> per hectare and year.

The following information is required to include the contract solution in the upscaling model:

- Objectives of the contract solution: Since the scope of the EX-ACT tool is the evaluation of carbon storage, this AEPG should be one of the objectives of the contract
- Aim: The measure or management practice promoted by the contract should be represented in one of the in EX-ACT categories, to obtain a quantitative estimation of the outcome
- Details of implementation: Target areas for contract intervention (land use, crop, ecological zone,...), expected number of participants in the contract and area of the typical land unit that joins the contract.

The analysis of the contract solution at the local scale provides not only the outcome of the action,  $Y$ , but also the functional relation between local conditions  $(x_1, x_2, x_3, \dots, x_k)$  and the outcome.

$$Y = f(x_1, x_2, x_3, \dots, x_k)$$

where

$Y$ : outcome of the participation in the contract (net CO<sub>2</sub> balance) in equivalent tonnes of CO<sub>2</sub> per hectare and year

$x_1, x_2, x_3, \dots, x_k$ : Variables describing the local context (climate, soil, type of crop, crop yield, management practices, etc)

The functional relation is encoded in the EX-ACT tool. By changing the variables describing the local context, the expected outcome of the intervention is also changed.

#### 4.3.3 Estimation of local variables

The third step consists of the estimation of local variables in each land unit participating in a contract. This is achieved by applying the compiled datasets to the coordinates of the land units obtain the variables listed as relevant for each type of contract. The potential variables considered in EX-ACT are the following:

Variable  $x_1$ : Climate

- Boreal
- Cool Temperate
- Warm Temperate
- Tropical
- Tropical Mountain

Variable  $x_2$ : Moisture regime

- Dry
- Moist
- Wet

Variable  $x_3$ : Dominant Regional Soil Type

- HAC Soils
- LAC Soils
- Sandy Soils
- Spodic Soils
- Volcanic Soils
- Wetland Soils

Variable  $x_4$ : Forest ecological region

- Forest type 1: Temperate oceanic forest
- Forest type 2: Temperate continental forest
- Forest type 3: Temperate mountain systems
- Forest type 4: Subtropical dry forest

Variable  $x_5$ : Annual crop

- Beans & pulses
- Grains
- Root crops
- Tubers
- Barley
- Maize
- Oats
- Potatoes
- Soybeans
- Wheat

Variable  $x_6$ : Annual crop yield (Numerical value)

Variable  $x_7$ : Organic amendment type for rice (straw or other)

- Straw exported
- Straw burnt
- Compost
- Farm yard manure
- Straw incorporated long (>30d) before cultivation
- Green manure
- Straw incorporated shortly (<30d) before cultivation

Variable  $x_8$ : Degradation level of the vegetation

- None
- Very low
- Low
- Moderate
- Large
- Extrem

Variable  $x_9$ : Degradation level of the grassland

- Non degraded
- Improved with inputs improvement

- Improved without inputs management
- Moderately Degraded
- Severely Degraded

Variable  $x_{10}$ : Percentage (area) of ditches (from 0% to 100%)

There are maps available for six of these variables ( $x_1, x_2, x_3, x_4, x_5, x_6$ ). In these cases, the local variables are obtained from the corresponding maps, described in section 4.1.3. For the remaining variables, values were obtained from a randomization procedure that replicates the improvement obtained in the condition of the land resulting from the beneficial management practices.

#### 4.3.4 Estimating indicators of marginal costs in the Pilot Modelling Exercises

In this section we present an assessment of marginal social costs in the selected contracts. Full cost assessment is beyond the scope of this task. Rather, we focus our effort on identifying relevant indicators of marginal costs of implementing the contracts to establish a relative qualitative ranking of the costs of implementation of the different types of contracts. The factors to be considered are discussed in the next section, and in the following one, an attempt is made to obtain estimates of the relative values of these indicators for each type of contract.

The suggested indicators are far from comprising an exhaustive list, nor are they to be taken as a set menu of cost factors. Rather they are meant to reflect the difficulties that may arise in the implementation of measures induced by contracts. At the same time marginal cost depends on local conditions. For instance, in areas with considerable social and economic inequality implementation cost may be intensified while compared with more developed regions. The indicators selected are: cost to farmers, environmental and social externalities, ease of implementation, time frame to obtain results, and coordination with existing policies.

#### 4.3.5 Indicators of marginal costs in the Pilot Modelling Exercises

Table 4 provides an assessment of relative costs of the different types of projects analysed in the Pilot Modelling Exercise regarding the five indicators described in the previous section. Cost for farmer, environmental and social externalities, ease of implementation, time frame to obtain results and coordination with existing policies are estimated for each contract type using a simple qualitative scale.

The proposed qualitative is inspired on the Likert scale. Likert scaling is a bipolar scaling method, measuring either positive or negative response to a statement. Cost indicators were evaluated in relative terms and classified in the following categories:

Good (2): This category means that the management practice applied to the local farming system will certainly produce a positive result (negative cost) for the indicator under consideration with respect to the existing practice.

Fair (1): This category means that the management practice applied to the local farming system has potential to produce a positive result for the indicator under consideration with respect to the existing practice.

Neutral (0): This category represents a neutral impact of the management practice applied to the local farming system for the indicator under consideration.

Poor (-1): This category means that the management practice applied to the local farming system may produce a positive result for the indicator under consideration with respect to the existing practice.

Adverse (-2): This category means that the management practice applied to the local farming system will certainly produce a negative result for the indicator under consideration with respect to the existing practice.

The resulting values adopted for the indicators for each contract type are presented in Table 4. The indicators are developed using the approach and information provided in Sanchez et al (2016).

*Table 4: Assessment of relative costs for the indicators selected*

| Contract type   | Cost for farmer | Environ. externalities | Ease of implement. | Time frame | Policies in place |
|---|-----------------|------------------------|--------------------|------------|-------------------|
| 1a: Reforestation from annual crops                         | -2              | 2                      | -1                 | -2         | 1                 |
| 1b: Reforestation from perennial tree crops                 | -2              | 1                      | -1                 | -2         | 1                 |
| 1c: Reforestation from grassland                            | -1              | 2                      | -1                 | -2         | 1                 |
| 2a: Land Use Change from annual crop to perennial tree crop | 1               | 0                      | -1                 | -1         | 0                 |
| 2b: Land Use Change from annual crop to grassland           | -1              | 2                      | -1                 | -1         | 0                 |
| 3a: Substitution of annual crop by soybean                  | 1               | 0                      | 2                  | 1          | 2                 |
| 4a: Improved management in perennial systems                | 2               | 1                      | 2                  | 1          | 1                 |
| 4b: Improved management in rice                             | 2               | 1                      | 2                  | 2          | 0                 |
| 5a: Grassland systems degradation and management            | -1              | 2                      | 2                  | 0          | 1                 |
| 5b: Forest degradation and management                       | -1              | 2                      | 2                  | 0          | 0                 |

|                                     |   |   |   |   |   |
|-------------------------------------|---|---|---|---|---|
| 5c: Restoration of drained peatland | 0 | 2 | 2 | 0 | 0 |
|-------------------------------------|---|---|---|---|---|

The individual cost factors for the indicators were aggregated by applying a weighted mean:

$$WQE = \sum_{i=1}^{i=5} \gamma_i I_i$$

Where:

$WQE$  is the weighted qualitative effort required to fully implement the measure

$I_i$  is the indicator of marginal cost  $i$

$\gamma_i$  is the weight assigned to indicator  $i$

The proposed weights for the indicators of marginal cost are presented in Table 5.

*Table 5: Weights adopted for the indicators of marginal cost*

| Indicator of marginal cost              | Weight |
|---|--------|
| Cost to farmers                         | 5      |
| Environmental and social externalities: | 3      |
| Ease of implementation:                 | 2      |
| Time frame to obtain results:           | 2      |
| Coordination with existing policies:    | 1      |

#### 4.3.6 Construction of the Marginal Abatement Cost Curve

The analyses carried out allow the estimation of the Marginal Abatement Cost Curve for the types of contracts analysed in the Pilot Modelling Exercises. The main results are summarized in Table 6. The table shows the estimated average outcome of contract implementation, in ton C/ha.yr, and the Weighted Qualitative Effort implied.

*Table 6: Main results of the analysis of contract types*

| Contract type                               | Contract average outcome (tonC/ha.yr) | Weighted Qualitative Effort |
|---|---------------------------------------|-----------------------------|
| 1a: Reforestation from annual crops         | 15.71                                 | -9                          |
| 1b: Reforestation from perennial tree crops | 5.45                                  | -12                         |
| 1c: Reforestation from grassland            | 12.23                                 | -4                          |

|   |       |    |
|---|-------|----|
| 2a: Land Use Change from annual crop to perennial tree crop | 5.91  | 1  |
| 2b: Land Use Change from annual crop to grassland           | 2.02  | -3 |
| 3a: Substitution of annual crop by soybean                  | 1.90  | 13 |
| 4a: Improved management in perennial systems                | 0.72  | 20 |
| 4b: Improved management in rice                             | 4.51  | 21 |
| 5a: Grassland systems degradation and management            | 0.48  | 6  |
| 5b: Forest degradation and management                       | 7.23  | 5  |
| 5c: Restoration of drained peatland                         | 10.74 | 10 |

The results of Table 6 were used to build the Marginal Abatement Cost Curve shown in Figure 9. Contract categories were sorted from least to highest value of WQE and represented on the curve.

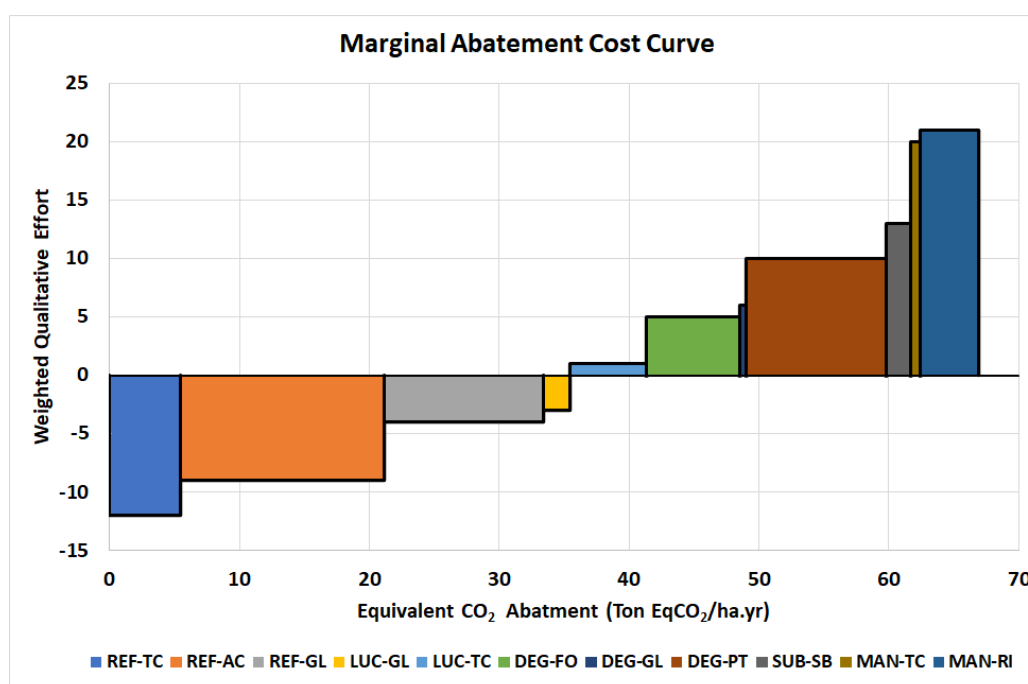


Figure 9: Estimated Marginal Abatement Cost Curve

#### 4.3.7 Marginal abatement cost and benefits at the regional level

The final step is the application of the EX-ACT tool to all participants in each contract, to obtain the distribution of expected outcomes. The EX-ACT tool encodes the functional relation between local conditions and expected outcomes. The application is achieved with an Excel macro that reads the value of local conditions from the Monte Carlo simulation process, inserts the suitable values in the corresponding cells of the Ex-Act Excel sheet and compiles the final outcomes in each land unit, expressed in tonnes of CO<sub>2</sub> per hectare per year. The multiplication of these outcomes by the areas of individual land unit yields the net result of the application of the contract. An example of the analysis is shown in Figure 10.

| Contract | Area (ha) | Climate        | Moisture | Soil          | Total Emissions (tCO <sub>2</sub> -eq) |
|----------|-----------|----------------|----------|---------------|--|
| 2        | 34        | Warm Temperate | Dry      | HAC Soils     | -539.31                                |
| 2        | 3         | Warm Temperate | Dry      | HAC Soils     | -42.59                                 |
| 2        | 9         | Warm Temperate | Dry      | HAC Soils     | -139.22                                |
| 2        | 12        | Warm Temperate | Dry      | HAC Soils     | -197.44                                |
| 2        | 8         | Warm Temperate | Dry      | HAC Soils     | -132.43                                |
| 2        | 5         | Warm Temperate | Dry      | HAC Soils     | -79.54                                 |
| 2        | 36        | Cool Temperate | Dry      | HAC Soils     | -501.13                                |
| 2        | 45        | Warm Temperate | Dry      | HAC Soils     | -715.22                                |
| 3        | 57        | Cool Temperate | Dry      | Wetland Soils | -855.62                                |
| 3        | 36        | Cool Temperate | Dry      | Spodic Soils  | -462.13                                |
| 3        | 9         | Cool Temperate | Dry      | Spodic Soils  | -110.95                                |

Figure 10: Example of application of the functional relation to different land units

## 4.4 Spatial data catalogue

This section presents the sources of information consulted to build the spatial data catalogue used in the upscaling model. Local context in EX-ACT is formulated in terms of IPCC classifications for climate regions and soil types and FAO classification for ecological zones. Sources of information are classified in five categories: climate data, soil data, forest ecological zones data, agriculture data and land use data. For each source of information, we describe the information related to the type of data available and present a figure showing the actual data used for the upscaling model.

### 4.4.1 Climate data

The climate classification adopted in EX-ACT is based on the classification scheme for default climate regions proposed in Figure 11 of the 2006 National Greenhouse Gas Inventories (Bickel et al. 2006), shown on Figure 11. Climate regions are identified following a classification scheme based on elevation, mean annual temperature (MAT), mean annual precipitation (MAP), mean annual precipitation to potential evapotranspiration ratio (MAP:PET), and frost occurrence. The following categories are considered:

- Warm Temperate
- Cool Temperate
- Polar
- Boreal
- Tropical Montane
- Tropical

Most of these categories are further subdivided into “dry”, “moist” or “wet”, depending on the dominant moisture regime. The detailed classification of climate data adopted for the upscaling model is shown in Figures 11 and 12.

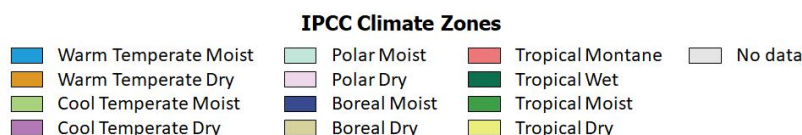
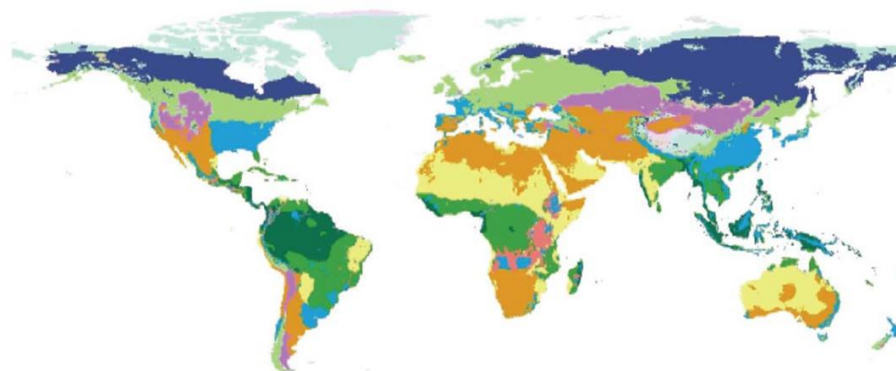


Figure 11: Representation of IPCC climate zones (Bickel et al. 2006)

#### IPCC Climate zones

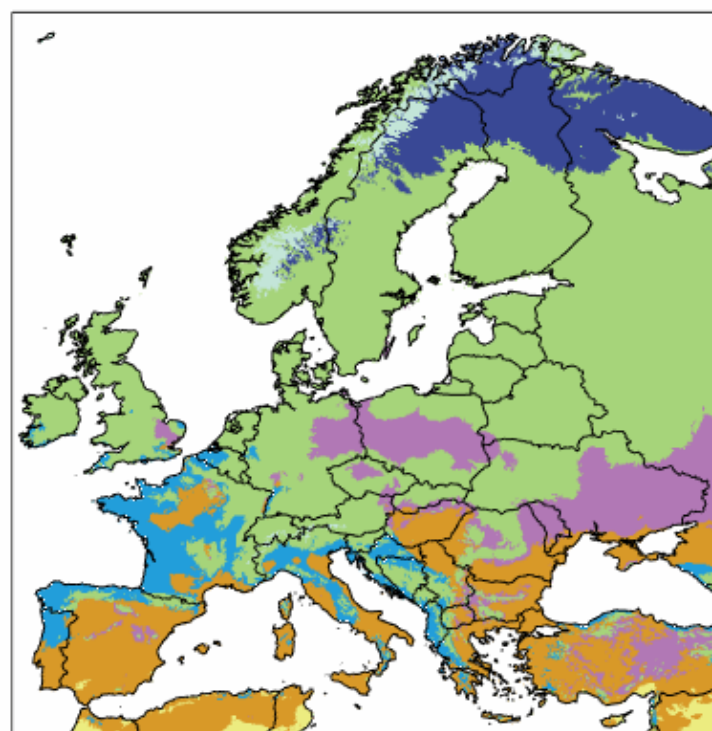
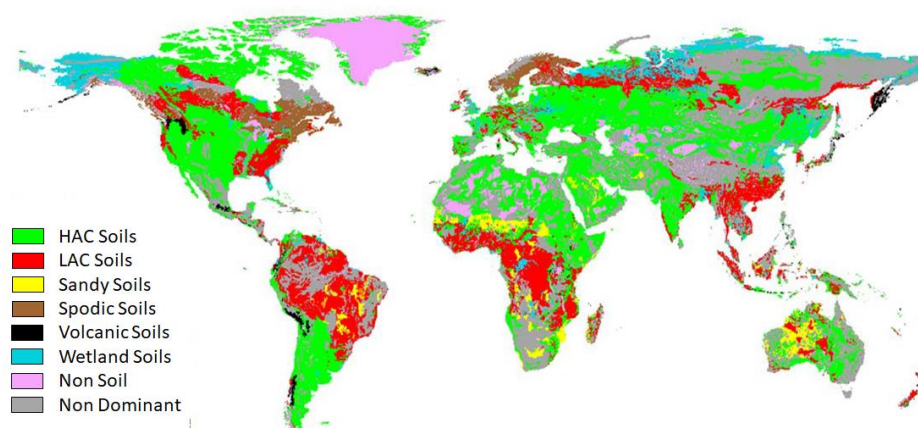


Figure 12: IPCC climate zones adopted in the upscaling model for Europe

#### 4.4.2 Soil data

The soil classification adopted in EX-ACT is based on the classification scheme suggested by Bickel et al. 2006 for simplified soil classification for mineral soil types

based on World Reference Base for Soil Resources (WRB) classification. The result of the classification is shown on Figure 13, taken from the EX-ACT application Help page.



*Figure 13: Representation of IPCC soil categories (EX-ACT Help page)*

The following categories are considered in EX-ACT:

**High Activity Clay Soils (HAC).** These mineral soils are light to moderately weathered soils which are dominated by 2:1 silicate clay minerals. Following the World Reference Base for Soil Resources (WRB), they include Leptosols, Vertisols, Kastanozems, Chernozems, Phaeozems, Luvisols, Alisols, Albeluvisols, Solonetz, Calcisols, Gypsisols, Umbrisols, Cambisols, and Regosols. In accordance with the USDA soil taxonomy, HAC soils include Mollisols, Vertisols, high-base status Alfisols, Aridisols, Inceptisols. As exception Ferric and Plinthic Luvisol are categorized as LAC Soils.

**Low Activity Clay Soils (LAC).** LAC soils are highly weathered soils, dominated by a composition of 1:1 clay minerals and amorphous iron and aluminium oxides. In accordance with WRB this includes Acrisols, Lixisols, Nitisols, Ferralsols, Durisols, while in the case of the USDA classification it comprises Ultisols, Oxisols, acidic Alfisols.

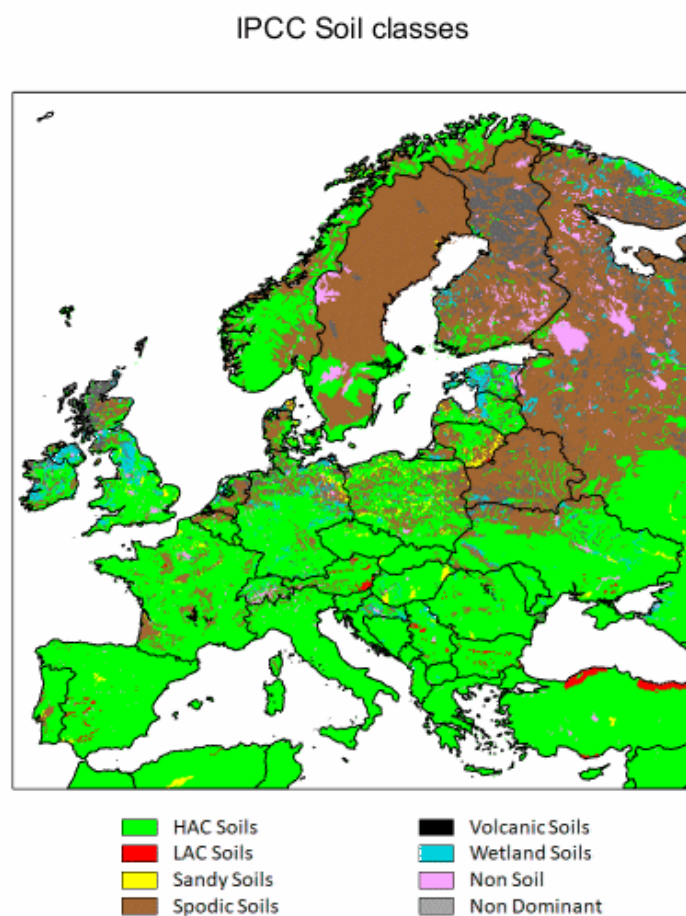
**Sandy Soils** include (regardless of their taxonomic classification) all soils having > 70% sand and < 8% clay, based on standard textural analyses. Following WRB this includes Aerosols, in accordance with the USDA classification it includes Psamments.

**Spodic Soils** are soils exhibiting strong podzolization. Following World Reference Base, this includes Podzols; in the USDA classification it comprises Spodosols.

**Volcanic Soils** are derived from volcanic ash with allophanic mineralogy. In accordance with the WRB classification they comprise Andosols, following the USDA taxonomy they comprise Andisols.

**Wetland Soils** are defined by restricted drainage leading to periodic flooding and anaerobic conditions. Wetland soils are Gleysols following WRS, and soils in aquatic suborders in the USDA classification.

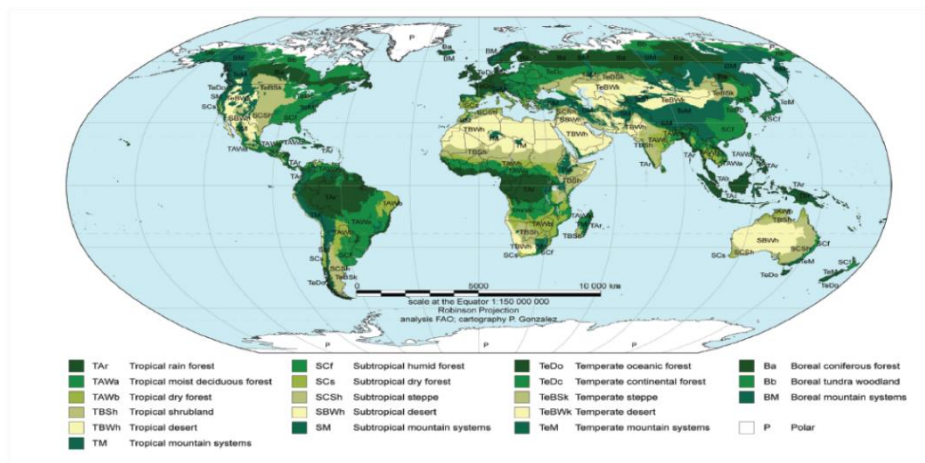
The detailed map of the seven general soil classes for Europe is presented on Figure 14.



*Figure 14: IPCC soil classes adopted in the upscaling model for Europe*

#### 4.4.3 Forest ecological zones data

Forest ecological zones considered in EX-ACT are based on FAO Global Ecological Zones (GEZ) classification and maps (FAO, 2010), which are used to present forest statistics including information on forest cover change. An Ecological Zone (EZ) is defined as a zone or area with broad yet relatively homogeneous natural vegetation formations. World ecological zones are classified into 20 categories as presented in Figure 15. Their identification is based on observed climate and vegetation patterns and they constitute a set of classes that have some ecological meaning that can be more generally understood as broad forest types (e.g. tropical rain forests, boreal forests etc.) (Figure 15).



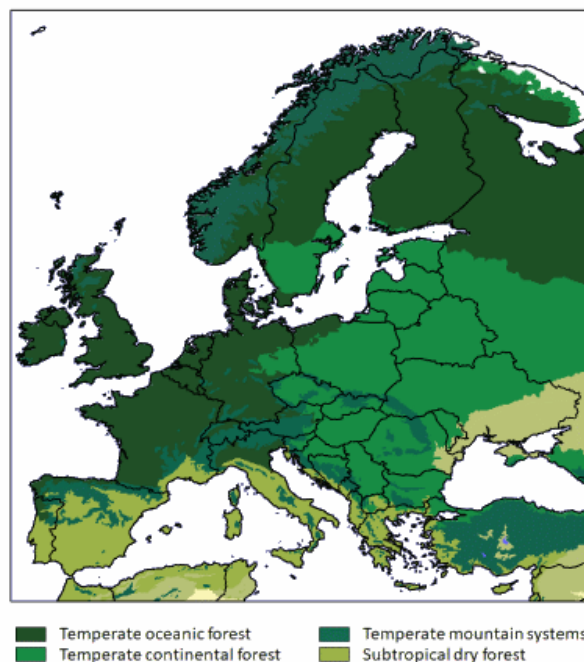
*Figure 15: Representation of FAO ecological zones*

EX-ACT refers to four categories of forest ecological zones:

- Forest type 1: Temperate oceanic forest
- Forest type 2: Temperate continental forest
- Forest type 3: Temperate mountain systems
- Forest type 4: Subtropical dry forest

The distribution of these four forest ecological zones over Europe is shown on Figure 16.

#### Global ecological zones



*Figure 16: FAO ecological zones adopted in the upscaling model for Europe*

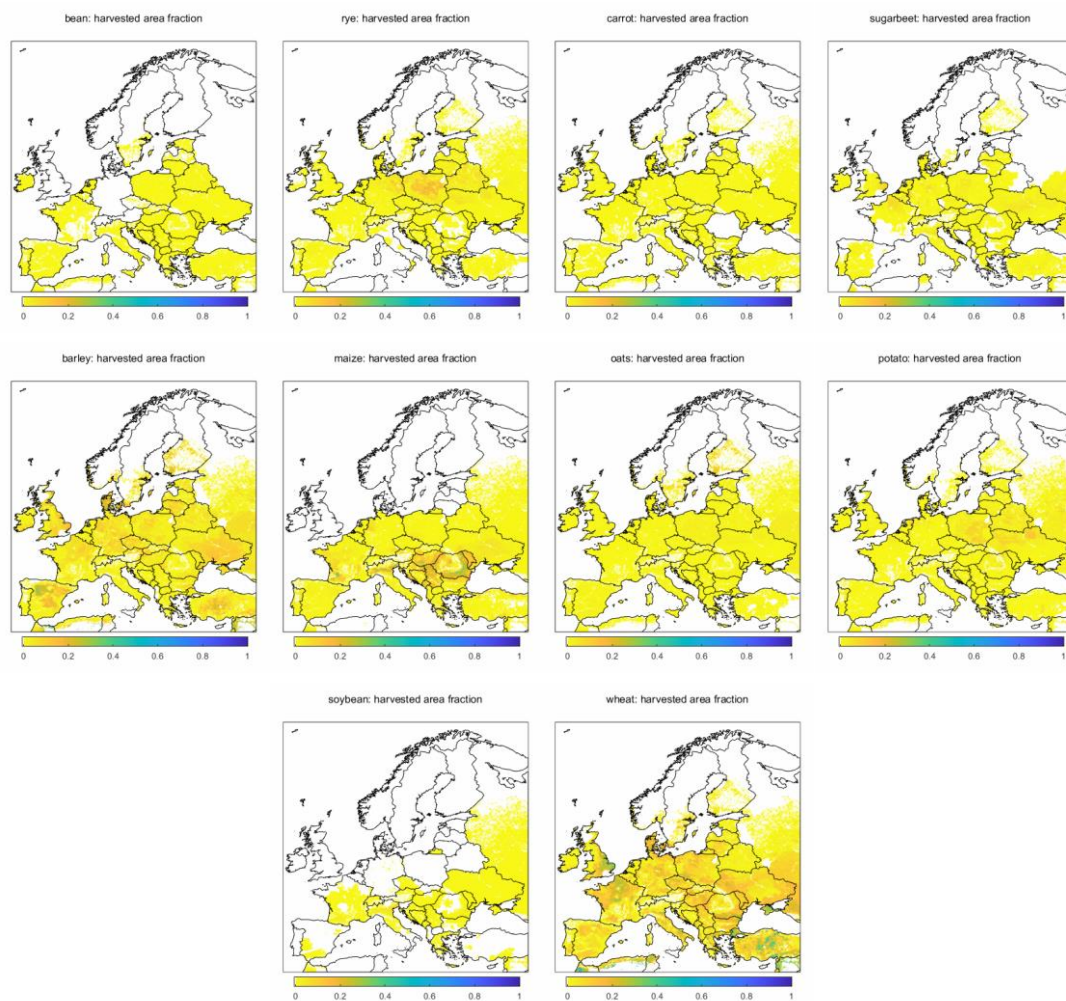
#### 4.4.4 Agriculture data

The analyses in EX-ACT require information on specific crops or crop categories. Information on crops has been taken from Earth Stat. Earth Stat is a collaboration between the Global Landscapes Initiative at the University of Minnesota's Institute on the Environment and the Land Use and Global Environment lab at the University of British Columbia. It serves geographic data sets created by combining national, state, and county level census statistics with a global data set of croplands on a five-arc-minute by five-arc-minute (~10 km by 10 km) latitude/longitude grid (Monfreda et al. 2008). The resulting land use data sets depict the area (harvested) and yield of 175 distinct crops of the world.

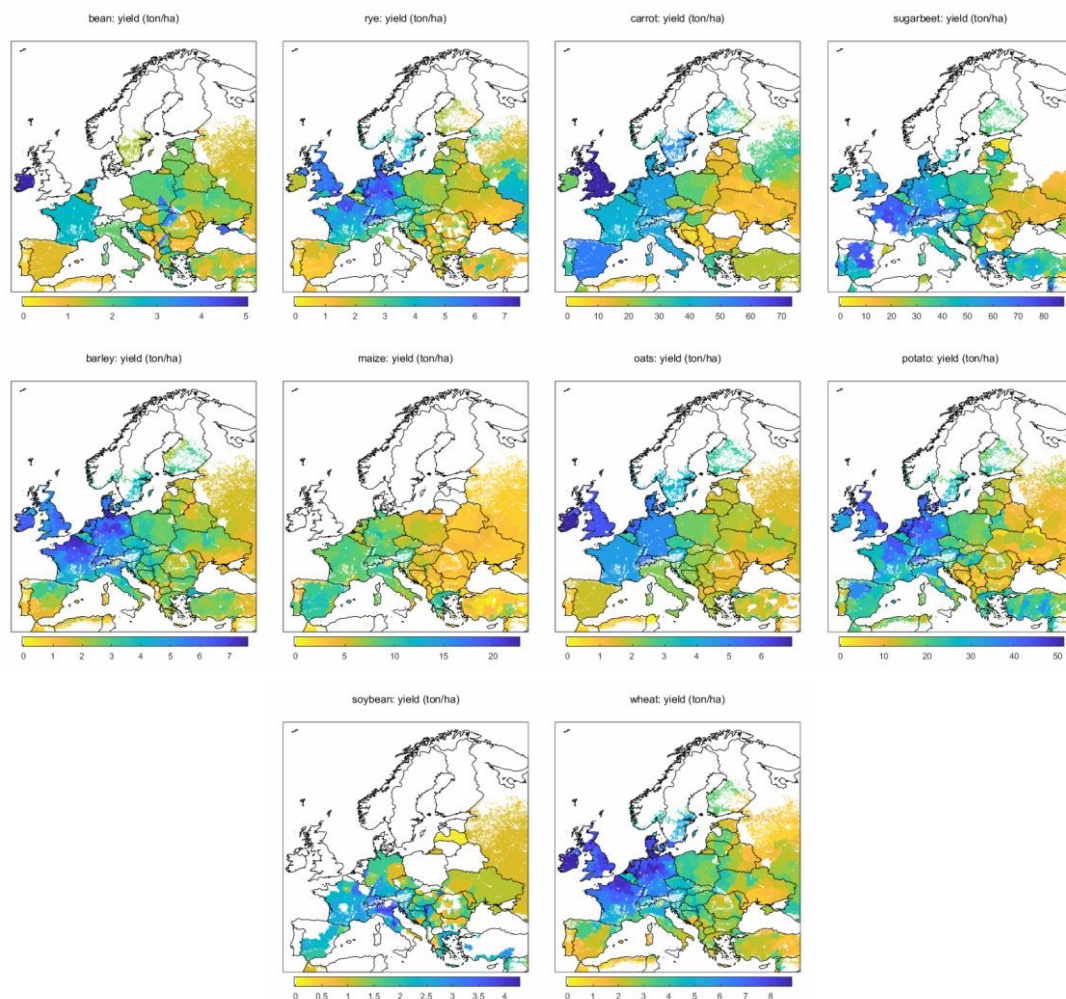
EX-ACT refers to ten crops or categories of annual crops.

- Beans & pulses
- Grains
- Root crops
- Tubers
- Barley
- Maize
- Oats
- Potatoes
- Soybeans
- Wheat

A representative crop was chosen for each crop category: beans were selected for "Beans & pulses", rye was selected for "Grains", carrot was selected for "Root crops" and sugar beet was selected for "Tubers". The other six entries in the list correspond to individual crops. The harvested area fraction and the mean annual yield of these ten representative crops are shown on Figure 17 and Figure 18, respectively.



*Figure 17: Harvested area fraction of ten representative annual crops (data from Earth Stat)*



*Figure 18: Mean annual yield (ton/ha) of ten representative annual crops (data from Earth Stat)*

#### 4.4.5 Land use data

The land use data were taken from the last available update (2018) of the Corine Land Cover (CLC) inventory (Büttner et al. 2021). It consists of an inventory of land cover in 44 classes. CLC uses a Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena and a minimum width of 100 m for linear phenomena. CLC national databases are produced by the Eionet network National Reference Centres Land Cover (NRC/LC). CLC is produced by the majority of countries by visual interpretation of high-resolution satellite imagery. In a few countries semi-automatic solutions are applied, using national in-situ data, satellite image processing, GIS integration and generalisation. These databases are coordinated and integrated by the European Environmental Agency (EEA) and they are available in the Copernicus programme. The dataset is available at: <https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=download>. An example is shown in Figure 19.

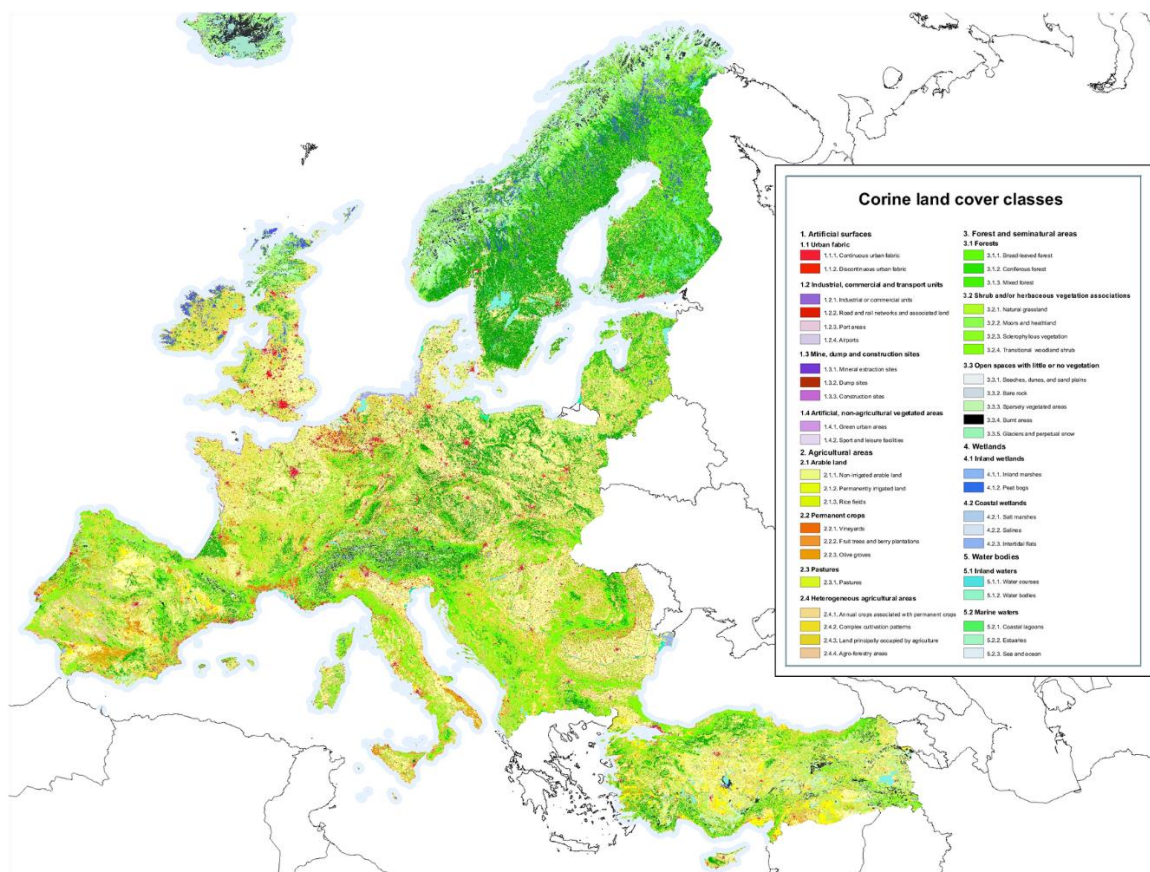


Figure 19: Map of Corine Land Cover (CLC) categories for Europe

The following CLC categories are relevant for the upscaling model:

- 12: Non-irrigated arable land
- 14: Rice fields
- 15: Vineyards
- 16: Fruit trees and berry plantations
- 17: Olive groves
- 18: Pastures
- 19: Annual crops associated with permanent crop
- 21: Land principally occupied by agriculture
- 23 Broad-leaved forest
- 24 Coniferous forest
- 25 Mixed forest
- 26 Natural grasslands
- 36 Peat bogs

## 5 Simulations of the Pilot Modelling Exercises

### 5.1 Definition of the Pilot Modelling Exercises

#### 5.1.1 Pilot Exercise 1a: Reforestation from annual crops

**Objective:** reduce carbon emissions by changing land use from existing annual crops to forest

**Similar to:** 6 (BE) FLANDERS – Flemish Forest Group

**Method in EX-ACT:** Sheet LUC 2.2 Afforestation and reforestation, shown on Figure 20.

| 2.2. Afforestation and Reforestation   |                 |                                   |   |                                       |      |                                      |  |         |         |         |
|--|-----------------|-----------------------------------|---|---------------------------------------|------|--------------------------------------|--|---------|---------|---------|
| AEZ map  |                 | Zone 1 = Temperate oceanic forest |   | Zone 2 = Temperate continental forest |      | Zone 3 = Temperate mountains systems |  |         |         |         |
| Type of vegetation that will be planted  | Fire Use? (y/n) | Previous land use                 | Area that will be afforested/reforested |                                       |      |                                      | Total Emissions (tCO <sub>2</sub> -eq) |         | Balance |         |
|  |                 |                                   | Without                                 | *                                     | With | *                                    | Without                                | With    |         |         |
| Forest Zone 1  | NO              | Annual Crop                       | 0                                       | D                                     | 100  | D                                    | 0                                      | -14,089 | -14,089 |         |
| Select the vegetation  | NO              | Select previous use               | 0                                       | D                                     | 0    | D                                    | 0                                      | 0       | 0       |         |
| Select the vegetation  | NO              | Select previous use               | 0                                       | D                                     | 0    | D                                    | 0                                      | 0       | 0       |         |
| Select the vegetation  | NO              | Select previous use               | 0                                       | D                                     | 0    | D                                    | 0                                      | 0       | 0       |         |
| Select the vegetation  | NO              | Select previous use               | 0                                       | D                                     | 0    | D                                    | 0                                      | 0       | 0       |         |
| Select the vegetation  | NO              | Select previous use               | 0                                       | D                                     | 0    | D                                    | 0                                      | 0       | 0       |         |
| Select the vegetation  | NO              | Select previous use               | 0                                       | D                                     | 0    | D                                    | 0                                      | 0       | 0       |         |
| Select the vegetation  | NO              | Select previous use               | 0                                       | D                                     | 0    | D                                    | 0                                      | 0       | 0       |         |
| * Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines) |                 |                                   |   |                                       |      |                                      |  |         |         |         |
| Tier 2   |                 |                                   |   |                                       |      |                                      | Total Af-/Reforestation                | 0       | -14,089 | -14,089 |

Figure 20: Method used in EX-ACT tool to describe Contract solution 1

**Target region:** land occupied by annual crops. CLC categories:

- Non-irrigated arable land
- Annual crops associated with permanent crop
- Land principally occupied by agriculture

**Induced action:** Land use change: substitute annual crop by forest.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 500 km Standard deviation: 100 km

Participants by contract: Mean: 40 Standard deviation: 20

Area of land unit: Mean: 20 ha

Variables:

Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Sheet 2. LUC

Variable  $x_4$ : Forest Ecological Region (Cell B31)

Sheet 3. Cropland

Variable  $x_5$ : Type of annual crop (Cell C14)

Variable  $x_6$ : Annual crop yield (Cell O14)

Comments:

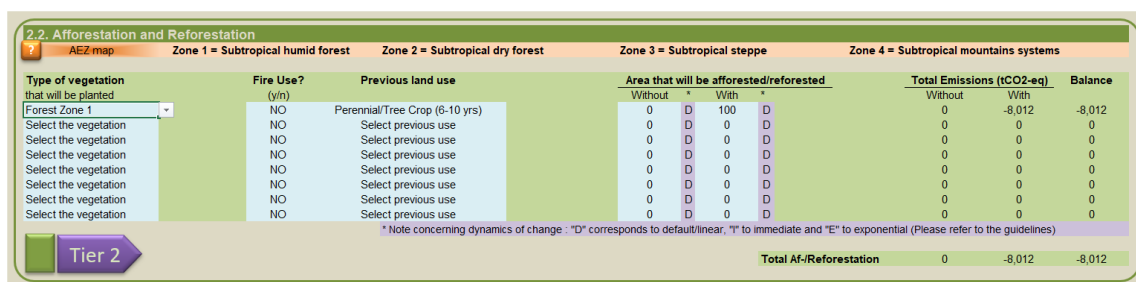
The target cells are identified from Corine land cover. The outcome is sensitive to the crop that will be substituted, to its average yield and to the type of management applied to it prior to the substitution. The existing crop is taken from Earth Stat data, choosing the representative crop with largest cultivated area in the cell. Management is set to maximize improved carbon storage. No management option in existing crop. Residue management is set to burned in existing crop. The variable with largest effect is yield, which is taken from Earth Stat data.

### 5.1.2 Pilot Exercise 1b: Reforestation from perennial tree crops

**Objective:** reduce carbon emissions by changing land use from existing perennial tree crops to forests

**Similar to:** 6 (BE) FLANDERS – Flemish Forest Group

**Method in EX-ACT:** Sheet LUC 2.2 Afforestation and reforestation, shown on Figure 21.



| Type of vegetation that will be planted |  | Fire Use? (y/n) | Previous land use              | Area that will be afforested/reforested |      |         |      | Total Emissions (tCO <sub>2</sub> -eq) |        | Balance |
|---|--|-----------------|--------------------------------|---|------|---------|------|--|--------|---------|
|   |  |                 |                                | Without                                 | With | Without | With | Without                                | With   |         |
| Forest Zone 1                           |  | NO              | Perennial/Tree Crop (6-10 yrs) | 0                                       | 100  | 0       | 0    | 0                                      | -8,012 | -8,012  |
| Select the vegetation                   |  | NO              | Select previous use            | 0                                       | 0    | 0       | 0    | 0                                      | 0      | 0       |
| Select the vegetation                   |  | NO              | Select previous use            | 0                                       | 0    | 0       | 0    | 0                                      | 0      | 0       |
| Select the vegetation                   |  | NO              | Select previous use            | 0                                       | 0    | 0       | 0    | 0                                      | 0      | 0       |
| Select the vegetation                   |  | NO              | Select previous use            | 0                                       | 0    | 0       | 0    | 0                                      | 0      | 0       |
| Select the vegetation                   |  | NO              | Select previous use            | 0                                       | 0    | 0       | 0    | 0                                      | 0      | 0       |
| Select the vegetation                   |  | NO              | Select previous use            | 0                                       | 0    | 0       | 0    | 0                                      | 0      | 0       |
| Select the vegetation                   |  | NO              | Select previous use            | 0                                       | 0    | 0       | 0    | 0                                      | 0      | 0       |
| Select the vegetation                   |  | NO              | Select previous use            | 0                                       | 0    | 0       | 0    | 0                                      | 0      | 0       |
| Total Aff-Reforestation                 |  |                 |                                | 0                                       | 0    | 0       | 0    | 0                                      | -8,012 | -8,012  |

Figure 21: Method used in EX-ACT tool to describe Contract solution 1b

**Target region:** land occupied by perennial tree crops. CLC categories:

- Vineyards
- Fruit trees and berry plantations
- Olive groves

**Induced action:** Land use change: substitute perennial tree crops by forest.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 300 km Standard deviation: 60 km

Participants by contract: Mean: 30 Standard deviation: 20

Area of land unit: Mean: 6 ha

Variables:

## Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

## Sheet 2. LUC

Variable  $x_4$ : Forest Ecological Region (Cell B31)

## Comments:

The target cells are identified from Corine land cover. The outcome is sensitive to residue management, which is set to burned in existing crop. Although there a cell to specify yield in perennial/tree crop, the result does not show any sensitivity to it, so the yield variable is not included in the model.

### 5.1.3 Pilot Exercise 1c: Reforestation from grassland

**Objective:** reduce carbon emissions by changing land use from existing grassland to forests

**Similar to:** 6 (BE) FLANDERS – Flemish Forest Group

**Method in EX-ACT:** Sheet LUC 2.2 Afforestation and reforestation, shown on Figure 22.

2.2. Afforestation and Reforestation

AEZ map

Zone 1 = Subtropical humid forest

Zone 2 = Subtropical dry forest

Zone 3 = Subtropical steppe

Zone 4 = Subtropical mountains systems

| Type of vegetation that will be planted | Fire Use? (y/n) | Previous land use   | Area that will be afforested/reforested |      |         |      | Total Emissions (tCO <sub>2</sub> -eq) |        | Balance |
|---|-----------------|---------------------|---|------|---------|------|--|--------|---------|
|   |                 |                     | Without                                 | With | Without | With | Without                                | With   |         |
| Forest Zone 4                           | NO              | Grassland           | 0                                       | D    | 100     | D    | 0                                      | -9,500 | -9,500  |
| Select the vegetation                   | NO              | Select previous use | 0                                       | D    | 0       | D    | 0                                      | 0      | 0       |
| Select the vegetation                   | NO              | Select previous use | 0                                       | D    | 0       | D    | 0                                      | 0      | 0       |
| Select the vegetation                   | NO              | Select previous use | 0                                       | D    | 0       | D    | 0                                      | 0      | 0       |
| Select the vegetation                   | NO              | Select previous use | 0                                       | D    | 0       | D    | 0                                      | 0      | 0       |
| Select the vegetation                   | NO              | Select previous use | 0                                       | D    | 0       | D    | 0                                      | 0      | 0       |
| Select the vegetation                   | NO              | Select previous use | 0                                       | D    | 0       | D    | 0                                      | 0      | 0       |
| Select the vegetation                   | NO              | Select previous use | 0                                       | D    | 0       | D    | 0                                      | 0      | 0       |
| Select the vegetation                   | NO              | Select previous use | 0                                       | D    | 0       | D    | 0                                      | 0      | 0       |
| Total Aff-Reforestation                 |                 |                     | 0                                       |      |         |      | 0                                      | -9,500 | -9,500  |

Tier 2

\* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

Figure 22: Method used in EX-ACT tool to describe Contract solution 1c

**Target region:** land occupied by perennial tree crops. CLC categories:

- Pastures
- Natural grasslands

**Induced action:** Land use change: substitute grassland by forest.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 500 km Standard deviation: 100 km

Participants by contract: Mean: 30 Standard deviation: 15

Area of land unit: Mean: 20 ha

Variables:

Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Sheet 2. LUC

Variable  $x_4$ : Forest Ecological Region (Cell B31)

Random options:

Sheet 5. Management

Variable  $x_9$ : Degradation level of the grassland. Initial state (Cell D14)

Variable  $x_9$ : Degradation level of the grassland. Final state: Without project (Cell J14)

Variable  $x_9$ : Degradation level of the grassland. Final state: With project (Cell N14)

Comments:

The target cells are identified from Corine land cover. The outcome is sensitive to residue management, which is set to burned in existing crop. Although there is a cell to specify grassland yield at the beginning and at the end of the project, the result does not show any sensitivity to it, so the yield variable is not included in the model.

#### 5.1.4 Pilot Exercise 2a: Land Use Change from annual crop to perennial tree crop

**Objective:** reduce carbon emissions by change land use from existing annual crops to perennial tree crops

Similar to:

**Method in EX-ACT:** Sheet LUC 2.3 Other Land Use Changes, shown on Figure 23.

2.3. Other Land Use Changes

| Fill with your description   | Initial land use | Final land use        | Message         | Fire Use?<br>(y/n) | Area transformed (ha) |      | Total Emissions (tCO <sub>2</sub> -eq) |      | Balance |
|--|------------------|-----------------------|-----------------|--------------------|-----------------------|------|--|------|---------|
|  |                  |                       |                 |                    | Without               | With | Without                                | With |         |
|  | Annual Crop      | Perennial/Tree Crop   |                 | NO                 | 0                     | 100  | 0                                      | 18   | 18      |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| Select Initial Land Use  |                  | Select Final Land Use | Fill initial LU | NO                 | 0                     | 0    | 0                                      | 0    | 0       |
| * Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines) |                  |                       |                 |                    |                       |      |  |      |         |
| <b>Total Other LUC</b>   |                  |                       |                 |                    |                       |      | 0                                      | 18   | 18      |

Tier 2

Figure 23: Method used in EX-ACT tool to describe Contract solution 2

**Target region:** land occupied by annual crops. CLC categories:

- Non-irrigated arable land
- Annual crops associated with permanent crop
- Land principally occupied by agriculture

**Induced action:** Land use change: substitute annual crop by perennial tree crop.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 300 km Standard deviation: 80 km

Participants by contract: Mean: 20 Standard deviation: 10

Area of land unit: Mean: 10 ha

Variables:

Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Sheet 3. Cropland

Variable  $x_5$ : Type of annual crop (Cell C16)

Variable  $x_6$ : Annual crop yield (Cell O16)

Comments:

The target cells are identified from Corine land cover. The outcome is sensitive to the crop that will be substituted, to its average yield and to the type of management applied to it prior to the substitution. The existing crop is taken from Earth Stat data, choosing the representative crop with largest cultivated area in the cell. Management is set to maximize improved carbon storage. No management option in existing crop. Residue management is set to burned in existing crop. The variable with largest effect is yield, which is taken from Earth Stat data. Although there a cell to specify yield also in perennial/tree crop, the result does not show any sensitivity to it, so that yield variable is not included in the model.

**Objective:** reduce carbon emissions by change land use from existing annual crops to perennial tree crops

**Method in EX-ACT:** Sheet LUC 2.3 Other Land Use Changes, shown on Figure 24.

Figure 24: Method used in EX-ACT tool to describe Contract solution 2b

- Non-irrigated arable land
- Annual crops associated with permanent crop
- Land principally occupied by agriculture

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 300 km Standard deviation: 80 km

Participants by contract: Mean: 20 Standard deviation: 10

Area of land unit: Mean: 10 ha

Variables:

Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)Variable  $x_5$ : Moisture Regime (Cell C12)Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Sheet 3. Cropland

Variable  $x_5$ : Type of annual crop (Cell C16)

Variable  $x_6$ : Annual crop yield (Cell O16)

Random options:

Sheet 5. Management

Variable  $x_9$ : Degradation level of the grassland. Initial state (Cell D15)

Variable  $x_9$ : Degradation level of the grassland. Final state: Without project (Cell J15)

Variable  $x_9$ : Degradation level of the grassland. Final state: With project (Cell N15)

Comments:

The target cells are identified from Corine land cover. The outcome is sensitive to the crop that will be substituted, to its average yield and to the type of management applied to it prior to the substitution. The existing crop is taken from Earth Stat data, choosing the representative crop with largest cultivated area in the cell. Management is set to maximize improved carbon storage. No management option in existing crop. Residue management is set to burned in existing crop. The variable with largest effect is yield, which is taken from Earth Stat data. Although there a cell to specify grassland yield at the beginning and at the end of the project, the result does not show any sensitivity to it, so the yield variable is not included in the model.

### 5.1.6 Pilot Exercise 3a: Substitution of annual crop by soybean

**Objective:** reduce carbon emissions by changing existing annual crop to soybean

**Similar to:** 49 (NL) Green Deal Dutch Soy

**Method in EX-ACT:** Sheet Cropland 3.1.2 Annual systems remaining annual systems, shown on Figure 25.

3.1.2. Annual systems remaining annual systems (total area must remain constant)

| Fill with your description | Main season crop | Management options           |                     |                             |                  |                    | Definitions? |         | Yield? |      | Residue management | Yield (t/ha/yr)  | Area (ha) |     |              | Total Emissions (tCO <sub>2</sub> -eq) |                      | Balance |        |        |        |
|----------------------------|------------------|------------------------------|---------------------|-----------------------------|------------------|--------------------|--------------|---------|--------|------|--------------------|------------------|-----------|-----|--------------|--|----------------------|---------|--------|--------|--------|
|                            |                  | Improved agronomic practices | Nutrient management | No till & residue retention | Water management | Manure application | Start        | Without | With   | With |                    |                  | Without   |     |              |  |                      |         |        |        |        |
| description 1              | Wheat            | No                           | No                  | No                          | No               | No                 |              |         |        |      | Burned             | 2 663 283 691    | 100       | 100 | 0            | 0                                      | 321                  | 80      | -241   |        |        |
| description 2              | Soybeans         | Yes                          | Yes                 | Yes                         | Yes              | Yes                |              |         |        |      |                    | 2 135 713 134 76 | 100       | 0   | 0            | 0                                      | -375                 | -1 501  | -1 126 |        |        |
| description 3              | Default          | ?                            | ?                   | ?                           | ?                | ?                  |              |         |        |      | Please select      | 0                | 0         | 0   | 0            | 0                                      | 0                    | 0       | 0      |        |        |
| description 4              | Default          | ?                            | ?                   | ?                           | ?                | ?                  |              |         |        |      | Please select      | 0                | 0         | 0   | 0            | 0                                      | 0                    | 0       | 0      |        |        |
| description 5              | Default          | ?                            | ?                   | ?                           | ?                | ?                  |              |         |        |      | Please select      | 0                | 0         | 0   | 0            | 0                                      | 0                    | 0       | 0      |        |        |
| description 6              | Default          | ?                            | ?                   | ?                           | ?                | ?                  |              |         |        |      | Please select      | 0                | 0         | 0   | 0            | 0                                      | 0                    | 0       | 0      |        |        |
| description 7              | Default          | ?                            | ?                   | ?                           | ?                | ?                  |              |         |        |      | Please select      | 0                | 0         | 0   | 0            | 0                                      | 0                    | 0       | 0      |        |        |
| description 8              | Default          | ?                            | ?                   | ?                           | ?                | ?                  |              |         |        |      | Please select      | 0                | 0         | 0   | 0            | 0                                      | 0                    | 0       | 0      |        |        |
| description 9              | Default          | ?                            | ?                   | ?                           | ?                | ?                  |              |         |        |      | Please select      | 0                | 0         | 0   | 0            | 0                                      | 0                    | 0       | 0      |        |        |
| description 10             | Default          | ?                            | ?                   | ?                           | ?                | ?                  |              |         |        |      | Please select      | 0                | 0         | 0   | 0            | 0                                      | 0                    | 0       | 0      |        |        |
| Total (ha)                 |                  |                              |                     |                             |                  |                    |              |         |        |      |                    | 200              | 100       | 100 | Check areas! |  | Total Annual Systems |         | -54    | -1 421 | -1 369 |

Tier 2

\* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

Figure 25: Method used in EX-ACT tool to describe Contract solution 3

**Target region:** land occupied by annual crops. CLC categories:

- Non-irrigated arable land
- Annual crops associated with permanent crop
- Land principally occupied by agriculture

**Induced action:** Land use change: substitute annual crop by soybean.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 500 km Standard deviation: 100 km

Participants by contract: Mean: 40 Standard deviation: 20

Area of land unit: Mean: 100 ha

Variables:

Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Sheet 3. Cropland

Variable  $x_5$ : Type of annual crop (Cell C22)

Variable  $x_6$ : Annual crop yield (Cell O22)

Variable  $x_6$ : Soybean yield (Cell O23)

Comments:

The target cells are identified from Corine land cover. The outcome is sensitive to the crop that will be substituted, to its average yield and to the type of management applied to it prior to the substitution. The existing crop is taken from Earth Stat data, choosing the representative crop with largest cultivated area in the cell. Management is set to maximize improved carbon storage. No management option in existing crop. Residue management is set to burned in existing crop. The variable with largest effect is yield, which is taken from Earth Stat data.

#### 5.1.7 Pilot Exercise 4a: Improved management in perennial systems

**Objective:** change the carbon sequestration of perennial systems through improved management techniques

**Similar to:** 13 (DE) Viticulture on steep slopes creates diversity in the Moselle valley (Steillagenweinbau schafft Vielfalt – Das Moselprojekt); 20 (ES) Organic wine in Rueda, Spain (Rueda); 21 (ES) Beneficial practices monitoring in Olive crops in the framework of the new eco-schemes; 22 (ES) Integrated production in olive groves

**Method in EX-ACT:** Sheet Cropland 3.2.2 Perennial systems remaining perennial systems, shown on Figure 26.

3.2.2. Perennial systems remaining perennial systems (total area must remain constant)

Fill with your description

|                                     | Residue/ biomass burning | Yield (t/ha/yr) | Area (ha) |         |      | Total Emissions (tCO <sub>2</sub> -eq) |      | Balance |
|-------------------------------------|--------------------------|-----------------|-----------|---------|------|--|------|---------|
|                                     |                          |                 | Start     | Without | With | Without                                | With |         |
| Existing system                     | YES                      | 50              | 50        | 50      | 0    | 315                                    | 79   | -236    |
| Improved system                     | NO                       | 50              | 0         | 0       | 50   | -41                                    | -165 | -124    |
| Enter description of your system 3  | NO                       | 0               | 0         | 0       | 0    | 0                                      | 0    | 0       |
| Enter description of your system 4  | NO                       | 0               | 0         | 0       | 0    | 0                                      | 0    | 0       |
| Enter description of your system 5  | NO                       | 0               | 0         | 0       | 0    | 0                                      | 0    | 0       |
| Enter description of your system 6  | NO                       | 0               | 0         | 0       | 0    | 0                                      | 0    | 0       |
| Enter description of your system 7  | NO                       | 0               | 0         | 0       | 0    | 0                                      | 0    | 0       |
| Enter description of your system 8  | NO                       | 0               | 0         | 0       | 0    | 0                                      | 0    | 0       |
| Enter description of your system 9  | NO                       | 0               | 0         | 0       | 0    | 0                                      | 0    | 0       |
| Enter description of your system 10 | NO                       | 0               | 0         | 0       | 0    | 0                                      | 0    | 0       |
| <b>Total (ha)</b>                   |                          |                 | 100       | 50      | 50   |  |      |         |

\* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Tier 2**

**Total Perennial Systems** 274 -86 -300

Figure 26: Method used in EX-ACT tool to describe Contract solution 4

**Target region:** land occupied by perennial systems. CLC categories:

- Vineyards
- Fruit trees and berry plantations
- Olive groves

**Induced action:** Improve management techniques to reduce emissions and enhance carbon sequestration.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 300 km Standard deviation: 60 km

Participants by contract: Mean: 30 Standard deviation: 20

Area of land unit: Mean: 6 ha

Variables:

Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Comments:

The target cells are identified from Corine land cover. Residue management is set to burned in existing crop. Although there a cell to specify yield in perennial/tree crop, the result does not show any sensitivity to it, so the yield variable is not included in the model.

### 5.1.8 Pilot Exercise 4b: Improved management in rice

**Objective:** change the carbon sequestration of rice fields through improved management techniques

**Similar to:** 19 (ES) Cooperative rice production in coastal wetlands in Southern Spain

**Method in EX-ACT:** Sheet Cropland 3.2.3 Flooded rice remaining flooded rice, shown on Figure 27.



Figure 27: Method used in EX-ACT tool to describe Contract solution 5

**Target region:** land occupied by rice crops. CLC categories:

- Rice fields

**Induced action:** Improve management techniques to reduce emissions and enhance carbon sequestration.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 200 km Standard deviation: 40 km

Participants by contract: Mean: 20 Standard deviation: 5

Area of land unit: Mean: 5 ha

Variables:

Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Random options:

Sheet 3. Cropland

Variable  $x_7$ : Organic amendment type for rice (straw or other): Without project (Cell O83)

Variable  $x_7$ : Organic amendment type for rice (straw or other): With project (Cell O84)

Comments:

The target cells are identified from Corine land cover. Management is set to maximize improved carbon storage. Without project: (a) During the cultivation period: Irrigated: Continuously flooded; (b) Before the cultivation period: Flooded pre-season (>30 days). With project: (a) During the cultivation period: Irrigated - Intermittently flooded; (b) Before the cultivation period: Non flooded pre-season >180 days.

**Objective:** change the degradation state of grassland through improved management techniques

**Similar to:** 9 (BG) Conservation of grasslands and meadows of high natural value through support for local livelihoods; 12 (BG) Conservation and restoration of grasslands in Strandzha and Sakra mountains for restoring local biodiversity and endangered bird species; 29 (FR) Eco-grazing - Grazing for ecological grasslands maintenance in the green areas of Brest Metropole; 36 (IRL) BRIDE - Biodiversity Regeneration in a Dairying Environment; 50 (NL) Biodiversity monitor for dairy farming

**Method in EX-ACT:** Sheet Grassland 4.1.2 Grassland systems remaining grassland systems, shown on Figure 28.

| 4.1.2. Grassland systems remaining grassland systems (total area must remain constant) |                   |                              |  |                     |  |                       |        |                    |        |       |                   |           |       |  |      |         |      |      |
|--|-------------------|------------------------------|--|---------------------|--|-----------------------|--------|--------------------|--------|-------|-------------------|-----------|-------|--|------|---------|------|------|
| Fill with your description   |                   | Final state of the grassland |  |                     |  | Fire use to manage?   |        |                    |        | Yield |                   | Area (ha) |       | Total Emissions (tCO <sub>2</sub> -eq) |      | Balance |      |      |
| Initial State  |                   | Without project              |  | With project        |  | Periodicity (without) |        | Periodicity (with) |        | Start | Without (t/ha/yr) | With      | Start | Without                                | With |         |      |      |
|  |                   |                              |  |                     |  | (y/m)                 | (year) | (y/m)              | (year) |       |                   |           |       |  |      |         |      |      |
| Existing system  | Severely Degraded | Severely Degraded            |  | Moderately Degraded |  | YES                   | 5      | NO                 | 5      | 5     | 100               | 100       | D     | 100                                    | D    | 31      | -275 | -306 |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |
|  | Select state      | Select state                 |  | Select state        |  | NO                    | 5      | NO                 | 5      | 0     | 0                 | D         | 0     | D                                      | 0    | 0       | 0    | 0    |

Tier 2

\* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

|                         |  |  |  |  |  |  |  |  |  |  |  |  |  |    |      |      |
|-------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|----|------|------|
| Total Grassland Systems |  |  |  |  |  |  |  |  |  |  |  |  |  | 31 | -275 | -306 |
|-------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|----|------|------|

Figure 28: Method used in EX-ACT tool to describe Contract solution 6

**Target region:** land occupied by grassland. CLC categories:

- Pastures
- Natural grasslands

**Induced action:** Improve management to avoid degradation.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 500 km Standard deviation: 100 km

Participants by contract: Mean: 30 Standard deviation: 15

Area of land unit: Mean: 20 ha

### Variables:

## Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Random options:

Sheet 5. Management

Variable  $x_9$ : Degradation level of the grassland. Initial state (Cell D22)

Variable  $x_9$ : Degradation level of the grassland. Final state: Without project (Cell J22)

Variable  $x_9$ : Degradation level of the grassland. Final state: With project (Cell N22)

Comments:

The target cells are identified from Corine land cover. Although there is a cell to specify grassland yield at the beginning and at the end of the project, the result does not show any sensitivity to it, so the yield variable is not included in the model. This model requires Tier 2 values for carbon stocks as a function of degradation state because default values are set to zero. Values were taken from Janowiak et al. 2017. They provide a figure where total Carbon pool is estimated as 8014 gr/m<sup>2</sup> (80.14 ton C/ha). They state that soils in the Midwest have lost 25 to 40 metric tons of carbon per hectare due to cultivation. They also say that the recovery of soil carbon is typically a slow process. We estimate a fluctuation of 10% of total carbon stock due to degradation state:

| Customer                | Corresponding soil C stocks (tC/ha) |
|-------------------------|-------------------------------------|
| Non degraded            | 80                                  |
| Severely Degraded       | 72                                  |
| Moderately Degraded     | 74                                  |
| Improved without inputs | 76                                  |
| Improved with inputs    | 78                                  |
| improvement             |                                     |

#### 5.1.10 Pilot Exercise 5b: Forest degradation and management

**Objective:** change the degradation state of forests through improved management techniques

**Similar to:** 6 (BE) FLANDERS – Flemish Forest Group, 23 (US) Forest Bank (a forest conservation program in Indiana and Virginia, US), 24 (FI) Protected areas of private forests as tourism destination in Kuusamo; 27 (FI) Green jointly owned forest - TUOHI

**Method in EX-ACT:** Sheet Management 5.1 Forest degradation and management, shown on Figure 29.

Figure 29: Method used in EX-ACT tool to describe Contract solution 7

- Broad-leaved forest
- Coniferous forest
- Mixed forest

Comments:

The target cells are identified from Corine land cover. No fire occurrence was considered.

### 5.1.11 Pilot Exercise 5c: Restoration of drained peatland

**Objective:** recover carbon stocks in drained peatlands

**Similar to:** 25 (FI) Carbon Market (Hiilipörssi) – a marketplace for the restoration of ditched peatlands

**Method in EX-ACT:** Sheet Management 5.2. Degradation and management of organic soils (peatlands), shown on Figure 30.

| 5.2. Degradation and management of organic soils (peatlands)   |  |            |      |         |      |                              |            |      |   |                           |         |         |
|--|--|------------|------|---------|------|------------------------------|------------|------|---|---------------------------|---------|---------|
| 5.2.1. Drainage of organic soils   |  |            |      |         |      |                              |            |      |   |                           |         |         |
| Type of vegetation concerned by drainage   | Surfaces of drained organic soils (ha) |            |      |         |      | Percentage (area) of ditches |            |      | This should concern only area not accounted for elsewhere | Total Emissions (tCO2-eq) | Balance |         |
|  | Start                                  | At the end |      | Without | With | Start                        | At the end |      |   |                           |         |         |
|  |  | Without    | With |         |      |                              | Without    | With |   |                           |         |         |
| Forest   | 100                                    | 100        | D    | 0       | D    | 49%                          | 49%        | 15%  | 0   | 14,671                    | -11,003 |         |
| Plantation   | 0                                      | 0          | D    | 0       | D    | 5%                           | 5%         | 5%   | 0   | 0                         | 0       |         |
| Annual   | 0                                      | 0          | D    | 0       | D    | 5%                           | 5%         | 5%   | 0   | 0                         | 0       |         |
| Perennial  | 0                                      | 0          | D    | 0       | D    | 5%                           | 5%         | 5%   | 0   | 0                         | 0       |         |
| Grassland  | 0                                      | 0          | D    | 0       | D    | 5%                           | 5%         | 5%   | 0   | 0                         | 0       |         |
| * Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines) |  |            |      |         |      |                              |            |      |   |                           |         |         |
| Total for Drainage   |  |            |      |         |      |                              |            |      |   | 14,671                    | 3,668   | -11,003 |

Figure 30: Method used in EX-ACT tool to describe Contract solution 8

**Target region:** land occupied by peatlands. CLC categories:

- Peat bogs

**Induced action:** Restore drained peatlands by filling and damming the ditches.

Monte Carlo parameters:

Number of contracts: 10

Size of the region of influence: Mean: 50 km Standard deviation: 10 km

Participants by contract: Mean: 20 Standard deviation: 4

Area of land unit: Mean: 50 ha

Variables:

Sheet 1. Description

Variable  $x_1$ : Climate (Cell C11)

Variable  $x_2$ : Moisture Regime (Cell C12)

Variable  $x_3$ : Dominant Regional Soil Type (Cell C15)

Random options:

Sheet 5. Management

Variable  $x_{10}$ : Percentage (area) of ditches. Initial state (Cell M35)

Variable  $x_{10}$ : Percentage (area) of ditches. Final state: Without project (Cell N35)

Variable  $x_{10}$ : Percentage (area) of ditches. Final state: With project (Cell P35)

## Comments:

The target cells are identified from Corine land cover. Percentage area of ditches was estimated between 40%-90%. After the project, 20%-70% of that area was restored.

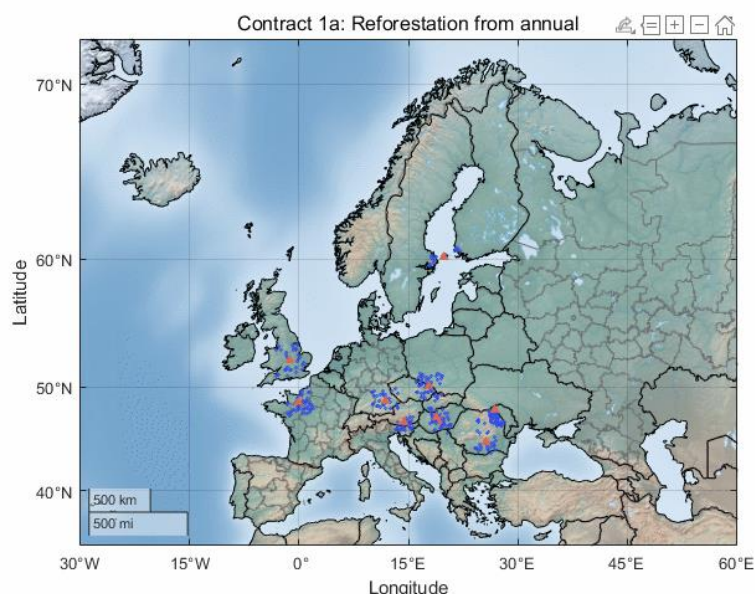
## 5.2 Simulations in the of the selected Pilot Modelling Exercises

The results obtained in the random simulation of contracts are presented in this section. For each contract time, we present the location of the contracts simulates, a summary table with the results and an analysis of the role of explicative variables.

An EX\_ACT spreadsheet was prepared for each Pilot Modelling Exercises. A Matlab script was developed to perform the Monte Carlo simulation of contract development and participation recruitment. Once the participants were identified, the geospatial databases were queried to obtain local values of the variables relevant for the EX-ACT analysis. A table was prepared with the values of these variables for each participant in every contract. The EX-ACT model was then used to estimate the outcome of the implementation of the measures incentivized by the contract, expressed in net reduction of carbon emissions in ton C-qe/ha.yr.

### 5.2.1 Pilot Exercise 1a: Reforestation from annual crops

The location of the random contracts simulated for type 1a are presented on Figure 31. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by annual crops (Non-irrigated arable land, Annual crops associated with permanent crop and Land principally occupied by agriculture) in a region of 500 km to the side around the centroid.



*Figure 31: Location of random simulated contracts of type 1a*

The mean results obtained in the simulation of contracts of type 1 are presented on Table 7. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 15.66 tC/ha.yr.

*Table 7: Mean results obtained in the simulation of contracts of type 1a*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 46.93    | 19.49   | 30           | 22.39          | 13.27                              | 297.00          | 8910        |
| 2        | 48.34    | 0.33    | 47           | 19.46          | 16.03                              | 311.90          | 14660       |
| 3        | 48.91    | 11.66   | 31           | 21.67          | 14.81                              | 320.96          | 9950        |
| 4        | 50.10    | 17.73   | 54           | 21.46          | 17.06                              | 366.06          | 19767       |
| 5        | 47.22    | 26.76   | 68           | 19.54          | 17.26                              | 337.29          | 22936       |
| 6        | 46.53    | 14.61   | 33           | 22.02          | 16.06                              | 353.59          | 11668       |
| 7        | 60.16    | 19.52   | 15           | 15.65          | 17.39                              | 272.15          | 4082        |
| 8        | 47.26    | 18.87   | 23           | 23.21          | 13.72                              | 318.44          | 7324        |
| 9        | 44.69    | 25.63   | 27           | 19.20          | 13.88                              | 266.52          | 7196        |
| 10       | 52.27    | -0.98   | 36           | 21.73          | 14.79                              | 321.35          | 11568       |
| Mean     |          |         | 36.4         | 20.72          | 15.66                              | 324.34          | 11806       |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 32. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. The best results are obtained for contract number 7, with a net reduction of 17.39 tC/ha.yr. The minimum reduction is obtained for contract number 1, with 13.27 tC/ha.yr. The largest variability is shown by contract number 6, with reductions ranging from 10.52 tC/ha.yr to 17.79 tC/ha.yr. Contract number 1 shows the least variability, with reductions ranging from 12.75 tC/ha.yr to 13.34 tC/ha.yr.

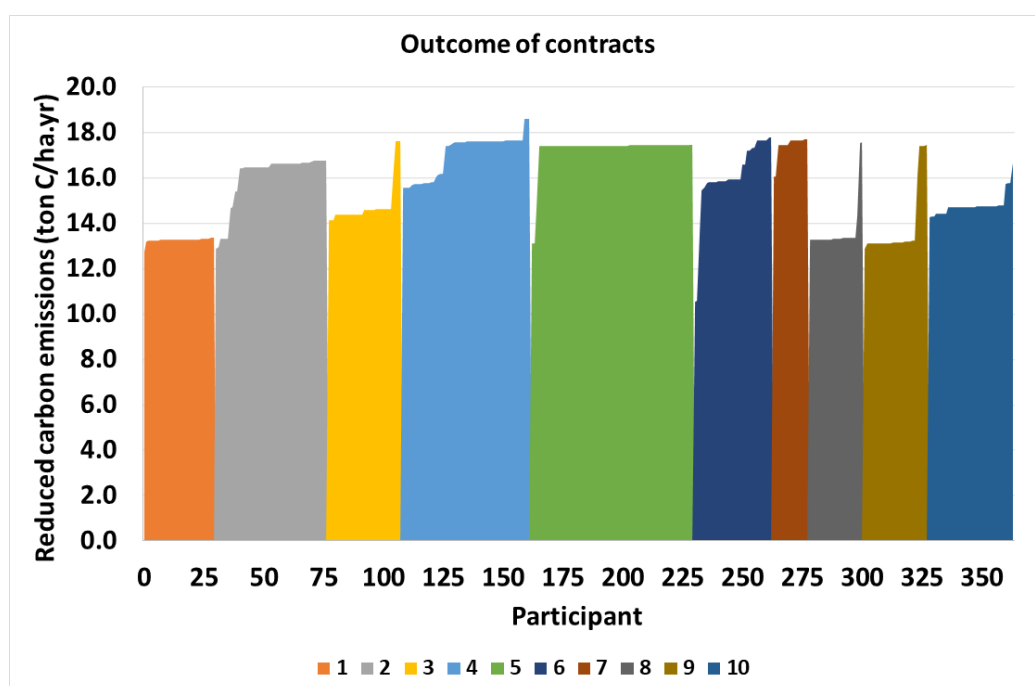
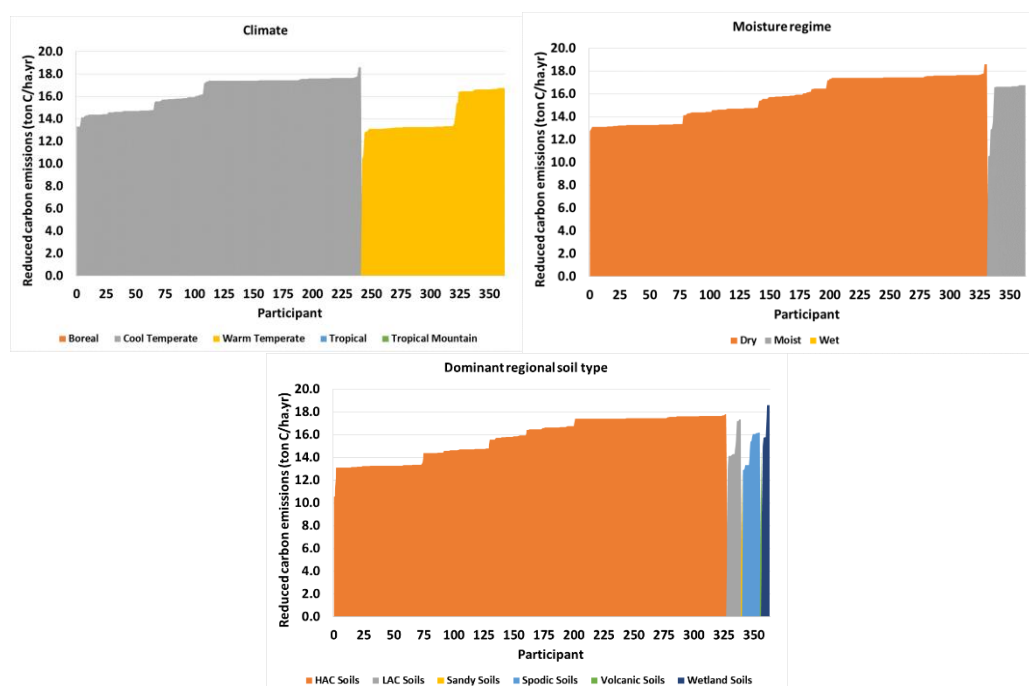


Figure 32: Distribution of net results as a function of contract for type 1a

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* category is shown on Figure 33. The upper row shows variables 1, Climate and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. The dominant climate is Cool Temperate, with 66% of the participants. The best performance is obtained for this type of climate, with a mean reduction of 16.41 tC/ha.yr. The dominant moisture regime is Dry, with 91% of the participants. The best performance is obtained for the Moist moisture regime, with a mean reduction of 15.95 tC/ha.yr. The dominant soil type is HAC Soils, with 90% of the participants. The best performance is obtained for Wetland Soils, with a mean reduction of 16.77 tC/ha.yr.

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *LUC* and *Cropland* categories is shown on Figure 34. The upper row shows variables 4, Forest ecological zone and 5, Annual crop. The lower row shows variable 6, Annual crop yield. The dominant ecological zone

is Forest zone 2, with 60% of the participants. The best performance is obtained for this type of ecological zone, with a mean reduction of 15.99 tC/ha.yr. The dominant annual crop is Wheat, with 51% of the participants, followed by Barley, with 40% of the participants. The best performance is obtained for Potatoes, with a mean reduction of 16.49 tC/ha.yr, but it only affects 1% of the participants. The most abundant range for crop yield is less than 3 t/ha.yr, which corresponds to 30% of the participants. The most effective reduction of emissions is obtained for this crop yield range, with 16.36 tC/ha.yr.



*Figure 33: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description category. Upper row: climate (left) and moisture regime (right). Lower row: soil type*

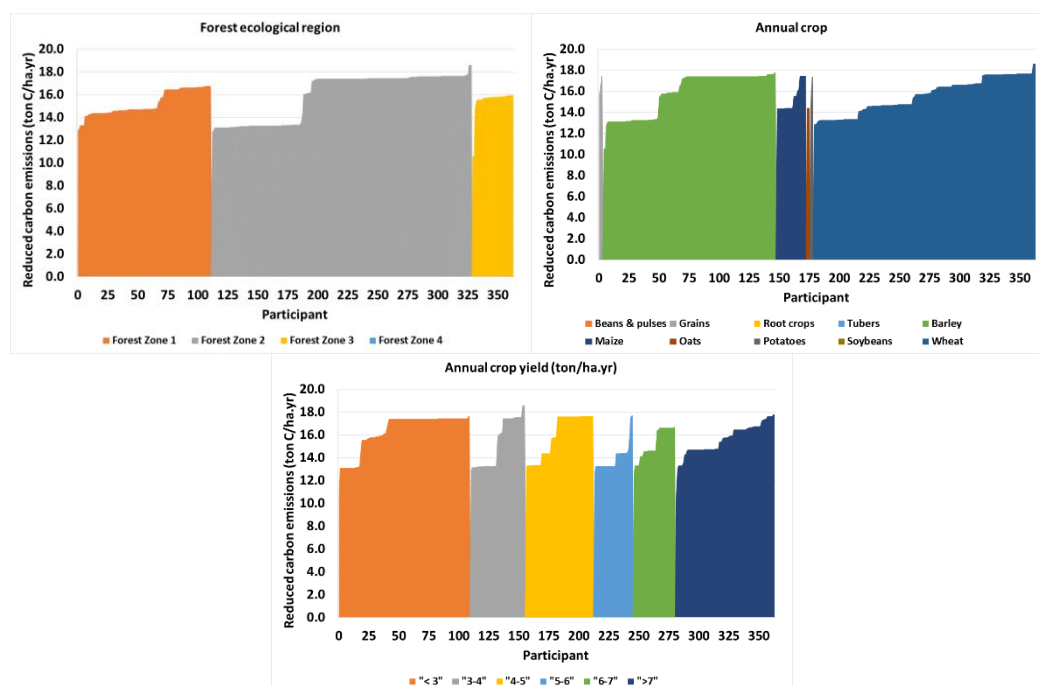


Figure 34: Distribution of net results as a function of the explanatory variables of EX-ACT model in the LUC and Cropland categories. Upper row: ecological region (left) and annual crop (right). Lower row: annual crop yield

The detailed balance of GHG emissions resulting from the application of contracts of type 1a is presented on Table 8. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, soil carbon storage represents 90.6% of total CO<sub>2</sub> balance. The contributions of N<sub>2</sub>O and CH<sub>4</sub> are also shown on the table. Overall, CO<sub>2</sub> represents 97.6% of the reduction, with 0.6% for N<sub>2</sub>O and 1.8% for CH<sub>4</sub>.

Table 8: Detailed balance of GHG emissions obtained in the simulation of contracts of type 1a

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |        |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|--------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With   | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |        |         |
| 1        | -11.92                       | -1.03 | 0.00  | -0.08           | -0.25           | 0.43             | -12.84 | 13.27   |
| 2        | -13.18                       | -2.26 | 0.00  | -0.14           | -0.45           | 0.78             | -15.25 | 16.03   |
| 3        | -13.06                       | -1.33 | 0.00  | -0.10           | -0.32           | 0.56             | -14.25 | 14.81   |
| 4        | -15.40                       | -1.33 | 0.00  | -0.08           | -0.25           | 0.44             | -16.61 | 17.06   |
| 5        | -15.73                       | -1.35 | 0.00  | -0.04           | -0.13           | 0.23             | -17.03 | 17.26   |
| 6        | -13.93                       | -1.66 | 0.00  | -0.11           | -0.35           | 0.62             | -15.44 | 16.06   |
| 7        | -15.88                       | -1.19 | 0.00  | -0.08           | -0.25           | 0.43             | -16.96 | 17.39   |
| 8        | -12.26                       | -1.12 | 0.00  | -0.08           | -0.26           | 0.46             | -13.26 | 13.72   |
| 9        | -12.65                       | -1.04 | 0.00  | -0.05           | -0.15           | 0.25             | -13.63 | 13.88   |

|      |        |       |      |       |       |      |        |       |
|------|--------|-------|------|-------|-------|------|--------|-------|
| 10   | -12.70 | -1.49 | 0.00 | -0.14 | -0.46 | 0.80 | -13.99 | 14.79 |
| Mean | -13.85 | -1.43 | 0.00 | -0.09 | -0.29 | 0.50 | -15.16 | 15.66 |

### 5.2.2 Pilot Exercise 1b: Reforestation from perennial tree crops

The location of the random contracts simulated for type 1b are presented on Figure 35. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by perennial tree crops (Vineyards, Fruit trees and berry plantations, Olive groves) in a region of 300 km to the side around the centroid.

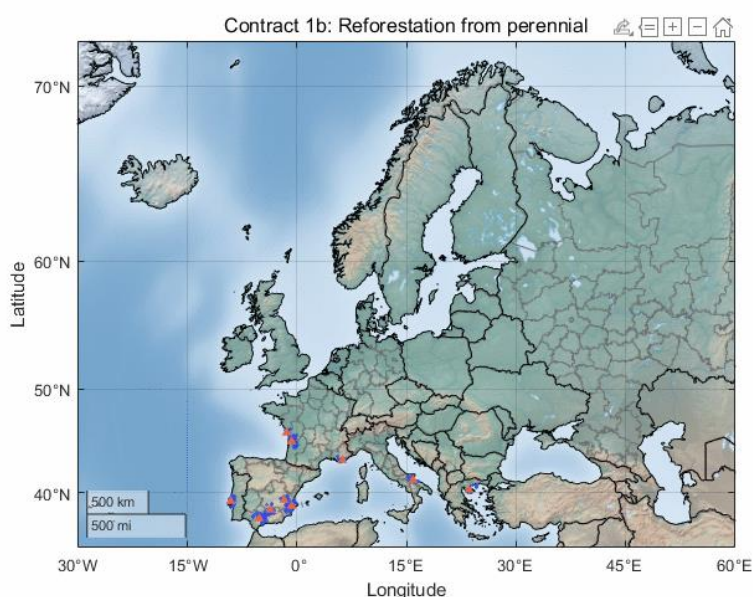


Figure 35: Location of random simulated contracts of type 1b

The mean results obtained in the simulation of contracts of type 1b are presented on Table 9. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 5.43 tC/ha.yr.

Table 9: Mean results obtained in the simulation of contracts of type 1b

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 43.43    | 6.02    | 12           | 5.17           | 4.63                               | 23.95           | 287         |
| 2        | 40.39    | 23.86   | 20           | 5.65           | 4.86                               | 27.47           | 549         |

|      |       |       |      |      |      |       |      |
|------|-------|-------|------|------|------|-------|------|
| 3    | 37.38 | -4.80 | 40   | 7.04 | 4.52 | 31.83 | 1273 |
| 4    | 38.01 | -3.68 | 39   | 5.81 | 4.86 | 28.28 | 1103 |
| 5    | 41.27 | 16.12 | 27   | 6.31 | 4.86 | 30.72 | 829  |
| 6    | 38.64 | -0.95 | 34   | 5.89 | 4.60 | 27.10 | 921  |
| 7    | 39.21 | -8.95 | 46   | 5.62 | 4.80 | 27.02 | 1243 |
| 8    | 45.87 | -1.10 | 29   | 5.42 | 8.21 | 44.50 | 1291 |
| 9    | 39.38 | -1.64 | 34   | 6.08 | 4.86 | 29.56 | 1005 |
| 10   | 45.09 | -0.32 | 35   | 6.15 | 8.21 | 50.49 | 1767 |
| Mean |       |       | 31.6 | 5.99 | 5.43 | 32.50 | 1027 |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 36. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. The EX-ACT model produces very little variability among the different contracts. The best results are obtained for contracts number 7 and 10, with a net reduction of 8.21 tC/ha.yr. The minimum reduction is obtained for contract number 3, with 4.52 tC/ha.yr. The largest variability is shown by contract number 3, with reductions ranging from 0.32 tC/ha.yr to 4.86 tC/ha.yr. Contracts number 4, 8, 9 and 10 do not show any variability, producing constant results of 4.86 tC/ha.yr for contracts 4 and 9 and 8.21 tC/ha.yr for contracts 8 and 10.

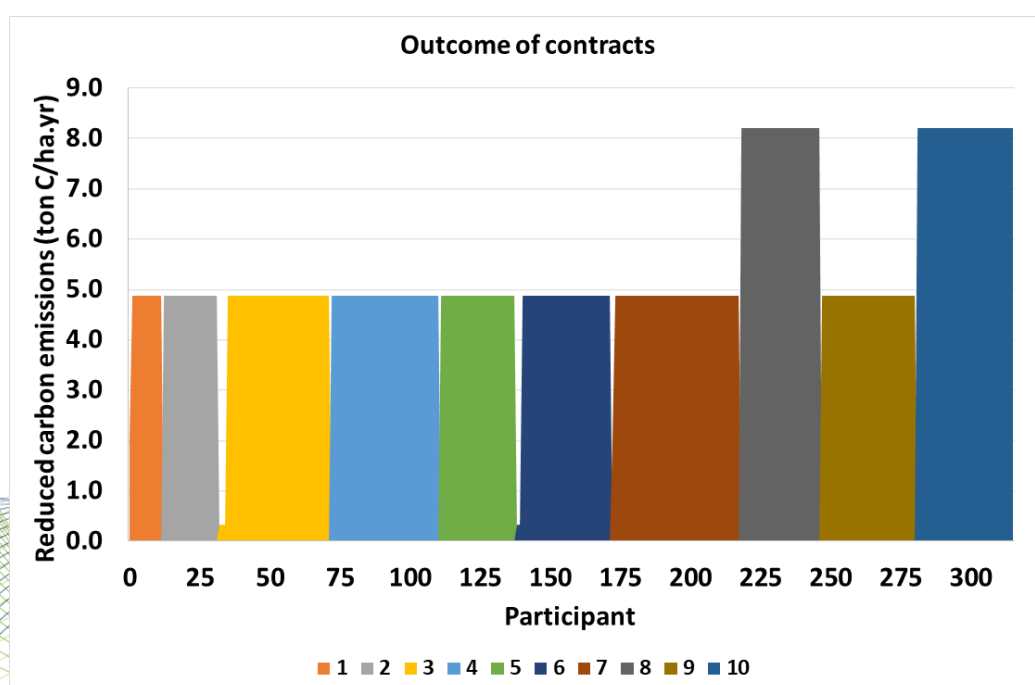


Figure 36: Distribution of net results as a function of contract for type 1b

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* and *LUC* categories is shown on Figure 37. The upper row shows variables 1, Climate and 2, Moisture regime. The lower row shows variables 3, Dominant regional soil type and 4, Forest ecological zone. The only climate category is Warm Temperate, with 100% of the participants. The dominant moisture regime is Dry, with 79% of the participants. The best performance is obtained for the Moist moisture regime, with a mean reduction of 8.02 tC/ha.yr. The dominant soil type is HAC Soils, with 92% of the participants. The best performance is obtained for Sandy Soils and Wetland Soils, with a mean reduction of 8.21 tC/ha.yr. The dominant ecological zone is Forest zone 4, with 80% of the participants, but the best performance is obtained for Forest zone 2, with a mean reduction of 8.21 tC/ha.yr. Clearly, the results of the EX-ACT model are mostly based on moisture regime and ecological zone, which are furthermore highly correlated. Wet moisture regimes in forest zone 2 produce the best results.

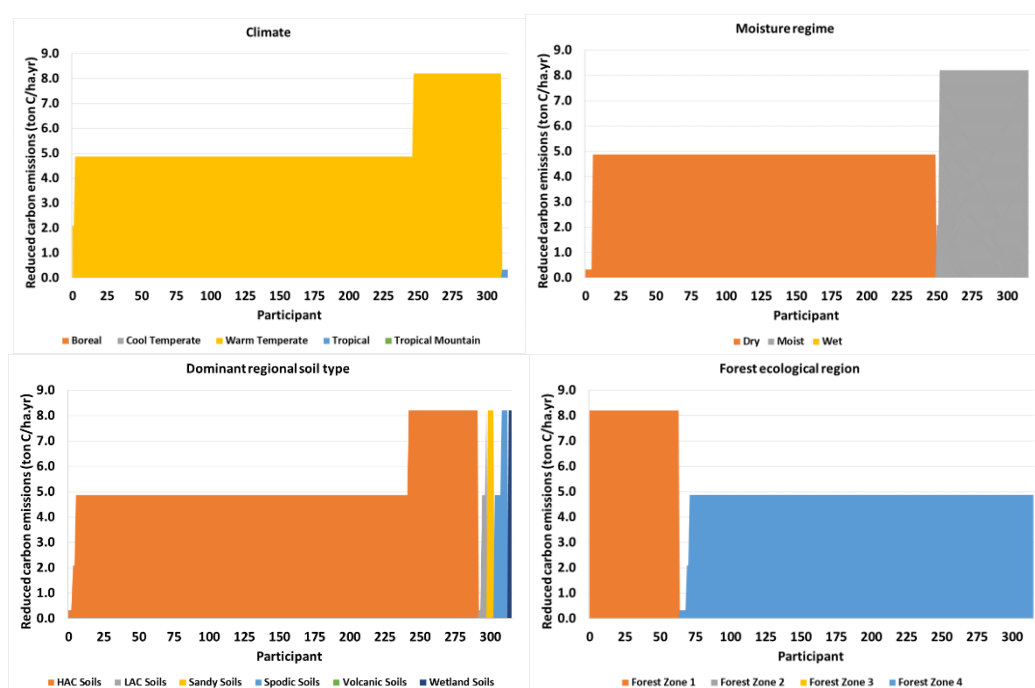


Figure 37: Distribution of net results as a function of the explanatory variables of EX-ACT model in the *Description* and *LUC* categories. Upper row: climate (left) and moisture regime (right). Lower row: soil type (left) and ecological zone (right)

The detailed balance of GHG emissions resulting from the application of contracts of type 1b is presented on Table 10. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, biomass carbon storage produces a reduction of emissions, while soil carbon storage produces an increase of emissions. The contributions of N<sub>2</sub>O and CH<sub>4</sub> are

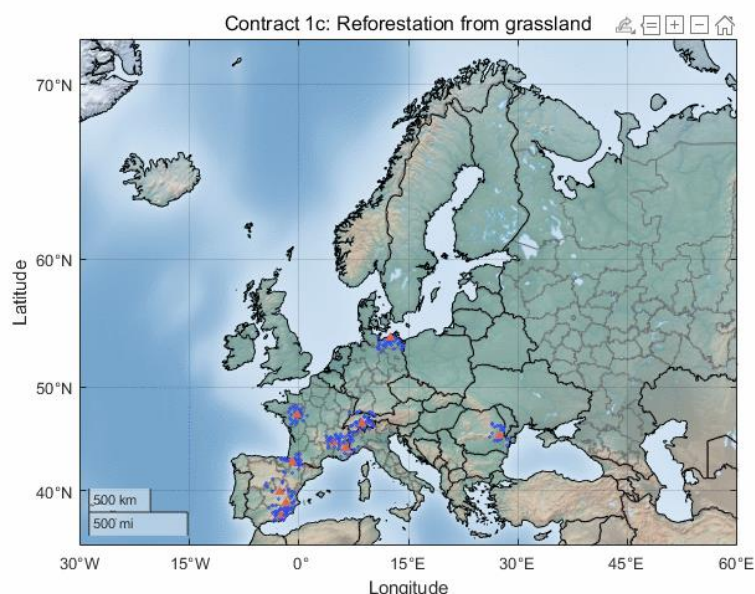
also shown on the table. Overall, CO<sub>2</sub> represents 86.7% of the reduction, with 6.9% for N<sub>2</sub>O and 6.4% for CH<sub>4</sub>.

*Table 10: Detailed balance of GHG emissions obtained in the simulation of contracts of type 1b*

| Contract | Share per GHG of the Balance |      |       |                 |                 | Results per year |       |         |
|----------|------------------------------|------|-------|-----------------|-----------------|------------------|-------|---------|
|          | CO <sub>2</sub>              |      |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With  | Balance |
|          | Biomass                      | Soil | Other |                 |                 |                  |       |         |
| 1        | -4.18                        | 0.27 | 0.00  | -0.38           | -0.35           | 0.60             | -4.03 | 4.63    |
| 2        | -4.39                        | 0.25 | 0.00  | -0.38           | -0.35           | 0.63             | -4.23 | 4.86    |
| 3        | -4.05                        | 0.25 | 0.00  | -0.38           | -0.35           | 0.63             | -3.89 | 4.52    |
| 4        | -4.39                        | 0.25 | 0.00  | -0.38           | -0.35           | 0.63             | -4.23 | 4.86    |
| 5        | -4.39                        | 0.25 | 0.00  | -0.38           | -0.35           | 0.63             | -4.23 | 4.86    |
| 6        | -4.12                        | 0.25 | 0.00  | -0.38           | -0.35           | 0.63             | -3.97 | 4.60    |
| 7        | -4.34                        | 0.25 | 0.00  | -0.38           | -0.35           | 0.62             | -4.18 | 4.80    |
| 8        | -8.01                        | 0.53 | 0.00  | -0.38           | -0.35           | 0.26             | -7.95 | 8.21    |
| 9        | -4.39                        | 0.25 | 0.00  | -0.38           | -0.35           | 0.63             | -4.23 | 4.86    |
| 10       | -8.01                        | 0.53 | 0.00  | -0.38           | -0.35           | 0.26             | -7.95 | 8.21    |
| Mean     | -5.01                        | 0.30 | 0.00  | -0.38           | -0.35           | 0.56             | -4.87 | 5.43    |

### 5.2.3 Pilot Exercise 1c: Reforestation from grassland

The location of the random contracts simulated for type 1c are presented on Figure 38. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by grasslands (Pastures, Natural grasslands) in a region of 50 km to the side around the centroid.



*Figure 38: Location of random simulated contracts of type 1c*

The mean results obtained in the simulation of contracts of type 1c are presented on Table 11. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 12.30 tC/ha.yr.

*Table 11: Mean results obtained in the simulation of contracts of type 1c*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 37.53    | -2.36   | 37           | 19.54          | 9.73                               | 190.03          | 7031        |
| 2        | 45.06    | 4.55    | 18           | 20.20          | 11.08                              | 223.84          | 4029        |
| 3        | 44.80    | 6.30    | 35           | 19.08          | 12.65                              | 241.39          | 8448        |
| 4        | 38.58    | -1.69   | 23           | 19.57          | 9.37                               | 183.26          | 4215        |
| 5        | 47.57    | -0.34   | 30           | 20.94          | 13.58                              | 284.39          | 8532        |
| 6        | 45.85    | 27.49   | 24           | 19.14          | 14.80                              | 283.25          | 6798        |
| 7        | 46.90    | 8.68    | 36           | 20.89          | 14.76                              | 308.30          | 11099       |
| 8        | 42.99    | -0.77   | 40           | 21.20          | 11.99                              | 254.20          | 10168       |
| 9        | 53.65    | 12.48   | 34           | 21.61          | 13.66                              | 295.27          | 10039       |
| 10       | 39.87    | -2.75   | 15           | 16.83          | 7.80                               | 131.24          | 1969        |
| Mean     |          |         | 29.2         | 20.14          | 12.30                              | 247.70          | 7233        |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is

presented on Figure 39. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. The best results are obtained for contract number 6, with a net reduction of 14.80 tC/ha.yr. The minimum reduction is obtained for contract number 10, with 7.80 tC/ha.yr. The largest variability is shown by contract number 2, with reductions ranging from 0.09 tC/ha.yr to 15.28 tC/ha.yr. Contract number 9 shows the least variability, with reductions ranging from 13.52 tC/ha.yr to 13.98 tC/ha.yr.

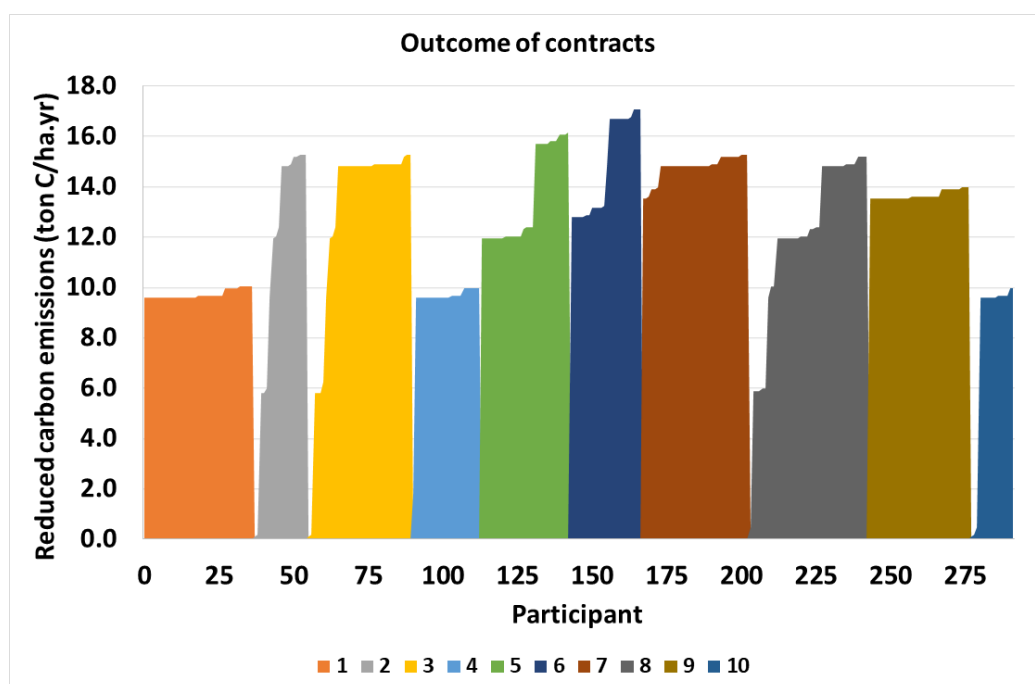
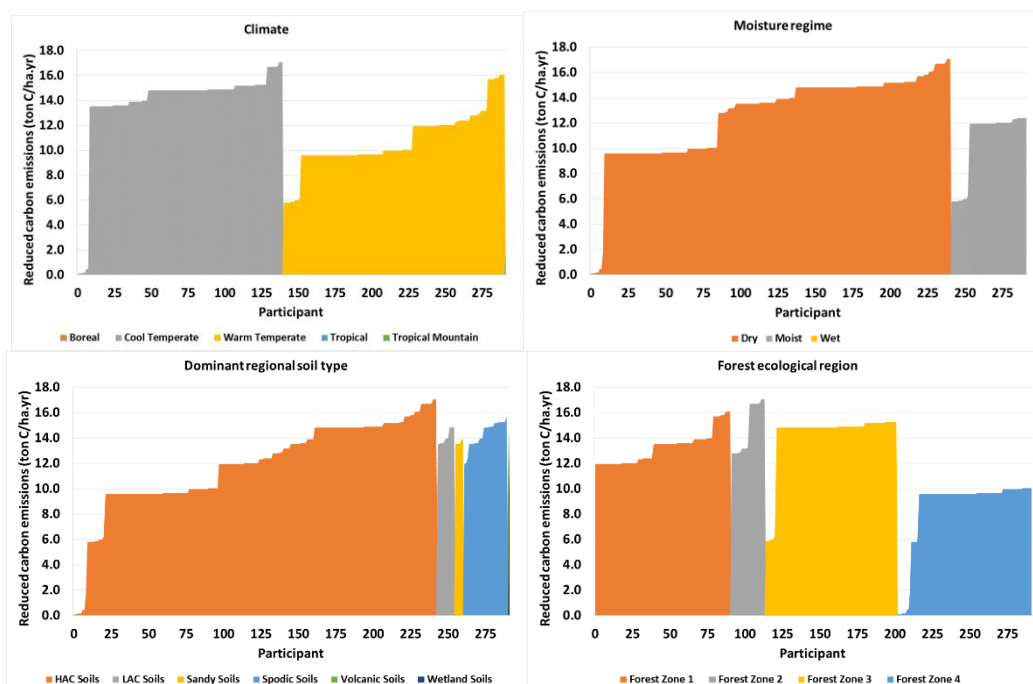


Figure 39: Distribution of net results as a function of contract for type 1c

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* and *LUC* categories is shown on Figure 40. The upper row shows variables 1, Climate, and 2, Moisture regime. The lower row shows variables 3, Dominant regional soil type, and 4, Forest ecological zone. The two climate types are well balanced. Warm Temperate dominates 52% of the participants and Cool Temperate dominates 48% of the participants. The best performance is obtained for this last type of climate, with a mean reduction of 13.89 tC/ha.yr. The dominant moisture regime is Dry, with 83% of the participants. The best performance is obtained for this type of moisture regime, with a mean reduction of 12.58 tC/ha.yr. The dominant soil type is HAC Soils, with 83% of the participants. The best performance is obtained for Wetland Soils, with a mean reduction of 14.91 tC/ha.yr, but this type of soil affects only one participant. The three ecological zones Forest zones 1, 3 and 4, share equally 90% of the participants. However, the best performance is obtained for Forest zone 2, with a mean reduction of 14.80 tC/ha.yr.



*Figure 40: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description and LUC categories. Upper row: climate (left) and moisture regime (right). Lower row: soil type (left) and ecological zone (right)*

The detailed balance of GHG emissions resulting from the application of contracts of type 1c is presented on Table 12. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, biomass carbon storage represents 98.2% of total CO<sub>2</sub> balance. The contributions of N<sub>2</sub>O and CH<sub>4</sub> are negligible.

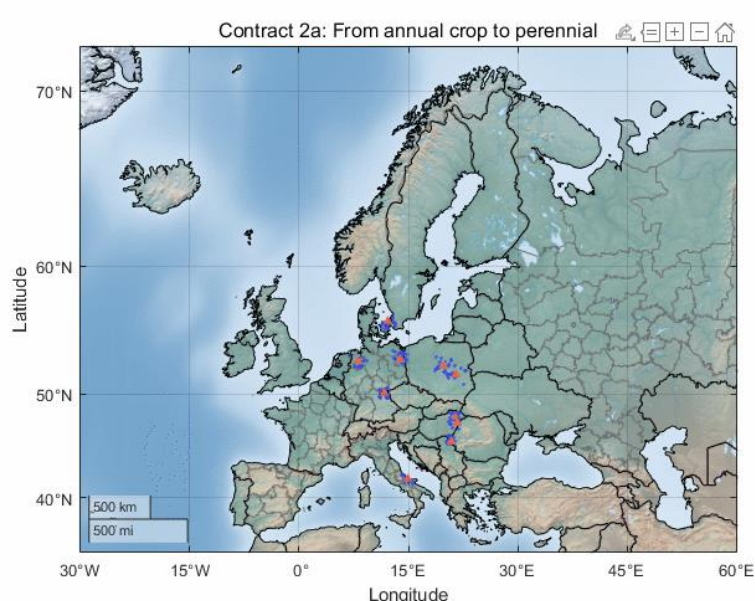
*Table 12: Detailed balance of GHG emissions obtained in the simulation of contracts of type 1c*

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |        |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|--------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With   | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |        |         |
| 1        | -9.50                        | -0.23 | 0.00  | 0.00            | 0.00            | 0.10             | -9.63  | 9.73    |
| 2        | -10.83                       | -0.25 | 0.00  | 0.00            | 0.00            | 0.12             | -10.96 | 11.08   |
| 3        | -12.47                       | -0.18 | 0.00  | 0.00            | 0.00            | 0.05             | -12.60 | 12.65   |
| 4        | -9.16                        | -0.21 | 0.00  | 0.00            | 0.00            | 0.10             | -9.27  | 9.37    |
| 5        | -13.35                       | -0.23 | 0.00  | 0.00            | 0.00            | 0.10             | -13.48 | 13.58   |
| 6        | -14.57                       | -0.23 | 0.00  | 0.00            | 0.00            | 0.12             | -14.67 | 14.80   |
| 7        | -14.51                       | -0.24 | 0.00  | 0.00            | 0.00            | 0.13             | -14.62 | 14.76   |
| 8        | -11.77                       | -0.22 | 0.00  | 0.00            | 0.00            | 0.10             | -11.89 | 11.99   |
| 9        | -13.43                       | -0.23 | 0.00  | 0.00            | 0.00            | 0.11             | -13.55 | 13.66   |
| 10       | -7.60                        | -0.20 | 0.00  | 0.00            | 0.00            | 0.07             | -7.72  | 7.80    |

|      |        |       |      |      |      |      |        |       |
|------|--------|-------|------|------|------|------|--------|-------|
| Mean | -12.08 | -0.22 | 0.00 | 0.00 | 0.00 | 0.10 | -12.20 | 12.30 |
|------|--------|-------|------|------|------|------|--------|-------|

#### 5.2.4 Pilot Exercise 2a: Land Use Change from annual crop to perennial tree crop

The location of the random contracts simulated for type 2a are presented on Figure 41. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by annual crops (Non-irrigated arable land, Annual crops associated with permanent crop and Land principally occupied by agriculture) in a region of 300 km to the side around the centroid.



*Figure 41: Location of random simulated contracts of type 2a*

The mean results obtained in the simulation of contracts of type 2a are presented on Table 13. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 5.90 tC/ha.yr.

*Table 13: Mean results obtained in the simulation of contracts of type 2a*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 52.61    | 8.24    | 13           | 9.08           | 6.01                               | 54.53           | 709         |
| 2        | 52.35    | 19.79   | 20           | 9.34           | 5.65                               | 52.78           | 1056        |
| 3        | 55.76    | 12.37   | 17           | 7.97           | 6.21                               | 49.47           | 841         |

|      |       |       |      |       |      |       |      |
|------|-------|-------|------|-------|------|-------|------|
| 4    | 50.04 | 11.68 | 28   | 9.84  | 5.96 | 58.68 | 1643 |
| 5    | 47.96 | 21.58 | 22   | 10.88 | 5.84 | 63.59 | 1399 |
| 6    | 47.57 | 21.09 | 11   | 10.31 | 5.92 | 60.99 | 671  |
| 7    | 51.78 | 21.44 | 11   | 8.73  | 5.68 | 49.60 | 546  |
| 8    | 45.78 | 20.76 | 21   | 8.59  | 5.99 | 51.49 | 1081 |
| 9    | 53.12 | 13.98 | 22   | 11.56 | 5.80 | 67.05 | 1475 |
| 10   | 41.84 | 14.82 | 14   | 8.10  | 6.07 | 49.18 | 689  |
| Mean |       |       | 17.9 | 9.57  | 5.90 | 56.48 | 1011 |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 42. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. There is little variability among contracts. The best results are obtained for contract number 3, with a net reduction of 6.21 tC/ha.yr. The minimum reduction is obtained for contract number 2, with 5.65 tC/ha.yr. The largest variability is shown by contract number 10, with reductions ranging from 5.82 tC/ha.yr to 8.90 tC/ha.yr. Contract number 3 shows the least variability, with reductions ranging from 6.06 tC/ha.yr to 6.40 tC/ha.yr.

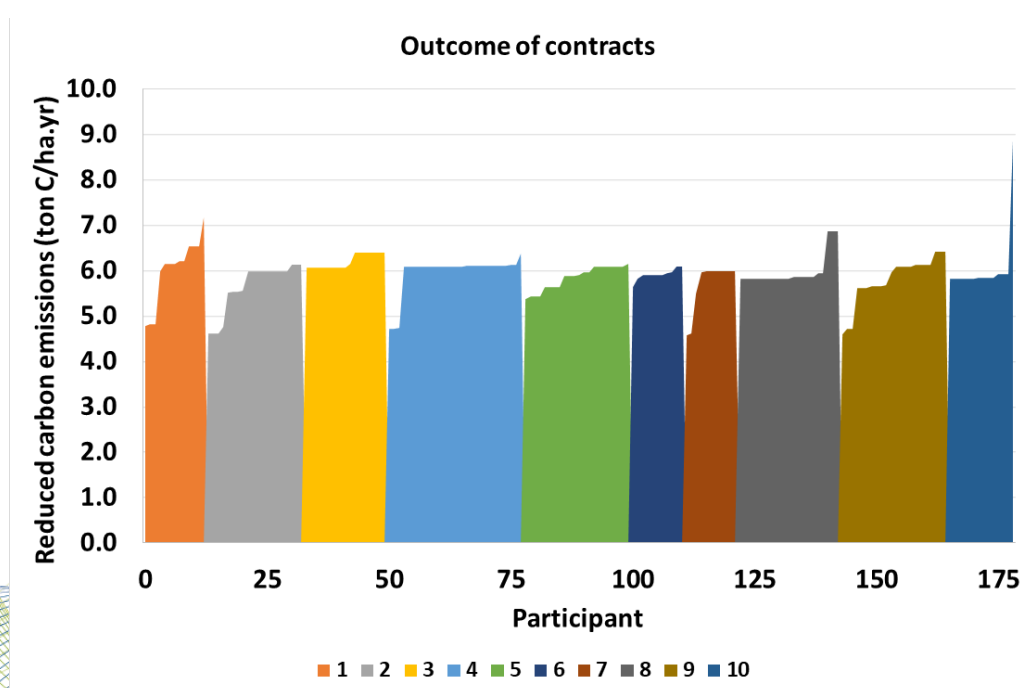


Figure 42: Distribution of net results as a function of contract for type 2a

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* category is shown on Figure 43. The upper row shows variables 1, Climate and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. The dominant climate is Cool

Temperate, with 70% of the participants. The best performance is obtained for Warm Temperate climate, with a mean reduction of 5.95 tC/ha.yr. Almost all participants fall in the Dry moisture regime. The dominant soil type is HAC Soils, with 77% of the participants. The best performance is obtained for Wetland Soils, with a mean reduction of 6.93 tC/ha.yr.

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Cropland* category is shown on Figure 43. The figure shows variables 5, Annual crop, and 6, Annual crop yield. The dominant annual crop is Wheat, with 30% of the participants, followed by Maize, with 26% of the participants. The best performance is obtained for Wheat, with a mean reduction of 6.12 tC/ha.yr. The most abundant range for crop yield is from 3 t/ha.yr to 4 t/ha.yr, which corresponds to 34% of the participants. The most effective reduction of emissions is obtained for the highest crop yield range, larger than 7 t/ha.yr, with 6.38 tC/ha.yr.

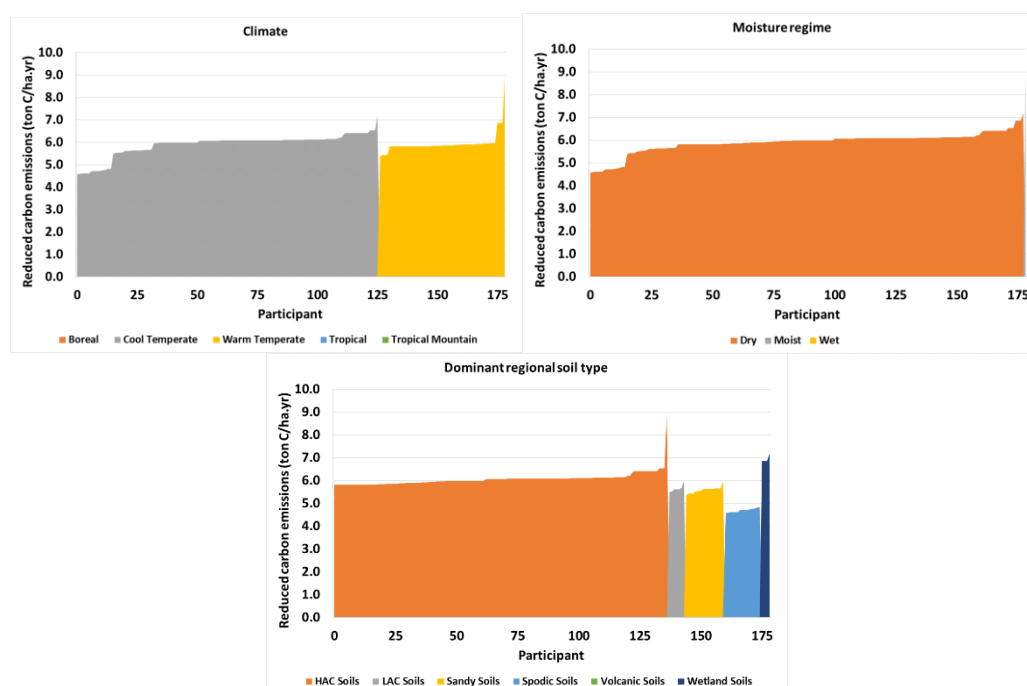


Figure 43: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description category. Upper row: climate (left) and moisture regime (right). Lower row: soil type

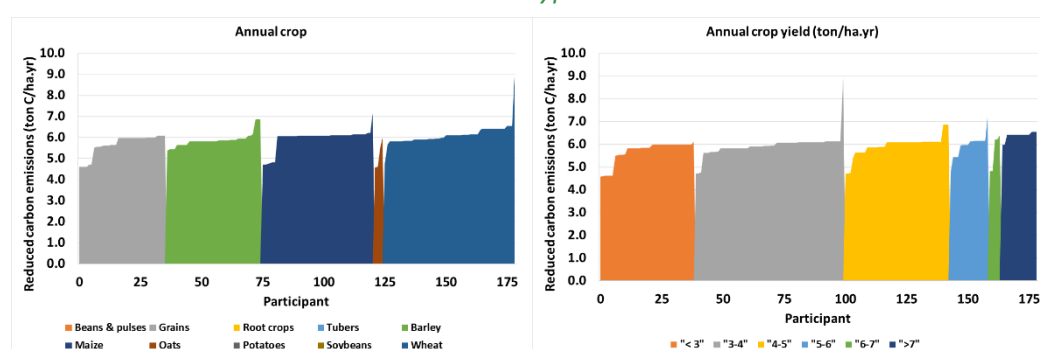


Figure 44: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Cropland category. Annual crop (left) and annual crop yield (right)

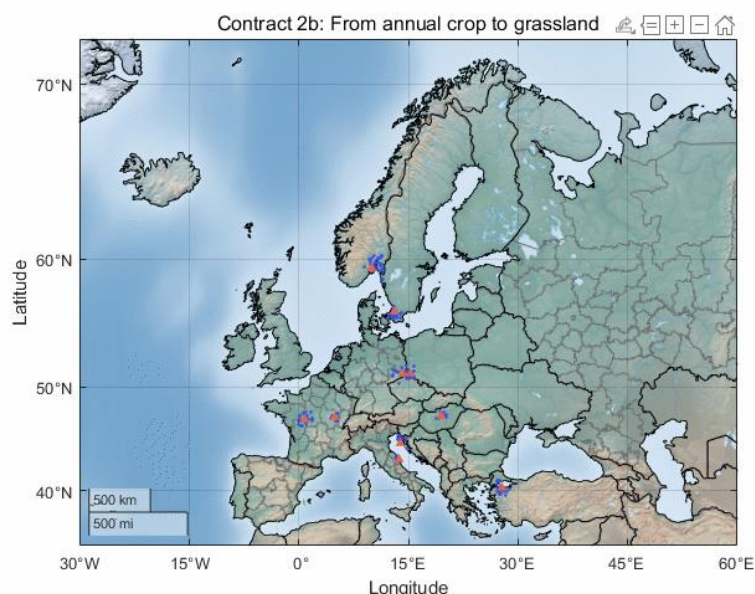
The detailed balance of GHG emissions resulting from the application of contracts of type 2a is presented on Table 14. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, biomass carbon storage represents 77.1% of total CO<sub>2</sub> balance and soil carbon storage represents 22.9% of total CO<sub>2</sub> balance. The contributions of N<sub>2</sub>O and CH<sub>4</sub> are also shown on the table. Overall, CO<sub>2</sub> represents 95.1% of the reduction, with 1.2% for N<sub>2</sub>O and 3.8% for CH<sub>4</sub>.

*Table 14: Detailed balance of GHG emissions obtained in the simulation of contracts of type 2a*

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |       |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|-------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With  | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |       |         |
| 1        | -4.33                        | -1.21 | 0.00  | -0.11           | -0.36           | 0.62             | -5.38 | 6.01    |
| 2        | -4.33                        | -1.12 | 0.00  | -0.05           | -0.15           | 0.27             | -5.38 | 5.65    |
| 3        | -4.33                        | -1.49 | 0.00  | -0.09           | -0.30           | 0.52             | -5.68 | 6.21    |
| 4        | -4.33                        | -1.34 | 0.00  | -0.07           | -0.23           | 0.39             | -5.57 | 5.96    |
| 5        | -4.33                        | -1.22 | 0.00  | -0.07           | -0.22           | 0.39             | -5.45 | 5.84    |
| 6        | -4.33                        | -1.31 | 0.00  | -0.07           | -0.22           | 0.38             | -5.54 | 5.92    |
| 7        | -4.33                        | -1.20 | 0.00  | -0.04           | -0.12           | 0.21             | -5.47 | 5.68    |
| 8        | -4.33                        | -1.43 | 0.00  | -0.06           | -0.18           | 0.31             | -5.68 | 5.99    |
| 9        | -4.33                        | -1.14 | 0.00  | -0.08           | -0.26           | 0.45             | -5.35 | 5.80    |
| 10       | -4.33                        | -1.51 | 0.00  | -0.06           | -0.18           | 0.32             | -5.75 | 6.07    |
| Mean     | -4.33                        | -1.28 | 0.00  | -0.07           | -0.22           | 0.39             | -5.51 | 5.90    |

### 5.2.5 Pilot Exercise 2b: Land Use Change from annual crop to grassland

The location of the random contracts simulated for type 2b are presented on Figure 45. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by annual crops (Non-irrigated arable land, Annual crops associated with permanent crop and Land principally occupied by agriculture) in a region of 300 km to the side around the centroid.



*Figure 45: Location of random simulated contracts of type 2b*

The mean results obtained in the simulation of contracts of type 2b are presented on Table 13. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 3.20 tC/ha.yr.

*Table 15: Mean results obtained in the simulation of contracts of type 2b*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 47.41    | 19.72   | 12           | -1.01          | 1.01                               | -1.02           | -12         |
| 2        | 47.08    | 0.93    | 20           | -3.45          | 3.45                               | -11.94          | -239        |
| 3        | 40.16    | 27.74   | 20           | -0.92          | 0.92                               | -0.85           | -17         |
| 4        | 45.20    | 13.96   | 24           | -4.87          | 4.87                               | -23.74          | -570        |
| 5        | 51.09    | 15.23   | 24           | -1.14          | 1.14                               | -1.29           | -31         |
| 6        | 47.21    | 5.01    | 12           | -4.59          | 4.59                               | -21.03          | -252        |
| 7        | 59.54    | 10.67   | 28           | -0.56          | 0.56                               | -0.31           | -9          |
| 8        | 51.31    | 13.83   | 10           | -1.08          | 1.08                               | -1.16           | -12         |
| 9        | 43.28    | 13.48   | 16           | -1.40          | 1.40                               | -1.95           | -31         |
| 10       | 55.94    | 13.14   | 23           | -1.48          | 1.48                               | -2.19           | -50         |
| Mean     |          |         | 18.9         | -2.02          | 3.20                               | -6.47           | -122        |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is

presented on Figure 46. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. Results are very heterogeneous and there is a large variability both within contracts and among different contracts. The best results are obtained for contract number 4, with a net reduction of 4.87 tC/ha.yr. The minimum reduction is obtained for contract number 7, with a mean reduction of 0.56 tC/ha.yr. Many participants in this contract obtained an increase of carbon emissions. The largest variability is shown by contract number 9, with reductions ranging from 0.87 tC/ha.yr to 5.12 tC/ha.yr. Contract number 3 shows the least variability, with reductions ranging from 0.79 tC/ha.yr to 1.12 tC/ha.yr.

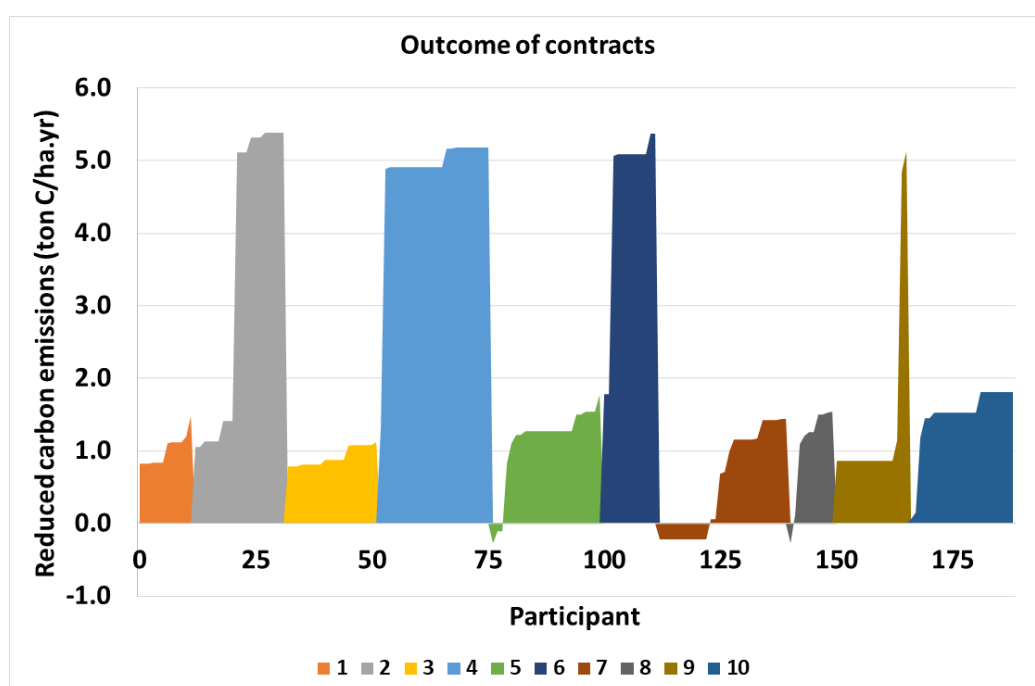


Figure 46: Distribution of net results as a function of contract for type 2b

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* category is shown on Figure 47. The upper row shows variables 1, Climate and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. The dominant climate is Warm Temperate, with 53% of the participants. The best performance is obtained for this type of climate, with a mean reduction of 2.88 tC/ha.yr. The dominant moisture regime is Dry, with 76% of the participants. However, the best result is obtained for the Moist regime, with a mean reduction of 5.11 tC/ha.yr. The dominant soil type is HAC Soils, with 87% of the participants. The best performance is obtained for this type of soil, with a mean reduction of 2.32 tC/ha.yr. Spodic soils, with 11% of the participants, produce a net increase of carbon emissions of 0.14 tC/ha.yr.

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Cropland* category is shown on Figure 47. The figure shows variables 5, Annual crop, and 6, Annual crop yield. The dominant

annual crop is Wheat, with 67% of the participants. The best performance is obtained for Barley, with a mean reduction of 4.87 tC/ha.yr. The most abundant range for crop yield is from 3 t/ha.yr to 4 t/ha.yr, which corresponds to 47% of the participants. The most effective reduction of emissions is obtained for the range of crop yield from 6 t/ha.yr to 7 t/ha.yr, with 4.12 tC/ha.yr.

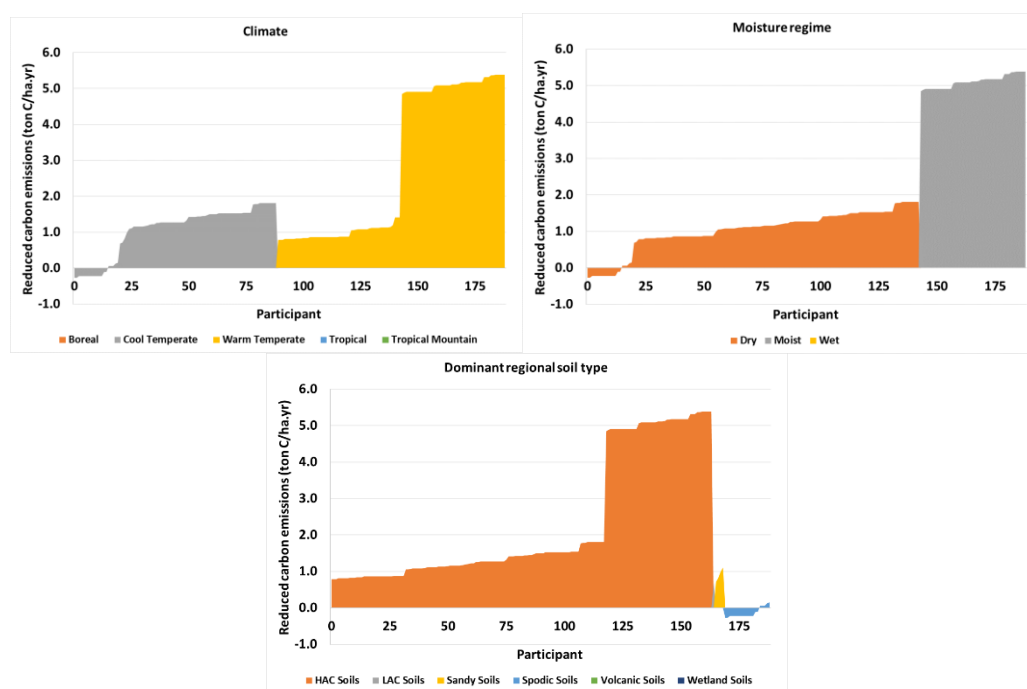


Figure 47: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description category. Upper row: climate (left) and moisture regime (right). Lower row: soil type

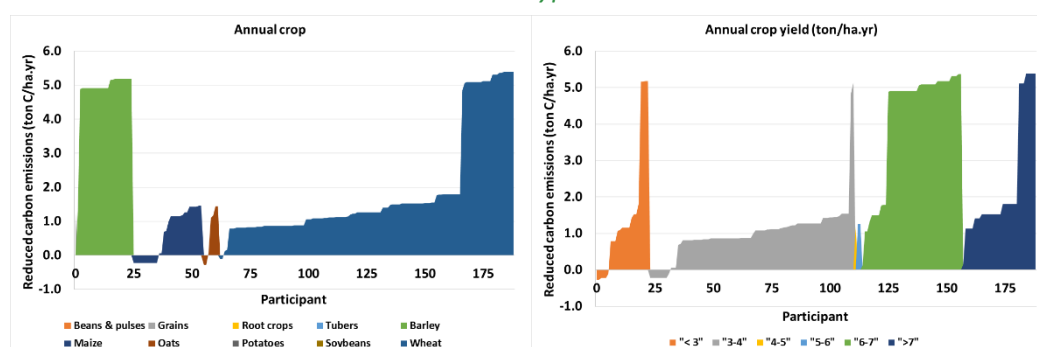


Figure 48: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Cropland category. Annual crop (left) and annual crop yield (right)

The detailed balance of GHG emissions resulting from the application of contracts of type 2b is presented on Table 14. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, soil carbon storage is responsible for almost all CO<sub>2</sub> balance. Biomass carbon storage fluctuates between positive and negative values with a mean close to

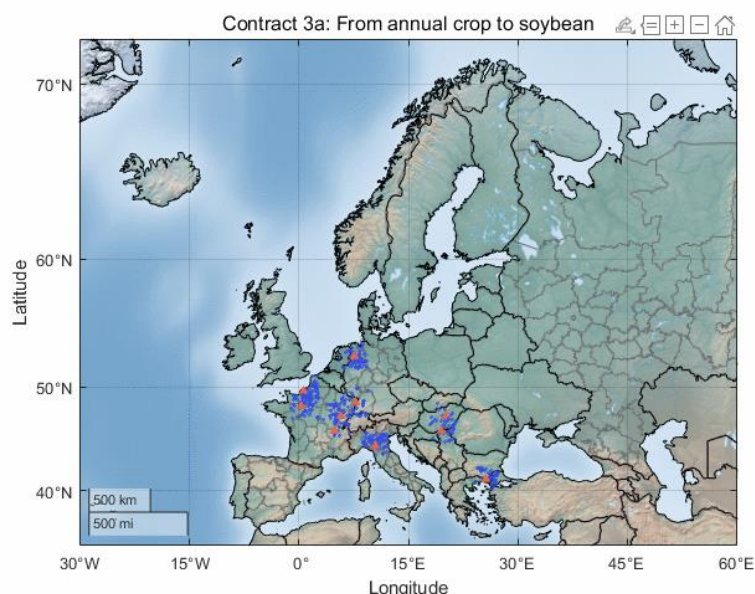
zero. Overall, CO<sub>2</sub> represents 86.3% of the reduction, with 3.2% for N<sub>2</sub>O and 10.5% for CH<sub>4</sub>.

*Table 16: Detailed balance of GHG emissions obtained in the simulation of contracts of type 2b*

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |       |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|-------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With  | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |       |         |
| 1        | 0.78                         | -1.49 | 0.00  | -0.07           | -0.23           | 0.40             | -0.61 | 1.01    |
| 2        | 0.08                         | -2.96 | 0.00  | -0.14           | -0.44           | 0.77             | -2.69 | 3.45    |
| 3        | 0.78                         | -1.42 | 0.00  | -0.07           | -0.22           | 0.38             | -0.54 | 0.92    |
| 4        | -0.44                        | -4.04 | 0.00  | -0.09           | -0.30           | 0.52             | -4.36 | 4.87    |
| 5        | 0.71                         | -1.50 | 0.00  | -0.08           | -0.27           | 0.47             | -0.67 | 1.14    |
| 6        | -0.29                        | -3.72 | 0.00  | -0.14           | -0.44           | 0.76             | -3.82 | 4.59    |
| 7        | 0.71                         | -1.05 | 0.00  | -0.05           | -0.17           | 0.29             | -0.27 | 0.56    |
| 8        | 0.71                         | -1.40 | 0.00  | -0.09           | -0.30           | 0.51             | -0.56 | 1.08    |
| 9        | 0.62                         | -1.69 | 0.00  | -0.08           | -0.25           | 0.44             | -0.96 | 1.40    |
| 10       | 0.71                         | -1.66 | 0.00  | -0.13           | -0.40           | 0.71             | -0.77 | 1.48    |
| Mean     | 0.10                         | -2.86 | 0.00  | -0.10           | -0.34           | 0.59             | -2.62 | 3.20    |

### 5.2.6 Pilot Exercise 3a: Substitution of annual crop by soybean

The location of the random contracts simulated for type 3a are presented on Figure 49. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by annual crops (Non-irrigated arable land, Annual crops associated with permanent crop and Land principally occupied by agriculture) in a region of 500 km to the side around the centroid.



*Figure 49: Location of random simulated contracts of type 3a*

The mean results obtained in the simulation of contracts of type 3a are presented on Table 17. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 1.91 tC/ha.yr.

*Table 17: Mean results obtained in the simulation of contracts of type 3a*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 46.64    | 4.68    | 17           | 91.66          | 2.38                               | 217.89          | 3704        |
| 2        | 49.45    | 1.69    | 58           | 105.97         | 2.28                               | 241.83          | 14026       |
| 3        | 47.10    | 20.35   | 17           | 113.28         | 1.43                               | 161.80          | 2751        |
| 4        | 48.32    | 0.62    | 51           | 121.25         | 2.13                               | 258.50          | 13184       |
| 5        | 52.40    | 7.88    | 57           | 89.45          | 1.58                               | 141.39          | 8059        |
| 6        | 44.99    | 10.62   | 58           | 98.67          | 2.17                               | 214.56          | 12444       |
| 7        | 47.57    | 5.32    | 45           | 94.67          | 2.11                               | 199.29          | 8968        |
| 8        | 48.42    | 7.61    | 40           | 90.06          | 1.67                               | 150.34          | 6014        |

|      |           |           |      |            |      |        |      |
|------|-----------|-----------|------|------------|------|--------|------|
| 9    | 46.0<br>8 | 19.9<br>8 | 27   | 109.9<br>6 | 1.45 | 159.87 | 4317 |
| 10   | 41.5<br>3 | 25.9<br>9 | 43   | 104.2<br>2 | 1.45 | 151.21 | 6502 |
| Mean |           |           | 41.3 | 101.5<br>7 | 1.91 | 193.63 | 7997 |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 50. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. Results are heterogeneous and there is a significant variability. The best results are obtained for contract number 1, with a net reduction of 2.38 tC/ha.yr. The minimum reduction is obtained for contract number 3, with a mean reduction of 1.43 tC/ha.yr. The largest variability is shown by contract number 9, with reductions ranging from 1.34 tC/ha.yr to 2.35 tC/ha.yr. Contract number 3 shows the least variability, with reductions ranging from 1.34 tC/ha.yr to 1.51 tC/ha.yr.

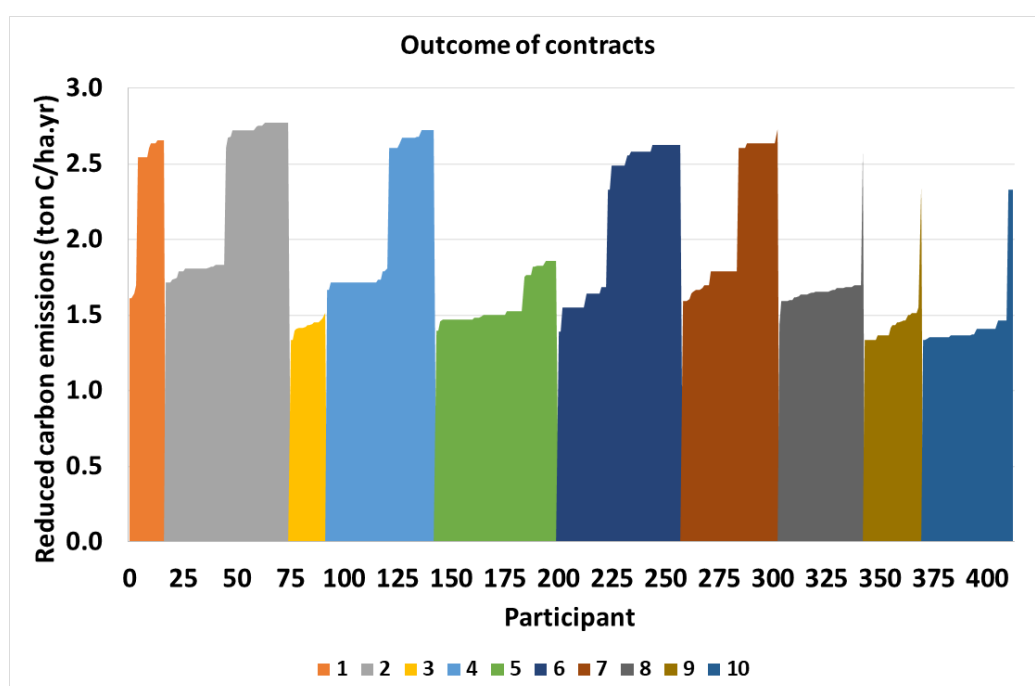


Figure 50: Distribution of net results as a function of contract for type 3a

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* category is shown on Figure 51. The upper row shows variables 1, Climate and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. The dominant climate is Warm Temperate, with 67% of the participants. The best performance is obtained for this type of climate, with a mean reduction of 2.03 tC/ha.yr. The dominant moisture regime is Dry, with 71% of the participants. The best result is obtained for

the Moist regime, with a mean reduction of 2.64 tC/ha.yr. The dominant soil type is HAC Soils, with 85% of the participants. The best performance is obtained for this type of soil, with a mean reduction of 1.93 tC/ha.yr.

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Cropland* category is shown on Figure 52. The figure shows variables 5, Annual crop, 6, Annual crop yield and 7, Annual soybean yield. The dominant annual crop is Wheat, with 69% of the participants. The best performance is obtained for Wheat and Barley, with a mean reduction of 1.95 tC/ha.yr. The most abundant range for crop yield is the largest, more than 7 t/ha.yr, which corresponds to 46% of the participants. The most effective reduction of emissions is obtained for this same range of crop yield, with 2.14 tC/ha.yr. Soybean yield is distributed between less than 3 t/ha.yr, which corresponds to 81% of the cases and from 3 t/ha.yr to 4 t/ha.yr, with the remaining 19%. The best result is obtained for this last category, with 2.01 tC/ha.yr.

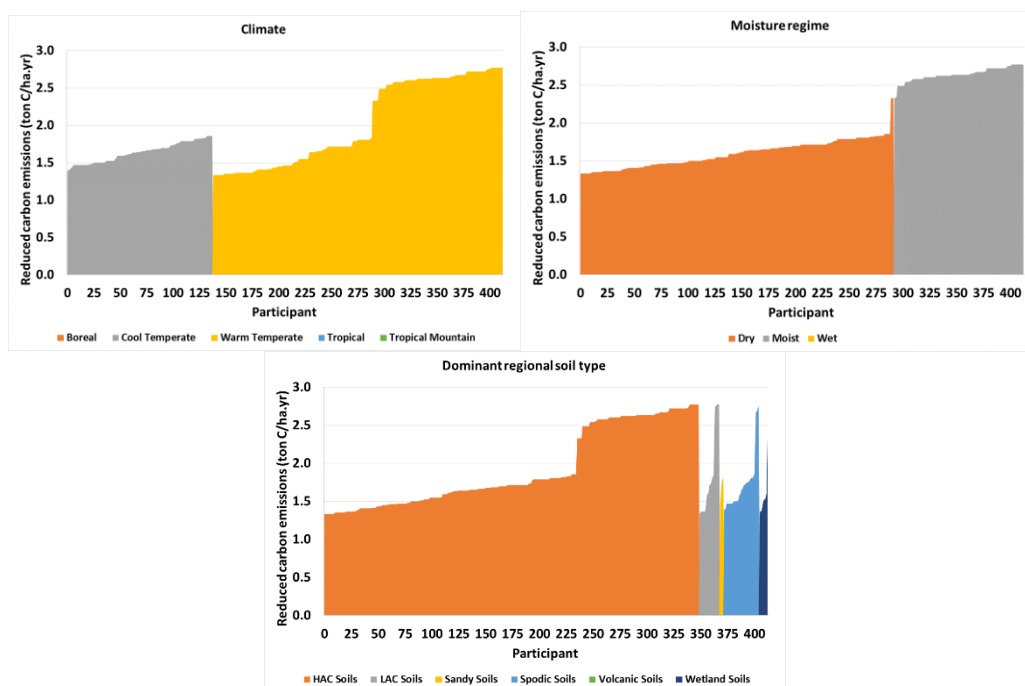


Figure 51: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description category. Upper row: climate (left) and moisture regime (right). Lower row: soil type

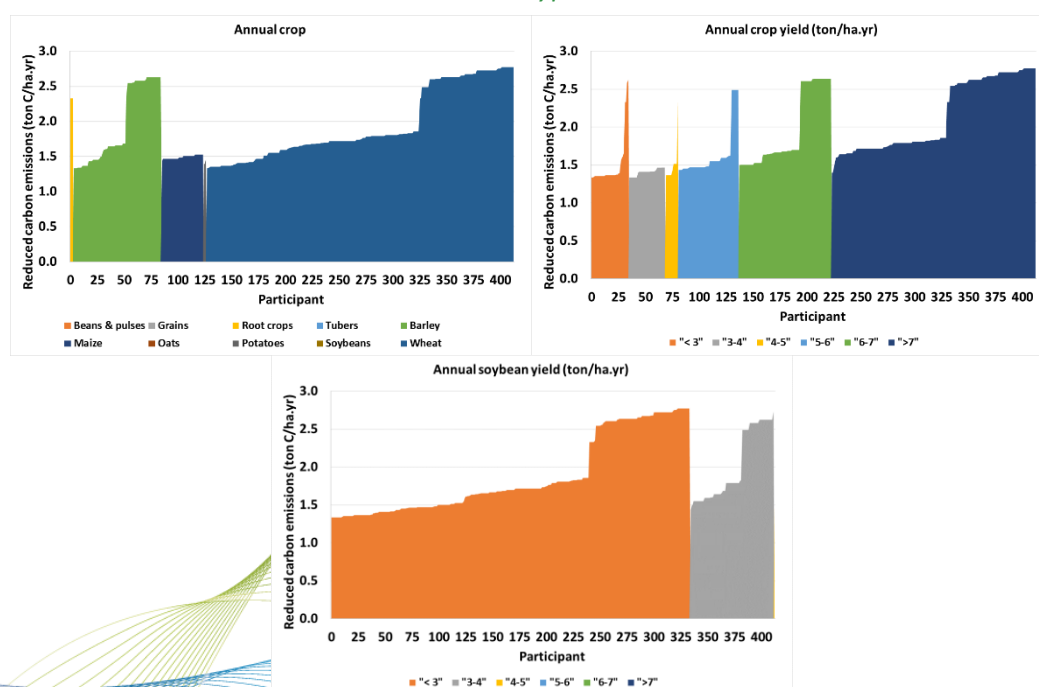


Figure 52: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Cropland category. Annual crop (left) and annual crop yield (right)

The detailed balance of GHG emissions resulting from the application of contracts of type 3a is presented on Table 18. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, soil

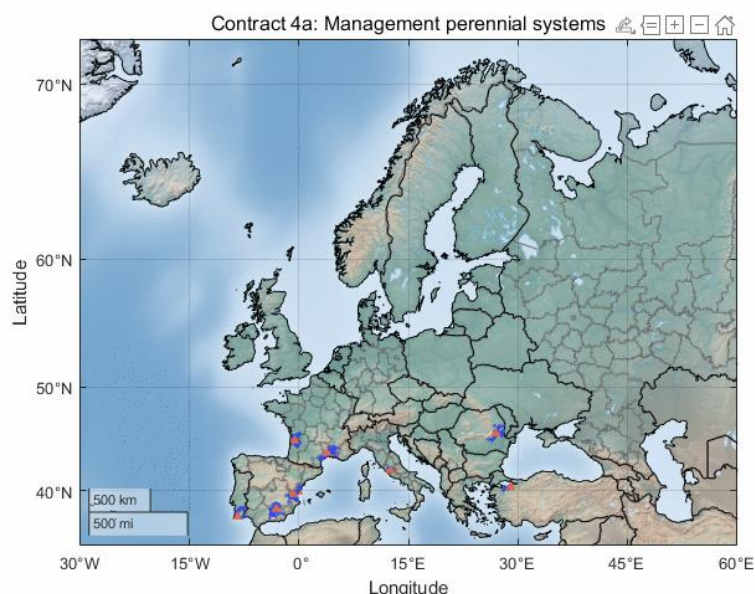
carbon storage is responsible for all CO<sub>2</sub> balance. Overall, CO<sub>2</sub> represents 75.2% of the reduction, with 4.5% for N<sub>2</sub>O and 20.2% for CH<sub>4</sub>.

*Table 18: Detailed balance of GHG emissions obtained in the simulation of contracts of type 3a*

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |       |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|-------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With  | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |       |         |
| 1        | 0.00                         | -1.87 | 0.00  | -0.09           | -0.41           | 0.11             | -2.27 | 2.38    |
| 2        | 0.00                         | -1.64 | 0.00  | -0.13           | -0.51           | 0.36             | -1.93 | 2.28    |
| 3        | 0.00                         | -1.16 | 0.00  | -0.04           | -0.23           | 0.02             | -1.41 | 1.43    |
| 4        | 0.00                         | -1.56 | 0.00  | -0.11           | -0.46           | 0.30             | -1.84 | 2.13    |
| 5        | 0.00                         | -1.16 | 0.00  | -0.08           | -0.35           | 0.23             | -1.35 | 1.58    |
| 6        | 0.00                         | -1.72 | 0.00  | -0.07           | -0.38           | 0.10             | -2.07 | 2.17    |
| 7        | 0.00                         | -1.55 | 0.00  | -0.10           | -0.45           | 0.28             | -1.82 | 2.11    |
| 8        | 0.00                         | -1.18 | 0.00  | -0.09           | -0.40           | 0.32             | -1.35 | 1.67    |
| 9        | 0.00                         | -1.19 | 0.00  | -0.04           | -0.22           | 0.01             | -1.45 | 1.45    |
| 10       | 0.00                         | -1.16 | 0.00  | -0.05           | -0.25           | 0.06             | -1.39 | 1.45    |
| Mean     | 0.00                         | -1.43 | 0.00  | -0.09           | -0.39           | 0.21             | -1.70 | 1.91    |

### 5.2.7 Pilot Exercise 4a: Improved management in perennial systems

The location of the random contracts simulated for type 4a are presented on Figure 53. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by perennial tree crops (Vineyards, Fruit trees and berry plantations, Olive groves) in a region of 300 km to the side around the centroid.



*Figure 53: Location of random simulated contracts of type 4a*

The mean results obtained in the simulation of contracts of type 4a are presented on Table 19. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 0.72 tC/ha.yr.

*Table 19: Mean results obtained in the simulation of contracts of type 4a*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 40.32    | 28.77   | 45           | 4.79           | 0.72                               | 3.45            | 155         |
| 2        | 44.00    | 4.66    | 23           | 6.52           | 0.72                               | 4.70            | 108         |
| 3        | 39.83    | -0.22   | 21           | 6.41           | 0.72                               | 4.62            | 97          |
| 4        | 37.86    | -3.35   | 38           | 6.91           | 0.72                               | 4.98            | 189         |
| 5        | 39.50    | -0.72   | 34           | 5.82           | 0.72                               | 4.19            | 142         |
| 6        | 45.00    | -0.26   | 63           | 5.66           | 0.72                               | 4.08            | 257         |
| 7        | 45.74    | 27.15   | 34           | 5.15           | 0.72                               | 3.71            | 126         |
| 8        | 43.71    | 3.90    | 40           | 6.50           | 0.72                               | 4.68            | 187         |
| 9        | 42.18    | 12.61   | 55           | 5.86           | 0.72                               | 4.23            | 232         |
| 10       | 37.74    | -7.99   | 39           | 6.37           | 0.72                               | 4.59            | 179         |
| Mean     |          |         | 39.2         | 5.93           | 0.72                               | 4.27            | 167         |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is

presented on Figure 54. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. The EX-ACT model produces no variability among the different contracts. All contracts produce the same result, with a net reduction of 0.72 tC/ha.yr.

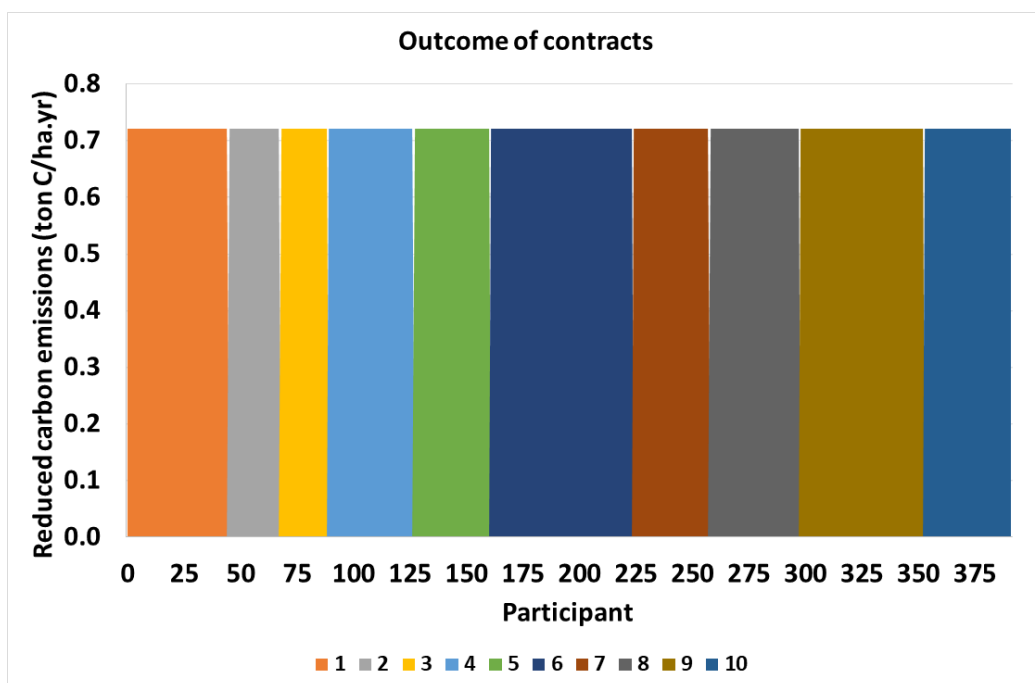
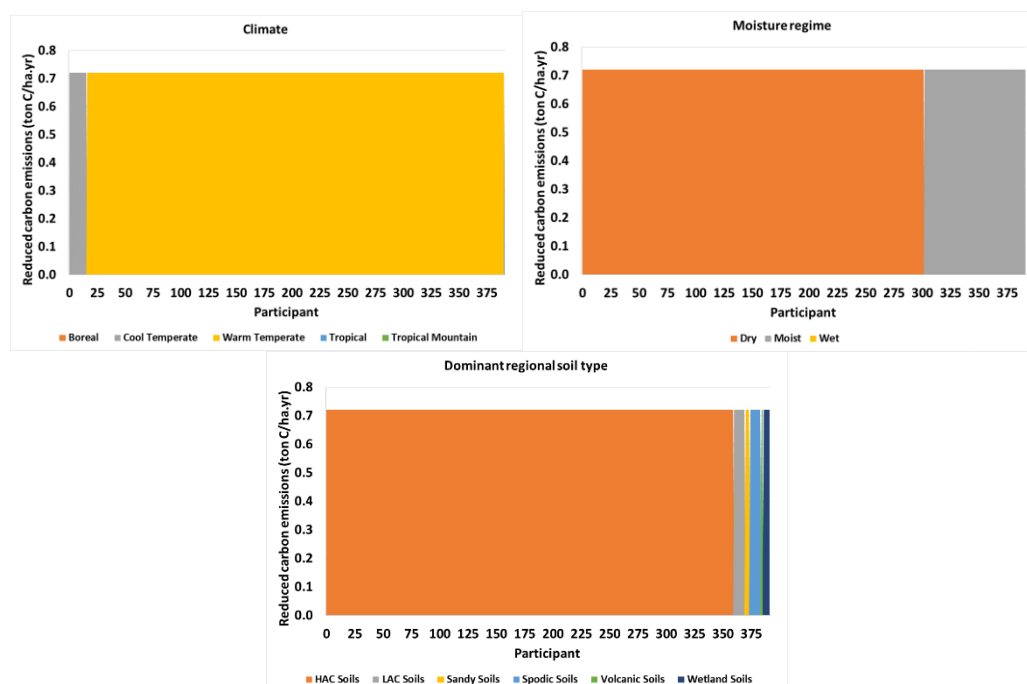


Figure 54: Distribution of net results as a function of contract for type 4a

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* category is shown on Figure 55. The upper row shows variables 1, Climate and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. As discussed before, there is no sensitivity of the results to any of the explanatory variables. This is probably a consequence of having chosen Tier 1 data for this analysis. Probably, the EX-ACT tool does not have enough data to discriminate the results for different types of climate or soils.



*Figure 55: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description category. Upper row: climate (left) and moisture regime (right). Lower row: soil type*

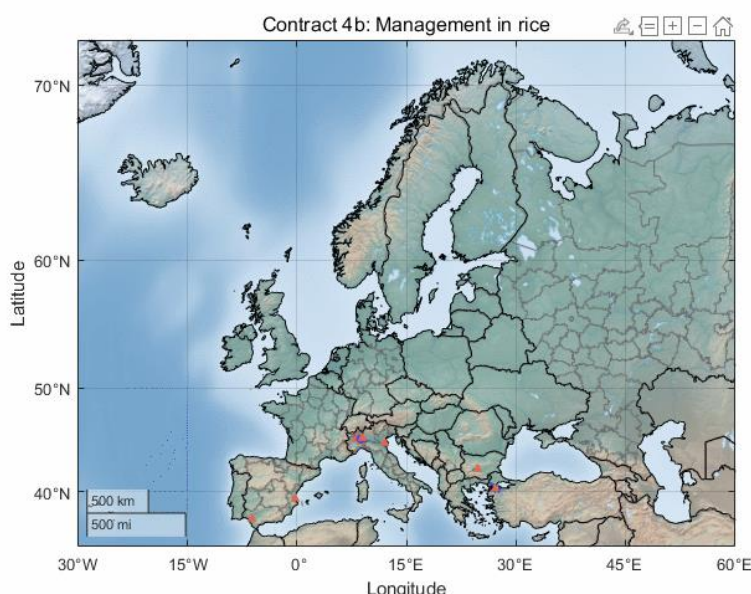
The detailed balance of GHG emissions resulting from the application of contracts of type 4a is presented on Table 20. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, there is no change in carbon emissions. The final results are all produced by N<sub>2</sub>O and CH<sub>4</sub>, with 52.1% for N<sub>2</sub>O and 47.9% for CH<sub>4</sub>.

*Table 20: Detailed balance of GHG emissions obtained in the simulation of contracts of type 4a*

| Contract | Share per GHG of the Balance |      |       |                 |                 | Results per year |       |         |
|----------|------------------------------|------|-------|-----------------|-----------------|------------------|-------|---------|
|          | CO <sub>2</sub>              |      |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With  | Balance |
|          | Biomass                      | Soil | Other |                 |                 |                  |       |         |
| 1        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.55             | -0.17 | 0.72    |
| 2        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.49             | -0.23 | 0.72    |
| 3        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.55             | -0.17 | 0.72    |
| 4        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.55             | -0.17 | 0.72    |
| 5        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.55             | -0.17 | 0.72    |
| 6        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.09             | -0.63 | 0.72    |
| 7        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.65             | -0.07 | 0.72    |
| 8        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.53             | -0.20 | 0.72    |
| 9        | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.36             | -0.36 | 0.72    |
| 10       | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.55             | -0.17 | 0.72    |
| Mean     | 0.00                         | 0.00 | 0.00  | -0.38           | -0.35           | 0.45             | -0.27 | 0.72    |

### 5.2.8 Pilot Exercise 4b: Improved management in rice

The location of the random contracts simulated for type 4b are presented on Figure 56. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by rice (Rice fields) in a region of 200 km to the side around the centroid.



*Figure 56: Location of random simulated contracts of type 4b*

The mean results obtained in the simulation of contracts of type 4b are presented on Table 21. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 5.53 tC/ha.yr.

*Table 21: Mean results obtained in the simulation of contracts of type 4b*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 45.27    | 8.64    | 25           | 4.96           | 4.61                               | 22.84           | 571         |
| 2        | 45.35    | 8.42    | 16           | 3.75           | 4.09                               | 15.31           | 245         |
| 3        | 42.25    | 24.61   | 19           | 5.13           | 3.93                               | 20.17           | 383         |
| 4        | 45.30    | 8.50    | 13           | 4.02           | 4.79                               | 19.28           | 251         |
| 5        | 44.85    | 12.05   | 22           | 5.63           | 4.71                               | 26.53           | 584         |

|      |       |       |      |      |      |       |     |
|------|-------|-------|------|------|------|-------|-----|
| 6    | 45.24 | 8.96  | 19   | 4.04 | 4.13 | 16.66 | 316 |
| 7    | 40.28 | 27.39 | 14   | 4.47 | 4.87 | 21.77 | 305 |
| 8    | 39.26 | -0.33 | 32   | 5.03 | 4.61 | 23.20 | 742 |
| 9    | 45.28 | 8.77  | 27   | 5.23 | 4.69 | 24.53 | 662 |
| 10   | 37.10 | -6.13 | 27   | 5.33 | 4.60 | 24.50 | 662 |
| Mean |       |       | 21.4 | 4.87 | 4.53 | 22.06 | 472 |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 57. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. The figure shows a significant variability within contracts, but all contracts show similar behavior. The best results are obtained for contract number 7, with a net reduction of 4.87 tC/ha.yr. The minimum reduction is obtained for contract number 3, with 3.93 tC/ha.yr. The largest variability is shown by contract number 10, with reductions ranging from 2.92 tC/ha.yr to 9.68 tC/ha.yr. Contract number 2 shows the least variability, with reductions ranging from 2.92 tC/ha.yr to 3.63 tC/ha.yr.

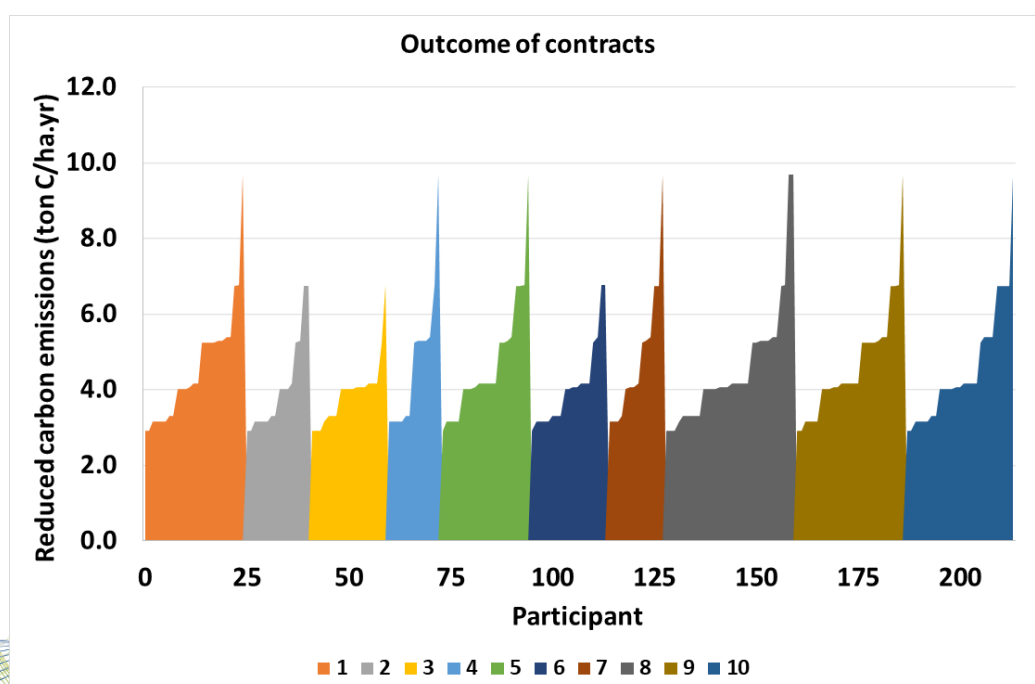
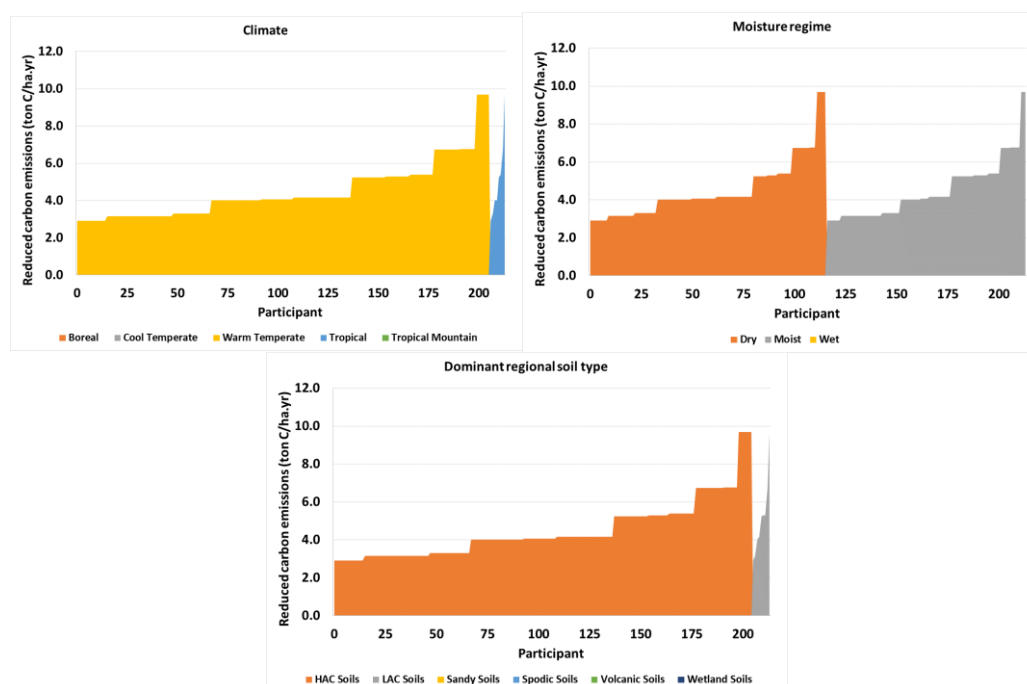


Figure 57: Distribution of net results as a function of contract for type 4b

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* category is shown on Figure 58. The upper row shows variables 1, Climate, and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. The dominant climate type is Warm

Temperate, which affects 96% of the participants, with the remaining 4% corresponding to Tropical. The best performance is obtained for this last type of climate, with a mean reduction of 5.17 tC/ha.yr. The dominant moisture regime is Dry, with 54% of the participants. The best performance is obtained for this type of moisture regime, with a mean reduction of 4.54 tC/ha.yr. The dominant soil type is HAC Soils, with 96% of the participants. The best performance is obtained for LAC Soils, with a mean reduction of 5.17 tC/ha.yr.



*Figure 58: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description category. Upper row: climate (left) and moisture regime (right). Lower row: soil type*

The detailed balance of GHG emissions resulting from the application of contracts of type 4b is presented on Table 22. The table shows the share of each GHG in the total balance of equivalent carbon emissions. In this type of contract, there is no change in carbon emissions. The final results are mostly produced CH<sub>4</sub>, with 52.1% for N<sub>2</sub>O and 47.9% for CH<sub>4</sub>.

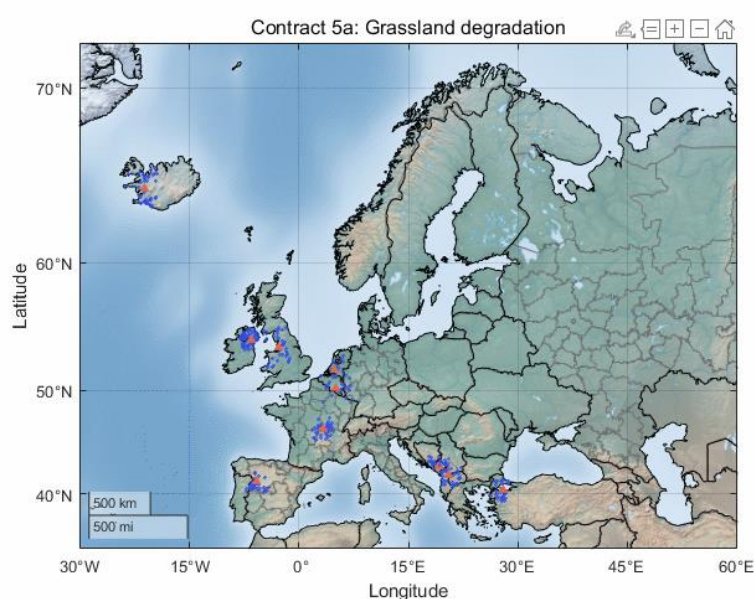
*Table 22: Detailed balance of GHG emissions obtained in the simulation of contracts of type 4b*

| Contract | Share per GHG of the Balance |      |       |                 |                 | Results per year |      |         |
|----------|------------------------------|------|-------|-----------------|-----------------|------------------|------|---------|
|          | CO <sub>2</sub>              |      |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With | Balance |
|          | Biomass                      | Soil | Other |                 |                 |                  |      |         |
| 1        | 0.00                         | 0.00 | 0.00  | 0.01            | -4.62           | 7.46             | 2.85 | 4.61    |
| 2        | 0.00                         | 0.00 | 0.00  | 0.02            | -4.10           | 6.77             | 2.69 | 4.09    |
| 3        | 0.00                         | 0.00 | 0.00  | 0.01            | -3.94           | 6.52             | 2.58 | 3.93    |
| 4        | 0.00                         | 0.00 | 0.00  | 0.01            | -4.80           | 7.71             | 2.92 | 4.79    |

|      |      |      |      |      |       |      |      |      |
|------|------|------|------|------|-------|------|------|------|
| 5    | 0.00 | 0.00 | 0.00 | 0.02 | -4.73 | 7.60 | 2.89 | 4.71 |
| 6    | 0.00 | 0.00 | 0.00 | 0.01 | -4.14 | 6.79 | 2.66 | 4.13 |
| 7    | 0.00 | 0.00 | 0.00 | 0.02 | -4.89 | 7.83 | 2.96 | 4.87 |
| 8    | 0.00 | 0.00 | 0.00 | 0.01 | -4.62 | 7.42 | 2.81 | 4.61 |
| 9    | 0.00 | 0.00 | 0.00 | 0.01 | -4.70 | 7.56 | 2.87 | 4.69 |
| 10   | 0.00 | 0.00 | 0.00 | 0.01 | -4.61 | 7.43 | 2.83 | 4.60 |
| Mean | 0.00 | 0.00 | 0.00 | 0.01 | -4.54 | 7.34 | 2.81 | 4.53 |

### 5.2.9 Pilot Exercise 5a: Grassland systems degradation and management

The location of the random contracts simulated for type 5a are presented on Figure 59. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by grasslands (Pastures, Natural grasslands) in a region of 200 km to the side around the centroid.



*Figure 59: Location of random simulated contracts of type 5a*

The mean results obtained in the simulation of contracts of type 5a are presented on Table 23. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 0.48 tC/ha.yr.

*Table 23: Mean results obtained in the simulation of contracts of type 5a*

| Contract | Centroid | Participants |  | Carbon balance (ton C-eq) per year |
|----------|----------|--------------|--|------------------------------------|
|----------|----------|--------------|--|------------------------------------|

|      | Lat<br>(°) | Lon<br>(°) |      | Mean<br>Area<br>(ha) | Per<br>hectare | Per<br>participant | Per<br>project |
|------|------------|------------|------|----------------------|----------------|--------------------|----------------|
| 1    | 50.28      | 5.49       | 21   | 18.68                | 0.48           | 8.99               | 189            |
| 2    | 43.10      | 19.14      | 32   | 19.70                | 0.51           | 10.01              | 320            |
| 3    | 46.38      | 3.43       | 37   | 21.42                | 0.47           | 10.13              | 375            |
| 4    | 41.88      | 20.79      | 39   | 18.21                | 0.53           | 9.73               | 380            |
| 5    | 64.60      | -20.95     | 44   | 19.64                | 0.50           | 9.82               | 432            |
| 6    | 40.28      | 27.75      | 42   | 19.53                | 0.46           | 9.02               | 379            |
| 7    | 53.68      | -2.92      | 38   | 19.32                | 0.44           | 8.44               | 321            |
| 8    | 40.87      | -5.80      | 34   | 17.15                | 0.48           | 8.16               | 277            |
| 9    | 54.32      | -7.01      | 64   | 19.15                | 0.49           | 9.41               | 602            |
| 10   | 51.96      | 5.24       | 12   | 21.63                | 0.45           | 9.67               | 116            |
| Mean |            |            | 36.3 | 19.32                | 0.48           | 9.34               | 339            |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 60. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. The figure shows some variability within contracts, but all contracts show similar behavior. The best results are obtained for contract number 4, with a net reduction of 0.53 tC/ha.yr. The minimum reduction is obtained for contract number 7, with 0.44 tC/ha.yr. The largest variability is shown by contract number 7, with reductions ranging from 0.31 tC/ha.yr to 0.86 tC/ha.yr. Contract number 4 shows the least variability, with reductions ranging from 0.30 tC/ha.yr to 0.87 tC/ha.yr.

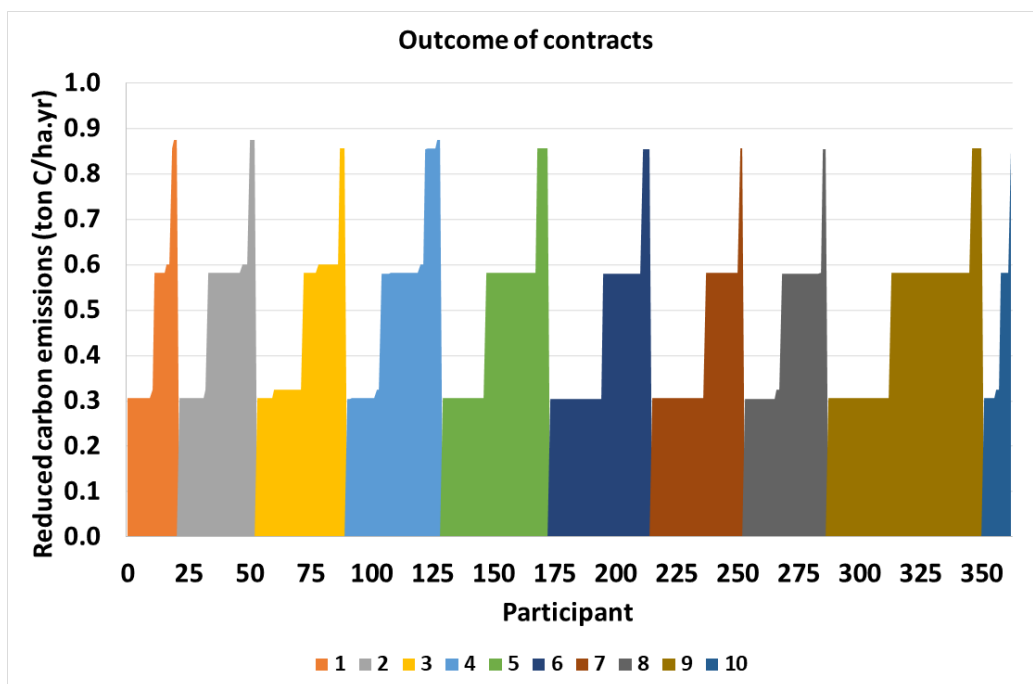


Figure 60: Distribution of net results as a function of contract for type 5a

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* category is shown on Figure 61. The upper row shows variables 1, Climate, and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. The dominant climate type is Cool Temperate, which affects 66% of the participants. The best performance is obtained for Warm Temperate, with a mean reduction of 0.49 tC/ha.yr. The dominant moisture regime is Dry, with 88% of the participants. The best performance is obtained for the Moist regime, with a mean reduction of 0.52 tC/ha.yr. The dominant soil type is HAC Soils, with 71% of the participants. The best performance is obtained for Spodic Soils, with a mean reduction of 0.53 tC/ha.yr.

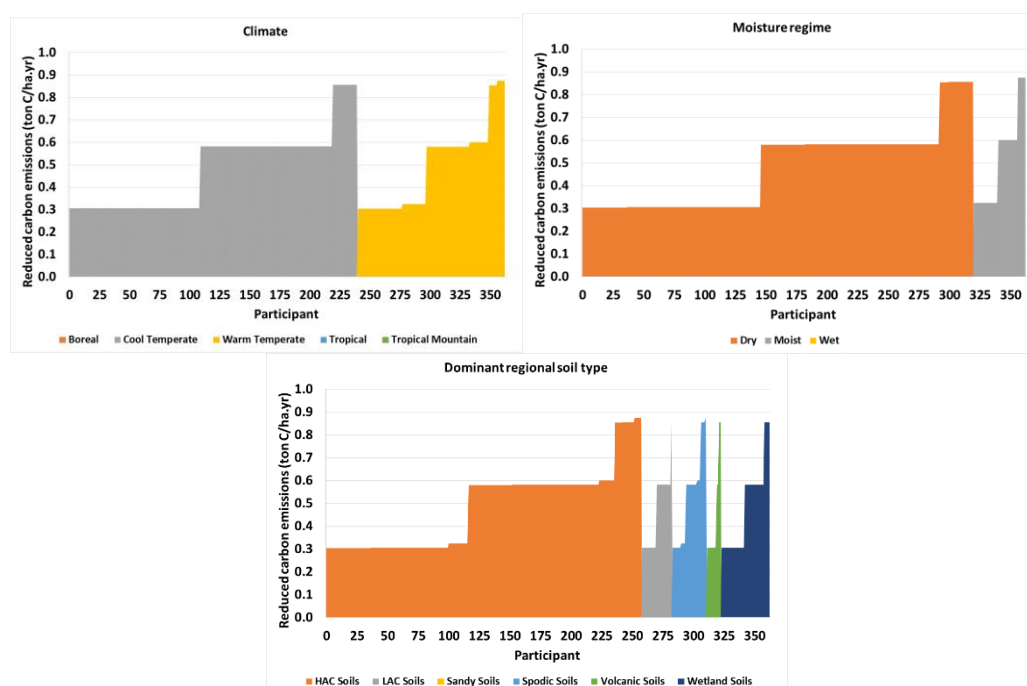


Figure 61: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description category. Upper row: climate (left) and moisture regime (right). Lower row: soil type

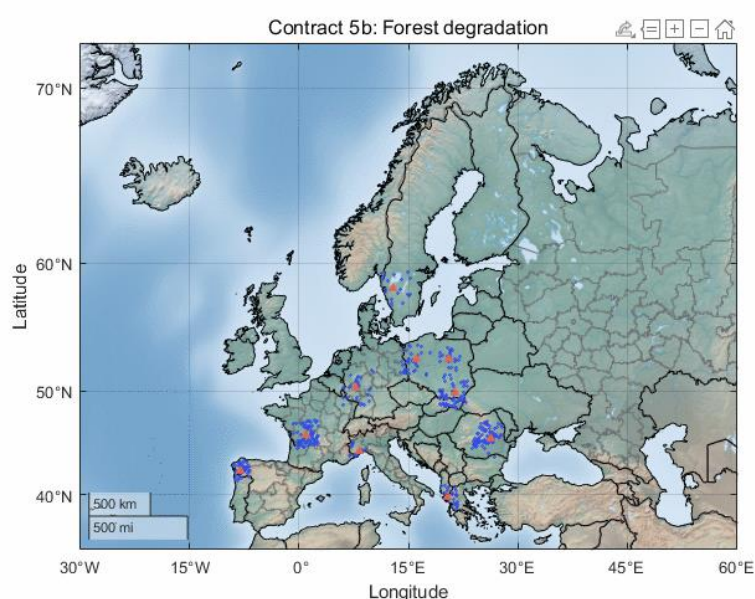
The detailed balance of GHG emissions resulting from the application of contracts of type 5a is presented on Table 24. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, soil carbon storage is responsible for all CO<sub>2</sub> balance. Overall, CO<sub>2</sub> represents 93.1% of the reduction, with 3.6% for N<sub>2</sub>O and 3.3% for CH<sub>4</sub>.

Table 24: Detailed balance of GHG emissions obtained in the simulation of contracts of type 5a

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |       |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|-------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With  | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |       |         |
| 1        | 0.00                         | -0.45 | 0.00  | -0.02           | -0.02           | 0.10             | -0.38 | 0.48    |
| 2        | 0.00                         | -0.47 | 0.00  | -0.02           | -0.02           | 0.15             | -0.36 | 0.51    |
| 3        | 0.00                         | -0.43 | 0.00  | -0.02           | -0.02           | 0.11             | -0.36 | 0.47    |
| 4        | 0.00                         | -0.50 | 0.00  | -0.02           | -0.02           | 0.13             | -0.41 | 0.53    |
| 5        | 0.00                         | -0.47 | 0.00  | -0.02           | -0.02           | 0.14             | -0.36 | 0.50    |
| 6        | 0.00                         | -0.43 | 0.00  | -0.02           | -0.01           | 0.09             | -0.37 | 0.46    |
| 7        | 0.00                         | -0.41 | 0.00  | -0.02           | -0.02           | 0.10             | -0.34 | 0.44    |
| 8        | 0.00                         | -0.44 | 0.00  | -0.02           | -0.01           | 0.10             | -0.37 | 0.48    |
| 9        | 0.00                         | -0.46 | 0.00  | -0.02           | -0.02           | 0.11             | -0.38 | 0.49    |
| 10       | 0.00                         | -0.41 | 0.00  | -0.02           | -0.02           | 0.10             | -0.34 | 0.45    |
| Mean     | 0.00                         | -0.45 | 0.00  | -0.02           | -0.02           | 0.11             | -0.37 | 0.48    |

## 5.2.10 Pilot Exercise 5b: Forest degradation and management

The location of the random contracts simulated for type 5b are presented on Figure 62. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by forests (Broad-leaved forest, Coniferous forest, Mixed forest) in a region of 500 km to the side around the centroid.



*Figure 62: Location of random simulated contracts of type 5b*

The mean results obtained in the simulation of contracts of type 5b are presented on Table 25. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 7.25 tC/ha.yr.

*Table 25: Mean results obtained in the simulation of contracts of type 5b*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 49.57    | 21.05   | 66           | 19.76          | 7.17                               | 141.76          | 9356        |
| 2        | 58.21    | 13.30   | 19           | 20.63          | 6.97                               | 143.90          | 2734        |
| 3        | 45.82    | 25.63   | 88           | 17.00          | 6.61                               | 112.29          | 9881        |
| 4        | 39.83    | 20.98   | 28           | 20.57          | 4.74                               | 97.45           | 2729        |

|      |       |       |      |       |      |        |       |
|------|-------|-------|------|-------|------|--------|-------|
| 5    | 52.88 | 20.71 | 27   | 18.02 | 6.67 | 120.16 | 3244  |
| 6    | 44.50 | 7.86  | 14   | 23.80 | 8.17 | 194.52 | 2723  |
| 7    | 42.64 | -7.79 | 40   | 17.39 | 6.91 | 120.19 | 4808  |
| 8    | 50.16 | 8.07  | 26   | 22.46 | 7.55 | 169.50 | 4407  |
| 9    | 52.50 | 15.50 | 33   | 21.37 | 6.13 | 130.92 | 4320  |
| 10   | 45.89 | 1.21  | 84   | 19.80 | 9.33 | 184.79 | 15522 |
| Mean |       |       | 42.5 | 19.38 | 7.25 | 140.53 | 5972  |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 63. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. There is large variability, both within each contract and among different contracts. The best results are obtained for contract number 10, with a net reduction of 9.33 tC/ha.yr. The minimum reduction is obtained for contract number 4, with 4.74 tC/ha.yr. The largest variability is shown by contract number 4, with reductions ranging from 0.0 tC/ha.yr to 12.93 tC/ha.yr. Contract number 2 shows the least variability, with reductions ranging from 3.61 tC/ha.yr to 10.84 tC/ha.yr.

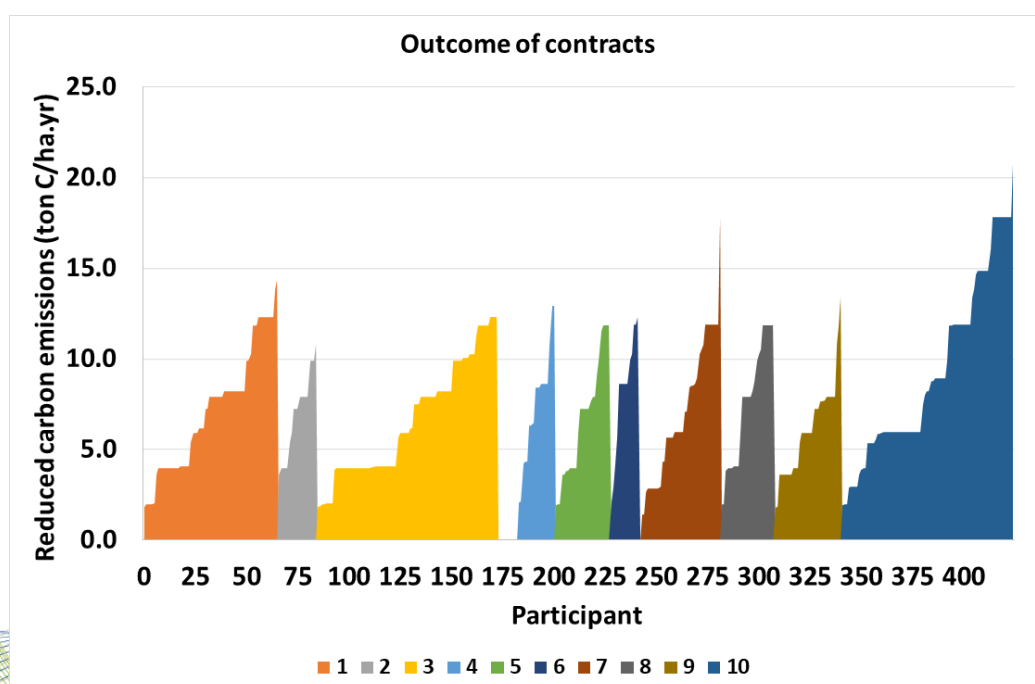
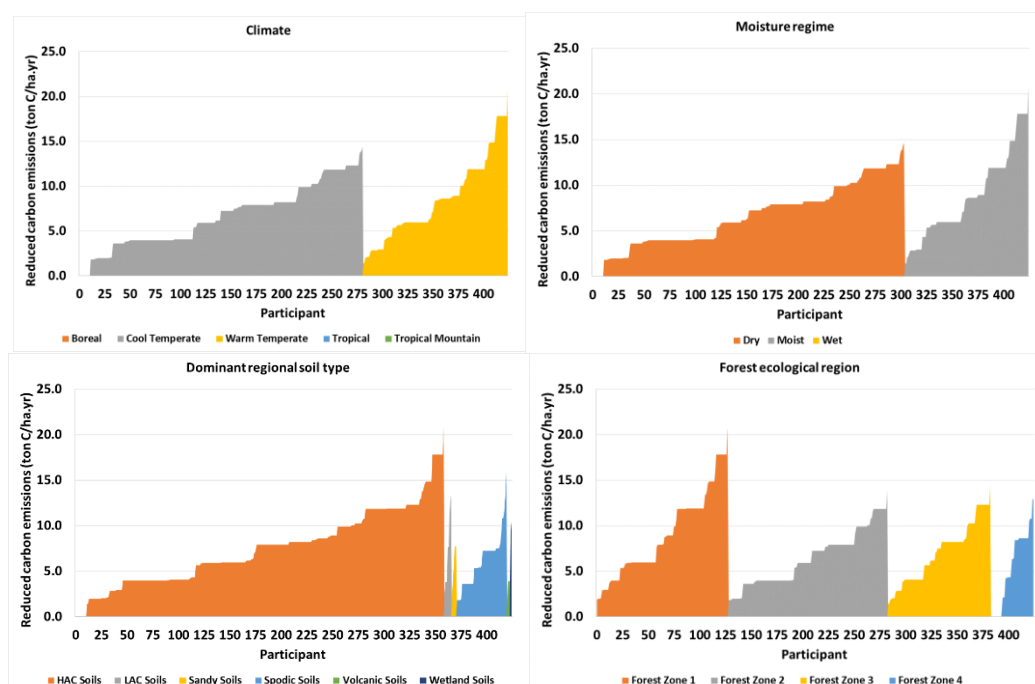


Figure 63: Distribution of net results as a function of contract for type 5b

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* and *LUC* categories is shown on Figure 64. The upper row shows variables 1, Climate, and 2, Moisture regime. The lower row shows variables 3, Dominant regional soil type, and 4, Forest ecological zone. The dominant climate type is Cool Temperate, with 66% of the participants. The best performance is obtained for Warm Temperate, with a mean reduction of

8.46 tC/ha.yr. The dominant moisture regime is Dry, with 72% of the participants. The best performance is obtained for the Moist regime, with a mean reduction of 8.77 tC/ha.yr. The dominant soil type is HAC Soils, with 84% of the participants. The best performance is obtained for Wetland Soils, with a mean reduction of 9.62 tC/ha.yr, but this type of soil affects only two participants. The three dominant ecological zone is Forest zone 2, with 36% of the participants. The best performance is obtained for Forest zone 1, with a mean reduction of 8.99 tC/ha.yr.



*Figure 64: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description and LUC categories. Upper row: climate (left) and moisture regime (right). Lower row: soil type (left) and ecological zone (right)*

The detailed balance of GHG emissions resulting from the application of contracts of type 5b is presented on Table 26. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, biomass carbon storage represents 91.4% of total CO<sub>2</sub> balance. The contributions of N<sub>2</sub>O and CH<sub>4</sub> are negligible.

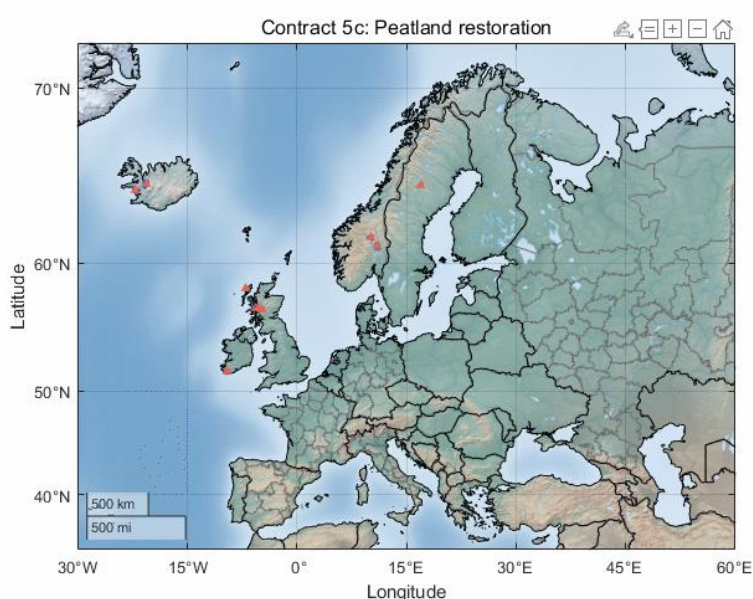
*Table 26: Detailed balance of GHG emissions obtained in the simulation of contracts of type 5b*

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |       |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|-------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With  | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |       |         |
| 1        | -6.60                        | -0.58 | 0.00  | 0.00            | 0.00            | 2.74             | -4.43 | 7.17    |
| 2        | -6.56                        | -0.42 | 0.00  | 0.00            | 0.00            | 3.43             | -3.54 | 6.97    |

|      |       |       |      |      |      |      |       |      |
|------|-------|-------|------|------|------|------|-------|------|
| 3    | -6.09 | -0.51 | 0.00 | 0.00 | 0.00 | 2.46 | -4.15 | 6.61 |
| 4    | -4.20 | -0.54 | 0.00 | 0.00 | 0.00 | 1.98 | -2.75 | 4.74 |
| 5    | -6.29 | -0.38 | 0.00 | 0.00 | 0.00 | 2.26 | -4.41 | 6.67 |
| 6    | -7.13 | -1.04 | 0.00 | 0.00 | 0.00 | 3.88 | -4.30 | 8.17 |
| 7    | -6.00 | -0.92 | 0.00 | 0.00 | 0.00 | 2.14 | -4.78 | 6.91 |
| 8    | -6.86 | -0.69 | 0.00 | 0.00 | 0.00 | 3.55 | -4.00 | 7.55 |
| 9    | -5.80 | -0.33 | 0.00 | 0.00 | 0.00 | 1.99 | -4.14 | 6.13 |
| 10   | -8.52 | -0.81 | 0.00 | 0.00 | 0.00 | 3.51 | -5.82 | 9.33 |
| Mean | -6.63 | -0.62 | 0.00 | 0.00 | 0.00 | 2.79 | -4.47 | 7.25 |

### 5.2.11 Pilot Exercise 5c: Restoration of drained peatland

The location of the random contracts simulated for type 5c are presented on Figure 65. The centroid of the contract is represented as a red triangle and individual participants are represented as blue dots. The location of the participants in the contracts was randomly chosen from land covered by peatlands (Peat bogs) in a region of 50 km to the side around the centroid.



*Figure 65: Location of random simulated contracts of type 5c*

The mean results obtained in the simulation of contracts of type 5c are presented on Table 27. The table shows the main characteristics of each contract (centroid, number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per project (tC/yr). The last line of the table shows the weighted average for all contracts. The mean value obtained for this contract type is 10.89 tC/ha.yr.

*Table 27: Mean results obtained in the simulation of contracts of type 5c*

| Contract | Centroid |         | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |             |
|----------|----------|---------|--------------|----------------|------------------------------------|-----------------|-------------|
|          | Lat (°)  | Lon (°) |              |                | Per hectare                        | Per participant | Per project |
| 1        | 58.17    | -6.95   | 20           | 45.18          | 11.72                              | 529.37          | 10587       |
| 2        | 61.68    | 10.18   | 14           | 40.24          | 4.00                               | 160.89          | 2253        |
| 3        | 65.00    | -20.69  | 21           | 45.51          | 11.82                              | 537.71          | 11292       |
| 4        | 61.15    | 10.99   | 18           | 66.84          | 11.38                              | 760.42          | 13688       |
| 5        | 64.62    | -22.08  | 24           | 43.54          | 11.80                              | 513.55          | 12325       |
| 6        | 51.75    | -9.61   | 19           | 68.57          | 11.57                              | 793.55          | 15078       |
| 7        | 56.71    | -5.74   | 16           | 44.65          | 11.63                              | 519.49          | 8312        |
| 8        | 56.81    | -5.37   | 15           | 49.47          | 11.80                              | 583.72          | 8756        |
| 9        | 64.88    | 17.02   | 14           | 38.70          | 7.33                               | 283.58          | 3970        |
| 10       | 56.67    | -4.74   | 20           | 40.40          | 11.62                              | 469.64          | 9393        |
| Mean     |          |         | 18.1         | 48.51          | 10.89                              | 528.47          | 9565        |

The distribution of the net carbon balance in each contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 66. The figure shows the results obtained in all participants, sorted by contract and ordered from less reduction to more reduction. The figure shows little variability for most contracts, but there are two where measures are not as effective. The best results are obtained for contract number 3, with a net reduction of 11.82 tC/ha.yr. The minimum reduction is obtained for contract number 2, with 4.00 tC/ha.yr. The largest variability is shown by contract number 9, with reductions ranging from 3.28 tC/ha.yr to 12.57 tC/ha.yr. Contract number 5 shows the least variability, with reductions ranging from 10.96 tC/ha.yr to 12.91 tC/ha.yr.

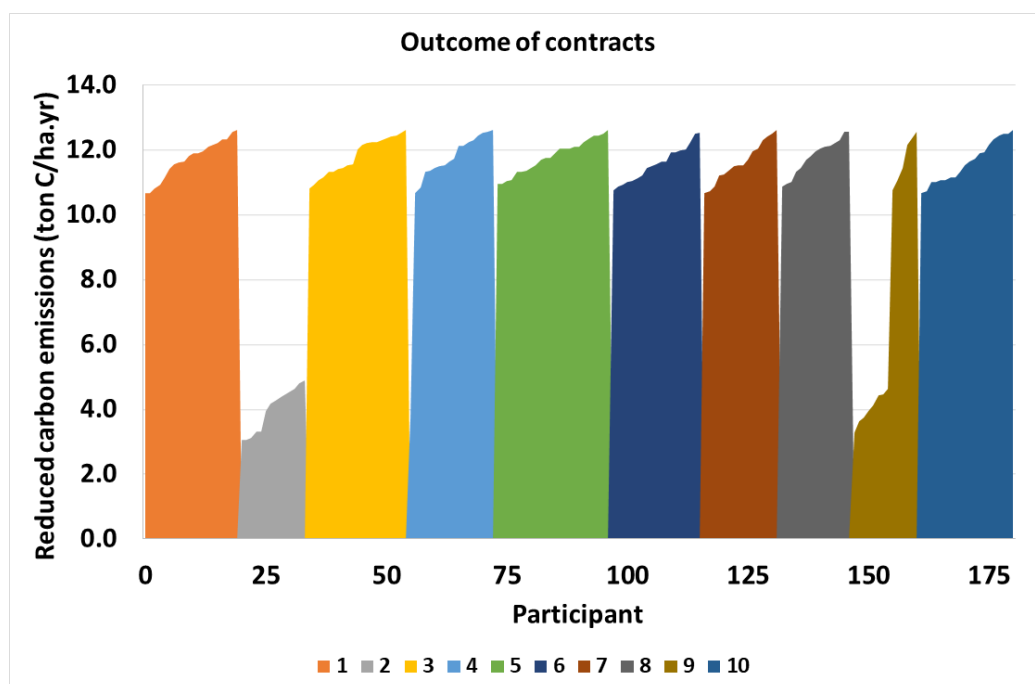


Figure 66: Distribution of net results as a function of contract for type 5c

The distribution of the net carbon balance as a function of the explanatory variables used in EX-ACT in the *Description* category is shown on Figure 67. The upper row shows variables 1, Climate, and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. The dominant climate type is Cool Temperate, which affects 86% of the participants. The best performance is obtained for Warm Temperate, with a mean reduction of 11.82 tC/ha.yr, but it only affects two participants. The climate type Cool Temperate has a very similar mean reduction, 11.72 tC/ha.yr. The dominant moisture regime is Dry, with 86% of the participants. The best performance is obtained for this moisture regime, with a mean reduction of 11.72 tC/ha.yr. The dominant soil type is LAC Soils, with 80% of the participants. The best performance is obtained for Volcanic Soils, with a mean reduction of 12.00 tC/ha.yr.

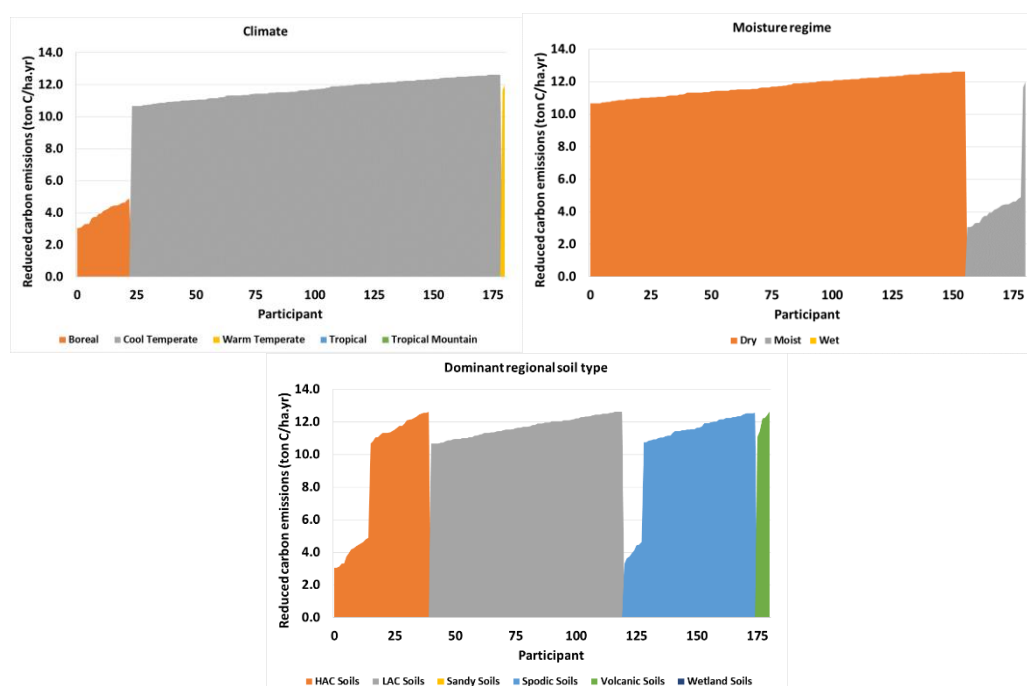


Figure 67: Distribution of net results as a function of the explanatory variables of EX-ACT model in the Description category. Upper row: climate (left) and moisture regime (right). Lower row: soil type

The detailed balance of GHG emissions resulting from the application of contracts of type 5c is presented on Table 28. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. In this type of contract, soil carbon storage is responsible for all CO<sub>2</sub> balance. Overall, CO<sub>2</sub> represents 66.8% of the reduction, with 8.1% for N<sub>2</sub>O and 25.1% for CH<sub>4</sub>.

Table 28: Detailed balance of GHG emissions obtained in the simulation of contracts of type 5c

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |      |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |      |         |
| 1        | 0.00                         | -8.00 | 0.00  | -0.98           | -2.73           | 15.62            | 3.91 | 11.72   |
| 2        | 0.00                         | -1.18 | 0.00  | -0.08           | -2.74           | 5.33             | 1.33 | 4.00    |
| 3        | 0.00                         | -8.00 | 0.00  | -0.98           | -2.83           | 15.75            | 3.94 | 11.82   |
| 4        | 0.00                         | -7.62 | 0.00  | -0.93           | -2.82           | 15.17            | 3.79 | 11.38   |
| 5        | 0.00                         | -8.00 | 0.00  | -0.98           | -2.81           | 15.73            | 3.93 | 11.80   |
| 6        | 0.00                         | -8.00 | 0.00  | -0.97           | -2.60           | 15.43            | 3.86 | 11.57   |
| 7        | 0.00                         | -8.00 | 0.00  | -0.98           | -2.65           | 15.51            | 3.88 | 11.63   |
| 8        | 0.00                         | -8.00 | 0.00  | -0.98           | -2.81           | 15.73            | 3.93 | 11.80   |
| 9        | 0.00                         | -4.11 | 0.00  | -0.47           | -2.76           | 9.77             | 2.44 | 7.33    |
| 10       | 0.00                         | -8.00 | 0.00  | -0.98           | -2.64           | 15.50            | 3.87 | 11.62   |

|      |      |       |      |       |       |       |      |       |
|------|------|-------|------|-------|-------|-------|------|-------|
| Mean | 0.00 | -7.27 | 0.00 | -0.88 | -2.74 | 14.53 | 3.63 | 10.89 |
|------|------|-------|------|-------|-------|-------|------|-------|

### 5.3 Summary of the results

A comparative summary of the results obtained in the different types of contracts analyzed is presented in this section. The mean results obtained in the simulation of every contract type are presented on Table 29. The table shows the main characteristics of each contract type (number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per type of contract (tC/yr). The last line of the table shows the weighted average for all contract types. The mean value obtained for all contract types is 5.19 tC/ha.yr.

*Table 29: Mean results obtained in the simulation of all contract types*

| Contract type | Participants | Mean Area (ha) | Carbon balance (ton C-eq) per year |                 |                      |
|---------------|--------------|----------------|------------------------------------|-----------------|----------------------|
|               |              |                | Per hectare                        | Per participant | Per type of contract |
| 1a            | 364          | 20.72          | 15.71                              | 325.51          | 118485               |
| 1b            | 316          | 5.99           | 5.45                               | 32.64           | 10315                |
| 1c            | 292          | 20.14          | 12.23                              | 246.34          | 71931                |
| 2a            | 179          | 9.57           | 5.91                               | 56.57           | 10126                |
| 2b            | 189          | 9.98           | 2.02                               | 20.16           | 3810                 |
| 3a            | 413          | 101.57         | 1.90                               | 193.09          | 79747                |
| 4a            | 392          | 5.93           | 0.72                               | 4.27            | 1674                 |
| 4b            | 214          | 4.87           | 4.51                               | 22.00           | 4709                 |
| 5a            | 363          | 19.32          | 0.48                               | 9.35            | 3394                 |
| 5b            | 425          | 19.38          | 7.23                               | 140.12          | 59552                |
| 5c            | 181          | 48.51          | 10.74                              | 521.10          | 94319                |
| Mean          | 302.55       | 26.52          | 5.19                               | 137.64          | 41642                |

The distribution of the net carbon balance in each type of contract, expressed as equivalent tons of reduced carbon emissions per hectare and per year is presented on Figure 68. The figure shows the results obtained in all participants, sorted by type of contract and ordered from less reduction to more reduction. The figure shows large variability among types of contracts. The best results are obtained for contracts of type 1a, with a net reduction of 15.71 tC/ha.yr. The minimum reduction is obtained for contract type 5a, with 0.48 tC/ha.yr. The largest variability is shown by contract type 5b, with reductions ranging from 0.0

tC/ha.yr to 20.82 tC/ha.yr. Contract type 4a shows the least variability, with all participants producing the same reduction of 0.72 tC/ha.yr.

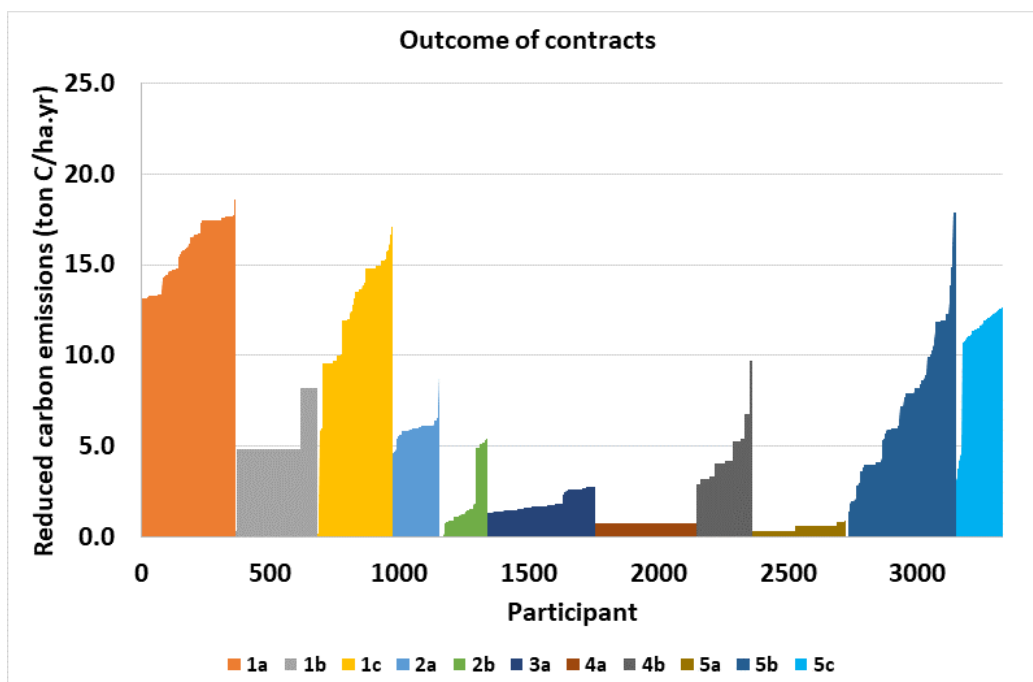


Figure 68: Distribution of net results as a function of contract type

The distribution of the net carbon balance as a function of the common explanatory variables used in all contract types is shown on Figure 69. The upper row shows variables 1, Climate, and 2, Moisture regime. The lower row shows variable 3, Dominant regional soil type. The dominant climate type is Warm Temperate, which affects 56% of the participants. The best performance is obtained for Cool Temperate, with a mean reduction of 7.55 tC/ha.yr. The dominant moisture regime is Dry, with 79% of the participants. The best performance is obtained for this moisture regime, with a mean reduction of 6.01 tC/ha.yr. The dominant soil type is HAC Soils, with 82% of the participants. The best performance is obtained for LAC Soils, with a mean reduction of 7.99 tC/ha.yr.

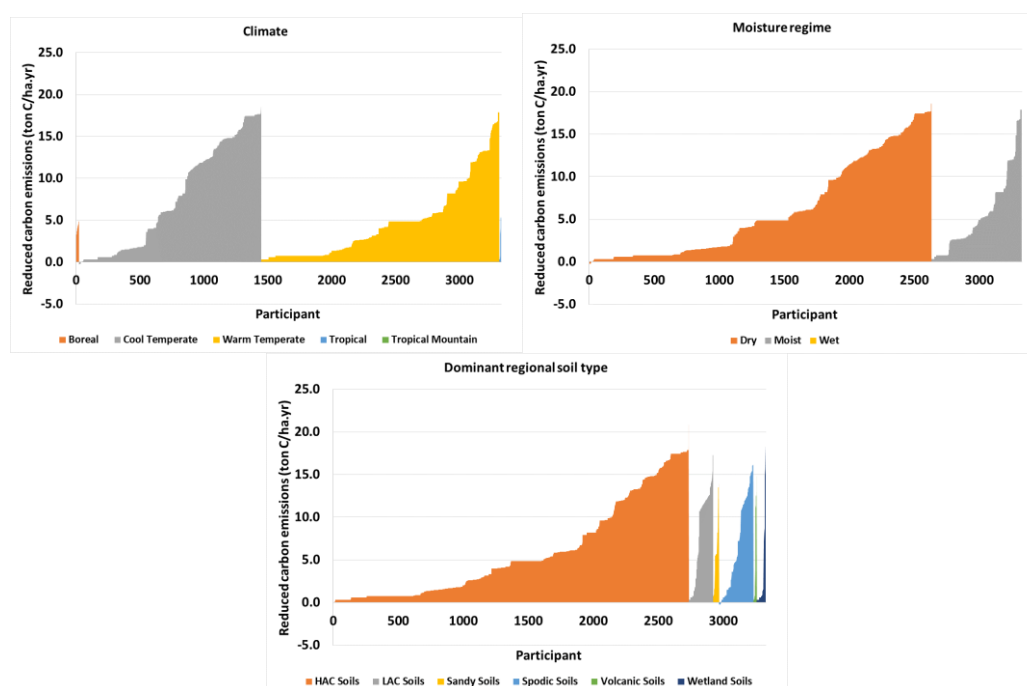


Figure 69: Distribution of net results as a function of the explanatory variables used in all contract types. Upper row: climate (left) and moisture regime (right). Lower row: soil type

The detailed balance of GHG emissions resulting from the application of all contract types is presented on Table 30. The table shows the share of each GHG in the total balance of equivalent carbon emissions. The contribution of CO<sub>2</sub> is divided into biomass, soil and other fraction. For the weighted average of all contract types, biomass carbon storage is responsible for 62.3% of the reductions of CO<sub>2</sub> emissions and soil carbon storage is responsible for the remaining 37.7%. Overall, CO<sub>2</sub> represents 86.2% of the reduction, with 3.0% for N<sub>2</sub>O and 10.8% for CH<sub>4</sub>.

Table 30: Detailed balance of GHG emissions obtained in the simulation of all contract types

| Contract | Share per GHG of the Balance |       |       |                 |                 | Results per year |        |         |
|----------|------------------------------|-------|-------|-----------------|-----------------|------------------|--------|---------|
|          | CO <sub>2</sub>              |       |       | NO <sub>2</sub> | CH <sub>4</sub> | Without          | With   | Balance |
|          | Biomass                      | Soil  | Other |                 |                 |                  |        |         |
| 1a       | -13.91                       | -1.43 | 0.00  | -0.09           | -0.28           | 0.49             | -15.22 | -15.71  |
| 1b       | -5.04                        | 0.31  | 0.00  | -0.38           | -0.34           | 0.55             | -4.90  | -5.45   |
| 1c       | -12.01                       | -0.22 | 0.00  | 0.00            | 0.00            | 0.10             | -12.13 | -12.23  |
| 2a       | -4.33                        | -1.29 | 0.00  | -0.07           | -0.22           | 0.39             | -5.52  | -5.91   |
| 2b       | 0.44                         | -2.07 | 0.00  | -0.09           | -0.29           | 0.51             | -1.51  | -2.02   |
| 3a       | 0.00                         | -1.43 | 0.00  | -0.09           | -0.39           | 0.21             | -1.69  | -1.90   |
| 4a       | 0.00                         | 0.00  | 0.00  | -0.38           | -0.34           | 0.45             | -0.27  | -0.72   |
| 4b       | 0.00                         | 0.00  | 0.00  | 0.01            | -4.53           | 7.32             | 2.81   | -4.51   |
| 5a       | 0.00                         | -0.45 | 0.00  | -0.02           | -0.02           | 0.11             | -0.37  | -0.48   |

|      |       |       |      |       |       |       |       |        |
|------|-------|-------|------|-------|-------|-------|-------|--------|
| 5b   | -6.61 | -0.62 | 0.00 | 0.00  | 0.00  | 2.76  | -4.47 | -7.23  |
| 5c   | 0.00  | -7.14 | 0.00 | -0.87 | -2.74 | 14.32 | 3.58  | -10.74 |
| Mean | -2.87 | -1.67 | 0.00 | -0.16 | -0.57 | 2.01  | -3.27 | -5.27  |

The results of the analysis are summarized on Figure 70. The figure shows a comparison of the reduction of carbon emissions in equivalent tC/ha.yr in the types of contracts analyzed. The types of contracts are sorted according to the net reduction obtained. The figure shows the average reduction as a red dot and the range of results obtained in all participants as a blue bar.

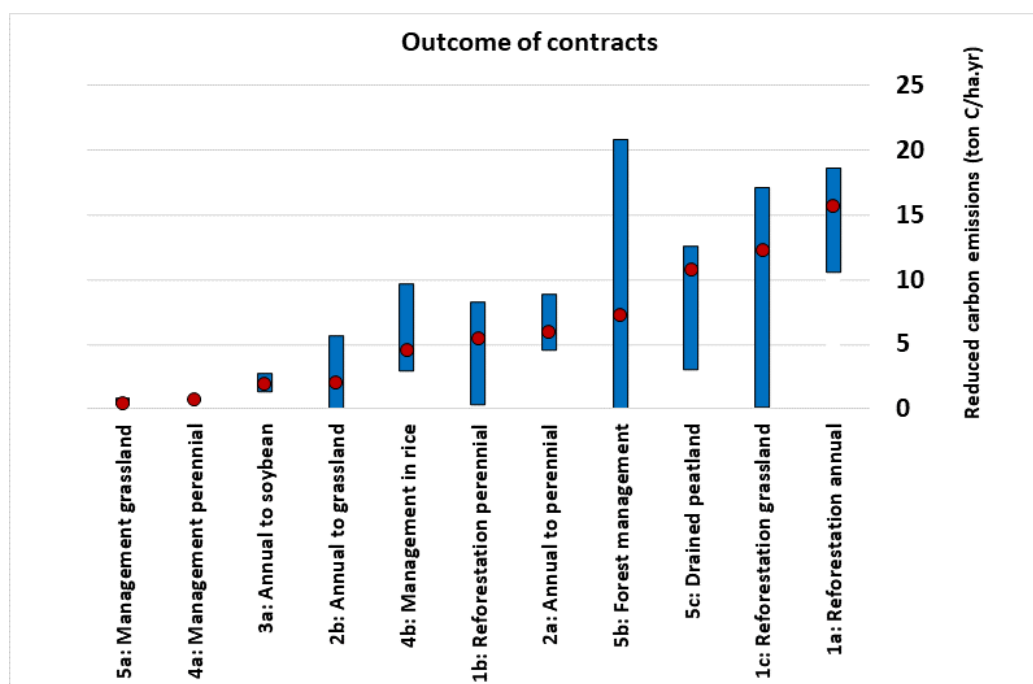


Figure 70: Final result of the analysis

## 6 Conclusions

The results of D4.5 show that: (a) Models are effective tools to define environmental effects (compared to traditional input-based schemes); (b) Spatial spill-over makes contracts successful; and (c) Modelling may improve expectations of farmers and encourages participation.

WP2 provided a portfolio of contracts that can contribute to reaching European mitigation targets. Many of the contracts imply the implementation of well tested agronomic and technical know-how, with proven benefits for farmers and the environment.

When implementing the contracts, three questions are important: Are they cost-effective for farmers? Do they reduce GHG emissions? What policies favour their implementation? D4.5 addressed these questions in three sequential steps. First, developing catalogue of case studies in Europe that describe contracts that aim to mitigate GHG emissions. Second, developing an upscaling model that links the agri-environmental characteristics to the wider geographical areas. Third, using a Marginal Abatement Cost Curve (MACC) approach for exploring the contracts in terms of their social cost and the environmental effectiveness.

In order to provide realism to the analysis we selected the empirical case studies described in WP2. Therefore, D4.5 restricts its attention to strategies that are relevant for these case studies and have linkages to climate mitigation.

The upscaling model to estimate performance intends to extend results of the analysis of contract solutions at the local level to a wider geographical context, to understand how the generalized application of contract solutions may lead to significant environmental gains. To perform this task, the model accounts for the basic processes that influence the provision of AECPGs as a result of changes in the behaviour of land managers induced by contract solutions. Some of these processes are extremely complex at the physical, chemical, biological, and socioeconomic levels, and therefore they need to be simplified to become manageable.

Assumptions about implementation and effectiveness in the model are derived from the individual model results reported in D4.2-4.4, that include the optimal use of information by farmers provided by the Environmental Extension Service, and that the value of information is homogeneous in the geographical space and type of agri-environmental system.

The European Union targets for reducing GHG emission have a clear agricultural contribution, due not only to technical feasibility, but also to potential implementation since the agricultural sector is subject to intervention. Therefore, the contracts that could be supported by agricultural policy represent a suitable subject for research. However, given the complex interactions of agricultural production with the environment and the sustainability of rural communities, these contracts need to be evaluated from agronomic and socioeconomic perspectives.

In this D4.5 the quantitative analysis of environmental gain is focused on a particular category of AECPG: reduction of GHG emissions to the atmosphere by sequestering soil organic carbon. The reasons for this decision are: (1) soil carbon storage can be quantified and measured; (2) climate change mitigation through carbon storage is a key policy in EU and (3) there is good knowledge to estimate the effect of contract solutions on carbon storage.

Cost effectiveness analysis for the purpose of analysing agro-environmental policy is distinct from financial analysis in the private sector. First, the effect takes place over time and has a social benefit component that is not accounted for in this type of analysis. Second, the incremental costs of implementing the practice account for more than just financial costs and its monetization is highly controversial. In this study we estimate if the implementation of a new contract, makes farmers worse- or better-off. Since it is not possible to account for all the costs and benefits of an empirical case study.

Concerns about cost effectiveness analysis tend to mirror more general critiques of controversial reliance on monetization of all costs. But the a clear presentation of the assumptions and linkages to the real case studies described in WP2, makes the analysis useful for decision-making.

The upscaling model identifies the target area for the type of contract and selects N random locations from the target area as centroid of the area of influence of each contract. The generation of contracts is achieved through a Monte Carlo simulation method. For each contract type.

A comparative summary of the results obtained in the different types of contracts analysed is presented. The main characteristics of each contract type (number of participants and mean area of participating land units) and the net carbon balance in equivalent tons of reduced carbon emissions. Results are presented as mean values per hectare (tC/ha.yr), per participant (tC/yr) and per type of contract (tC/yr). The last line of the table shows the weighted average for all contract types. The mean value obtained for all contract types is 5.19 tC/ha.yr.

The distribution of the net carbon balance as a function of the common explanatory variables used in all contract types and it is detailed in the report.

There are important limitations of our analysis. First, we addressed only forests, crop and grassland farming systems and contracts that aiming to reduce GHG emissions. Although livestock systems were not considered explicitly in the study, it was included in the farming classification of the spatial land use data used. Second, the static nature of our cost efficiency analysis, as it just considers average values for the calculation, is clearly limited. Consequently, our MACC is unable to account for the effects of temporal changes in the contracts as drivers of mitigation that might change the cost-effectiveness of the contracts. Third, D4.5 omits behavioural aspects which can have a substantial influence on land manager decision making. As an alternative, we used expert judgment to outline the uptake barriers and incentives of contracts according to technical, social and economic drivers. Finally, the lack of existing key data and empirical

evidence with respect to the effect of implementing contracts in terms economic costs or benefits is evident and therefore was estimated by using indicators, making the assessment more apparent than real and all indicators for the calculations had to be based on assumptions from studies previously reported in similar areas and on expert judgment.

The derived shortcomings of our cost-effectiveness analysis mean that the results are only indicative of the relative ranking of contracts is only a preliminary exploration and further research is needed to extend the knowledge of the underlying reasons for their implementation. Despite these limitations, the analysis advances our understanding of the social cost and the abatement that might be achieved by some contracts which could be used as a complementary tool supporting the new CAP measures.

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