Methodological Appendix

Multi-Criteria Decision Analysis (MCDA)

Sustainable Farming Systems for Five Major Crops in Portugal

Crops studied: Corn · Wheat · Rice · Vineyard · Olive yard

Farming systems: Conventional · Organic · Regenerative · Agroforestry · Agriculture 4.0

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Section 1 – Measures Characterisation

This study evaluates five farming systems applied to five crops that are widely cultivated in Portugal: corn, wheat, rice, vineyard and olive yard. Each measure is described below through three to five characteristic pillars. The five farming systems should be interpreted as stylised reference archetypes rather than exhaustive representations of all possible management combinations. In practice, farming systems may combine characteristics from multiple archetypes (e.g. organic agroforestry or precision regenerative agriculture). The separation adopted here is a deliberate modelling simplification that enables a transparent comparison between contrasting management strategies while preserving a tractable decision framework.

Measure 1 – Conventional

Current mainstream practices relying on synthetic inputs and standard irrigation, designed to maximise productivity. Tillage plays a central role in soil preparation.

- Synthetic fertilisers and chemical pesticides
- Standard irrigation techniques
- Intensive tillage
- Productivity-oriented management

Measure 2 – Organic

Farming system that excludes synthetic pesticides and mineral fertilisers in favour of organic inputs. The focus is on soil health and biodiversity, while tillage remains an important practice.

- No synthetic pesticides
- Organic fertilisers (compost, manure, green manure)
- Emphasis on soil health and biodiversity
- Tillage maintained

Measure 3 – Regenerative

Set of best-case regenerative practices aiming to rebuild soil health, sequester carbon and reduce operating costs through ecological intensification.

- Eliminating tillage
- Planting cover crops
- Increasing crop diversity (long rotations)
- Integrating animals with adaptive grazing
- Keeping living roots in the ground

Measure 4 – Agroforestry

Conventional agriculture combined with the integration of trees or hedges within the cropping system. The similar fertilisers and pesticides as in conventional are used, but the addition of woody elements brings long-term climate resilience and ecosystem benefits.

- Integration of trees or hedges in arable land
- Same fertilisers and pesticides as conventional
- Long-term climate resilience

Measure 5 – Agriculture 4.0

Digital and data-driven agriculture combining precision tools and innovative technologies to optimise inputs and improve decision-making.

- Digital innovation (sensors, IoT, farm connectivity)
- Drones and remote sensing
- Variable-rate technology and nanoparticles
- Data-driven management
- Alternate Wetting and Drying (AWD) for rice

Each of these measures will be applied to the five crops above, providing a 5 × 5 matrix of farming-system × crop combinations that constitutes the basis of the present study.

Methodological hierarchy

The inputs used throughout this report are drawn from four levels of methodological reliability, listed below in decreasing order of confidence:

1. **Empirical evidence** — measured data and official statistics (e.g. INE Estatísticas Agrícolas, Eurostat, peer-reviewed meta-analyses, expert communication).
2. **Derived assumptions** — values obtained by applying ratios from the literature to a Portuguese baseline (e.g. organic-to-conventional yield ratios).
3. **Expert judgment** — semi-quantitative scores attributed in the absence of measured data (e.g. resilience and social criteria).
4. **Qualitative interpretation** — narrative deductions where no quantification is feasible.

This hierarchy should be kept in mind when interpreting the performance matrix in Section 5: criteria do not all rest on evidence of equal strength.

Section 2 – MCDA

Choosing between farming systems is intrinsically a multi-dimensional problem. Sustainability in agriculture cannot be reduced to a single objective: a system that maximises short-term profit may degrade soil health, deplete groundwater, increase GHG emissions or be socially unattractive to the next generation of farmers. Single-criterion approaches such as benefit–cost analysis force every dimension to be translated into a monetary value. While monetisation methods do exist for non-market ecosystem services, including replacement cost, hedonic pricing and willingness-to-pay approaches, they remain controversial and subject to high uncertainty, particularly for environmental and social goods whose costs are difficult to measure or quantify (Strassert & Prato, 2002). Multi-Criteria Decision Analysis (MCDA) was developed precisely to overcome this limitation. It allows a finite set of options, here, five farming systems, to be compared simultaneously on a structured set of heterogeneous criteria, with no need to translate them into a common monetary unit, and accommodates qualitative as well as quantitative indicators (Carof et al., 2013). This makes MCDA a particularly suitable tool to compare farming systems whose strengths and weaknesses are spread across the economic, environmental and social pillars of sustainability.

The proposed MCDA framework is designed to compare the relative sustainability performance of representative farming-system archetypes under Portuguese conditions. It does not aim to assess transition pathways, adoption barriers, behavioural responses, investment costs, policy implementation, market dynamics or farm-specific optimisation. Likewise, the framework represents mature implementations of each farming system rather than the transition period during which environmental and economic performance may differ. These aspects remain important topics for future work but are beyond the scope of the present decision-support framework.

Beyond the diversity of available methods (Balancing & Ranking, MEACROS, MODAM, MASC, ROTOR, ELECTRE, VIKOR, MARCOS, AHP, etc.), every MCDA shares the same backbone. First, a finite set of options is defined (in our case the five farming systems) together with a consistent family of criteria that capture all the relevant sustainability dimensions. Second, the impact of each option on each criterion is quantified in a decision (or performance) matrix, using the most appropriate scale for each criterion. Third, the matrix is normalised so that criteria expressed in different units (€/t, kg CO_2e/t, mm/ha, 1–5 qualitative scores, etc.) become comparable. Fourth, criteria are weighted to reflect their relative importance, either elicited from decision-makers or derived objectively (e.g. Shannon entropy). Finally, the weighted normalised matrix is aggregated through a ranking or outranking procedure to produce a final ordering of the options. The transparency of this pipeline is what gives MCDA its practical value: every assumption (criterion choice, weight, aggregation rule) is explicit and can be challenged or revised in sensitivity analysis (Haloui et al., 2025).

The MCDA carried out in this report follows exactly this logic. The five options are the five farming systems characterised in Section 1 (Conventional, Organic, Regenerative, Agroforestry, Precision (4.0)), evaluated on the five main crops considered (corn, wheat, rice, vineyard, olive yard). The consistent family of criteria, detailed in Section 4, covers the three pillars of sustainability: three economic criteria (Total costs €/t, Gross revenue €/ha plus a composite Resilience score); four environmental criteria (Water consumption mm/t, Water pollution – nitrate leaching kg NO_3/ha, Biodiversity, GHG emissions kg CO_2e/t); and four social criteria (Job satisfaction, Attractiveness to young people, Job creation, Human health). For each criterion, Section 4 reports the quantification method, the underlying sources and the resulting performance matrix. The yields needed to convert per-hectare into per-tonne values are gathered separately in Section 3. Section 5 then applies the MCDA aggregation step proper: the performance matrix is normalised, criteria are weighted, and a final ranking of the five farming systems is produced. A sensitivity analysis is performed on the criteria weights to confirm the robustness of the ranking and to identify which dimensions are most decisive in the final ordering. A methodological caveat must be acknowledged at this stage. AHP, like most aggregation-based MCDA methods, assumes that criteria are mutually independent. In practice, several of the criteria retained here are **structurally correlated**: biodiversity and resilience capture overlapping ecological processes; soil health (implicit in several indicators) co-varies with water retention; agroforestry inherently combines tree integration with carbon sequestration; and profitability is partly driven by yield, itself influenced by the farming system. Treating these criteria as independent may therefore lead to a degree of double-counting, mechanically favouring systems that perform well on correlated dimensions (typically regenerative and agroforestry). Methods such as the Analytic Network Process (ANP) explicitly model these dependencies, but their additional complexity goes beyond the scope of the present study. The implications of this assumption are discussed in the sensitivity analysis (Section 5).

Among the methods listed above, the **Analytic Hierarchy Process (AHP)**, developed by Saaty (1980), is the approach retained in the present study. AHP is the most widely used MCDA technique in scientific and agricultural sustainability assessments, owing to three features that fit the structure of this work. First, its hierarchical decomposition naturally accommodates the three-pillar structure adopted here (economic, environmental, social), with criteria nested under each pillar. Second, weights are derived from pairwise comparisons on Saaty's 1–9 scale, which allows both measured indicators and expert-judgement-based scores to be handled within the same framework, a key requirement given the mixed nature of the criteria (Section 4). Third, AHP includes a built-in consistency check (Consistency Ratio, CR < 0.10) that flags incoherent judgements and reinforces the transparency of the weighting step. The detailed application of AHP to the present case (pairwise comparison matrices, weight vectors, consistency ratios and final aggregation) is reported in Section 5.

A final point concerns the orientation of the criteria. In the original data collection, some indicators were naturally expressed as costs to be minimised (for example, total costs, greenhouse gas emissions, water consumption and water pollution), while others were benefits to be maximised. To make the framework easier to read and to ensure that every criterion points in the same direction, all indicators have been reframed so that a higher value always means better performance. This is purely a presentation choice: the underlying data, quantification methods and sources remain exactly the same, and no result of the analysis is affected by it. In practice, four indicators were renamed to reflect their positive counterpart, and each of them keeps its original name as a subtitle so that the link with the source data stays clear. Total costs (€/t) becomes Cost competitiveness; GHG emissions (kgCO_2e/t) becomes Climate mitigation potential; Water consumption (mm/t) becomes Water use efficiency; and

Water pollution (kgNO_3/ha) becomes Water quality preservation. Throughout the rest of the document, these criteria appear with their new name followed by the original indicator in brackets.

Some of the criteria in this study rely on figures that are difficult to obtain from official statistics alone. To fill these gaps and to keep the analysis close to real farming practice, we established direct contacts with a number of Portuguese farmers who run conventional commercial operations. Whenever a value comes from these exchanges, it is referenced in the rest of the document simply as "expert communication". We chose to rely on these contacts because they are more representative of the mainstream production systems studied here than aggregated national statistics: sources such as INE, for instance, also include family farming and other smaller-scale practices that are less comparable to the commercial systems compared in this report.

Section 3 – Yields

Yield is not a criterion as such in the present MCDA, but it deserves a dedicated section because it underpins the construction of nearly every other criterion.

This section therefore establishes, for each of the five crops, the yield retained for each of the five farming systems. The yields of the four alternative systems are derived from this conventional baseline using ratios drawn from the literature, with hypotheses stated explicitly when no Portugal-specific data was available.

Reference data – Share of organic land in Portugal

The data available from INE statistics cover all types of farming in Portugal. These could not be used directly for our alternatives, as they were not specific enough to be reliable for this purpose. For the conventional baseline, we instead relied on expert communications with several farmers from the Ribatejo region. Increments for the other four farming systems were then derived through a review of the scientific literature.

Corn

Conventional

Expert communication: 13.2 t/ha

Organic

Following Seufert et al. (2012), an organic-to-conventional ratio of 0.70 is retained (≈ 30 % yield reduction): 13.2 × 0.70 = 9.24 t/ha.

Regenerative

Pittelkow et al. (2015) report a 2.5 % yield reduction for no-till combined with residue retention and crop rotation: 13.2 × 0.975 = 12.87 t/ha.

Agroforestry

Dupraz et al. (2005) report a silvoarable-to-control yield ratio of 0.925 (10-year average, 1992–2001): 13.2 × 0.925 = 12.21 t/ha.

Precision (4.0)

Balafoutis et al. (2017) report a +5 % yield gain for corn with variable-rate fertilisation using GreenSeeker technology: 13.2 × 1.05 = 13.86 t/ha.

3.2 Wheat

Conventional

Expert communication: 3.5 t/ha

Organic

No Portugal-specific organic-to-conventional yield ratio was found in the literature. European data reported by FSDN (2023) show ratios ranging from 42 % in Luxembourg to 71 % in Italy. A central hypothesis of **50 %** is retained for Portugal, positioned in the lower half of this European range to reflect agronomic conditions that differ substantially from both reference countries.

Portugal's Mediterranean climate, with hot dry summers and concentrated winter rainfall, imposes recurrent water stress at the grain-filling stage, a constraint that penalises organic systems more strongly than conventional ones, as the slower nitrogen release of organic management amplifies the impact of drought on grain yield. By contrast, Luxembourg's temperate oceanic climate and parts of northern Italy benefit from more regular rainfall throughout the growing season. Portuguese arable soils are also typically shallow, acidic and low in organic matter, particularly in the South: organic farming, which depends on slow nutrient mineralisation from organic matter, is more penalised under such conditions than on the deeper, more fertile soils of Luxembourg or the Po Valley. Irrigation reinforces this gap. Portuguese wheat is only partly irrigated and remains largely rainfed, whereas Italian wheat benefits from substantially more widespread irrigation, particularly in the North; irrigation partially offsets the nitrogen-limitation penalty of organic systems and helps explain the relatively high Italian ratio.

Taken together, these factors suggest that the Portuguese organic-to-conventional ratio is likely closer to the Luxembourg end of the European range than to the Italian one, justifying the 50 % central value retained here: 3.5 × 0.5 = 1.75 t/ha.

Regenerative

Same hypothesis as for corn (Pittelkow et al., 2015): −2.5 % vs. conventional. 3.5 × 0.975 = 3.4125 t/ha.

Agroforestry

Same hypothesis as for corn (Dupraz et al., 2005): silvoarable-to-control ratio of 0.925. 3.5 × 0.925 = 3.2375 t/ha.

Precision (4.0)

Balafoutis et al. (2017): +8 % yield gain for wheat with variable-rate fertilisation (GreenSeeker). 3.5 × 1.08 = 3.78 t/ha.

3.3 Rice

Conventional

Expert communication: 6.3 t/ha

Organic

According to “On-farm assessment of rice yield variability and productivity gaps between organic and conventional cropping systems under Mediterranean climate”, average organic and conventional yields stand at 4.3 and 6.3 t/ha respectively, i.e. an organic-to-conventional ratio of 0.68. 6.3 × 0.68 = 4.284 t/ha.

Regenerative

No regenerative alternative is defined for rice, as most of the practices underlying this model — such as cover cropping and no-till — are not applicable to rice cultivation.

Agroforestry

Same reduction factor as for corn and wheat (Dupraz et al., 2005 – ratio 0.925) applied to the conventional yield: 6.3 × 0.925 = 5.8275 t/ha.

Precision (4.0)

Rice yields and water use under alternate wetting and drying irrigation: A meta-analysis reports that AWD irrigation decreases yields by 5.4 % on average. The hypothesis adopted is that other Agriculture 4.0 techniques compensate for this loss, so that Precision (4.0) yield ≈ Conventional yield: 6.3 t/ha.

3.4 Vineyard

Conventional

Expert communication: 9.1 t/ha

Organic

Merot & Smits (2020) report an organic-to-conventional yield ratio of approximately 0.90 for perennial crops, including vineyards. 9.1 × 0.90 = 8.19 t/ha.

Regenerative

Zumkeller et al. (2023) find that cover crop type does not affect yield components in Mediterranean vineyard agroecosystems. The regenerative yield is therefore considered equal to the conventional yield: 9.1 t/ha.

Agroforestry

Belowground services in vineyard agroforestry systems indicate that trees within 4 m of vines slightly reduce growth, quality and yield (likely due to nitrogen competition). A hypothesis of 0.95 × conventional yield is retained: 9.1 × 0.95 = 8.645 t/ha.

Precision (4.0)

ADVID (Vine and Wine Cluster, Precision Viticulture) estimates that the implementation of precision-viticulture strategies can increase agricultural production by up to 20 %: 9.1 × 1.20 = 10.92 t/ha.

3.5 Olive yard (intensive and super intensive)

Conventional

Expert communication:

- Intensive: 7.5 t/ha.
- Super-intensive: 15.8 t/ha.

Organic

Seufert et al. (2012) note that organic-to-conventional yield gaps for rain-fed perennials range from −5 % to −13 %. A central hypothesis of −10 % is retained for olive.

- Intensive: 7.5 × 0.90 = 6.75 t/ha.
- Super-intensive: 15.8 × 0.90 = 14.22 t/ha.

Regenerative

Durán Zuazo et al. (2020) report that olive yield is practically unaffected by the soil-management strategy applied. The regenerative yield is therefore considered equal to the conventional yield.

- Intensive: 7.5 t/ha.
- Super-intensive: 15.8 t/ha.

Agroforestry

No robust agroforestry-specific data was found in the literature for olive yards. A hypothesis of 0.90 × conventional yield is retained.

- Intensive: 7.5 × 0.90 = 6.75 t/ha.
- Super-intensive: 15.8 × 0.90 = 14.22 t/ha

Precision (4.0)

No quantitative ratio comparing Agriculture 4.0 olive yields to conventional yields was found in the literature. Fernandes et al. (2025) note that UAV-based monitoring helps evaluate plant vigour and plan optimal harvest timing, ultimately maximising both yield and olive oil quality. In the absence of a quantified differential, the Agriculture 4.0 yield is conservatively set equal to the conventional yield.

- Intensive: 7.5 t/ha.
- Super-intensive: 15.8 t/ha.

3.6 Summary – Yields across crops and farming systems

The following synthesis matrix gathers all yields (in t/ha) used as the quantitative basis for the per-tonne criteria of the MCDA.

Table 1 — Yields across crops and farming systems — t/ha

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	13.2	3.5	6.3	9.1	7.5 / 15.8
Organic	9.24	1.75	4.284	8.19	6.75 / 14.22
Regenerative	12.87	3.4125	N/A	9.1	7.5 / 15.8
Agroforestry	12.21	3.2375	5.8275	8.645	6.75 / 14.22
Precision (4.0)	13.86	3.78	6.3	10.92	7.5 / 15.8

Section 4 – Criteria

This section presents each criterion of the MCDA, grouped by the three pillars of sustainability: economic, environmental and social. For each criterion a brief description is provided, followed by the chosen quantification method and a synthesis table giving the value of the criterion for each (crop × farming system) combination.

4.1 Economic criteria

4.1.1 Cost competitiveness – T*otal costs (€/ha)*

Description

Total Costs aggregate all recurring and structural production costs, defined here as the sum of Specific costs (seeds, fertilisers, plant protection, energy), Non-specific costs (contract work, machinery maintenance, overheads), Depreciation and External factors (paid labour, land rents, interest); equivalent to the FADN aggregate SE270. Reporting at the Total Costs level avoids the arbitrariness of allocating items between CAPEX and OPEX and provides a more robust basis for comparing systems, since year-to-year reallocations between cost components partially offset each other in the aggregate. The land rent was not included in the calculation of the total costs.

Quantification method

Reference values in €/ha for the conventional systems are drawn from expert communication. FADN/FSDN data for Portugal shows the difference between organic and conventional total costs. For arable crops (corn, wheat, rice), the FSDN dashboard “Organic farming in arable crops” provides directly comparable conventional and organic Total Costs figures for these crops. As the two are consistently close in the underlying data, this simplification is retained here, with the same €/ha value applied to both systems for corn, wheat and rice. For olive yards and vineyards, no organic-vs-conventional dashboard is available but, Crowder & Reganold (2015) report no significant Total Costs difference between organic and conventional systems, so a 0 % delta is retained.

The other alternatives are derived from the conventional baseline using literature-based adjustments. For regenerative agriculture, Omulo et al. (2022) report Total Variable Costs reductions of −5.2 % to −5.8 % for direct seeding versus disc harrowing, leading to a retained proxy of −5 % vs. conventional, applied uniformly across crops. This assumption should be considered low-confidence, exploratory and highly context-dependent: cost savings from regenerative practices depend strongly on local prices of fuel, herbicides and labour, the transition phase typically generates additional costs before savings materialise (Datta et al., 2025), and the source covers only one agronomic operation rather than a complete mature regenerative cost profile. For agroforestry, García de Jalón et al. (2017) quantify the additional cost introduced by the tree component (annualised establishment + maintenance) at approximately +105 €/ha/year, added to the conventional baseline. For Agriculture 4.0, Bahmutsky et al. (2024) anchor the retained proxy at −10 % vs. conventional, calibrated on Fabiani et al. (2020) and Colaço et al. (2020).

Values

The following table reports Total Costs (€/ha) for each crop × farming system combination, derived from the inputs and methodology described above:

Table 2 — Total costs per crop and farming system — €/ha

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	2267	1050	2367	3200	3626 / 4277
Organic	2267	1050	2367	3200	3626 / 4277
Regenerative	2154	998	N/A	3040	3445 / 4063
Agroforestry	2372	1155	2472	3305	3731 / 4382
Precision (4.0)	2040	945	2130	2880	3263 / 3849

4.1.2 Gross revenue (€/ha)

Gross revenue per hectare, computed as price (€/t) × yield (t/ha) + state subsidies (€/ha).

Description

Gross revenue per hectare measures the value generated by the saleable output of each crop × farming system combination, before deducting any production cost. It is the natural revenue counterpart of Total Costs (€/ha) and, together with the latter, supports the construction of profitability and economic-resilience indicators. Gross revenue is computed as the product of the farm-gate price (€/t of raw product) and the system-specific yield (t/ha) reported in Section 3.6 and the addition of state subsidies (€/ha).

Quantification method

Farm-gate prices are extracted from expert communication in €/t. They reflect the real price of the products produced in Portugal's farms.

Organic price premia are derived by comparing conventional and organic series on the same DG AGRI portal, complemented when needed by Eurostat and INE Portugal organic-price data. The retained premia are: +50 % for maize and rice, +85 % for wheat, +21 % for olive oil and +0.26 % for wine.

As a simplifying assumption consistent with farm-level practice, the conventional price is applied to all farming systems except "Organic", which alone benefits from the organic price premium — reflecting the requirement for product certification to access organic markets.

The state subsidies are also expert communication.

Values

Table 3 — Gross revenue per crop and farming system — €/ha

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	3592	1245	3601	3458	4523 / 8674

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Organic	3744	1174	3652	3120	4925 / 9446
Regenerative	3516	1221	NA	3458	4523 / 8674
Agroforestry	3364	1174	3413	3285	4070 / 7807
Precision (4.0)	3744	1321	3602	4150	4523 / 8674

4.1.3 Resilience (composite)

Composite indicator aggregating drought, flood, soil health and yield-stability resilience.

Description

Resilience is understood here in the sense of the IPCC AR6 (2022), as *the capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure, while preserving the capacity for adaptation, learning and transformation* (Arctic Council, 2016). The Resilience indicator is a qualitative composite score that operationalises this definition through four climate-relevant dimensions: drought resilience, flood and extreme rainfall resilience, soil health and long-term productivity, and yield stability under climate variability. Each farming system is scored on each dimension on a five-level qualitative scale (Very low to Very high), mapped to a 1–5 numerical scale, and aggregated by simple averaging.

Unlike Total Costs and Gross Revenue, which rest on quantitative price and cost data, this Resilience score is **expert-judgement-based, semi-quantitative and non-empirical**, a structured interpretation of the literature rather than a direct measurement. The values should be read as relative orderings between farming systems, in line with the hierarchy of evidence introduced in Section 1."

Quantification method

The composite Resilience score is built from four climate-resilience criteria, each scored on a five-level qualitative scale (Very low = 1, Low = 2, Average = 3, High = 4, Very high = 5). The four criteria are: (i) drought resilience, (ii) flood and extreme rainfall resilience, (iii) soil health and long-term productivity, and (iv) yield stability under climate variability. Each system receives a score per criterion based on a structured review of the empirical literature; the composite score is the simple arithmetic mean of the four criterion scores. The system labelled “Regenerative” in this report is assessed on the basis of the conservation-agriculture literature (no-till, permanent soil cover, long rotations) which constitutes the closest documented proxy. Justifications by category for each criterion are provided below.

Drought resilience

Conventional (Very low) — No structural drought adaptation mechanisms. Yield losses during dry years are high and unmitigated. Dependence on external irrigation amplifies vulnerability when water resources are themselves under climate stress.

Organic (Low) — Although organic-matter inputs improve soil structure in the long run, frequent tillage used to control weeds without herbicides leaves the soil disturbed and largely uncovered for significant parts of the year, limiting water-holding-capacity gains during drought and increasing evaporation. Schmidt et al. (2023) confirm in an 8-year experiment that organic systems alone do not significantly buffer severe drought, with yield reductions comparable to conventional. Diversified cropping helps reduce exposure but does not compensate for the lack of permanent ground cover.

Regenerative (High) — No-till and permanent soil cover substantially reduce evaporation, protect soil moisture and limit erosion. The Zimbabwe panel data (Michler et al., 2019) confirms strong mitigation of yield losses during rainfall shortfalls, and the 30-year MSU KBS LTER experiment (Robertson et al.) documents greater resilience of no-till systems to weather extremes thanks to improved water-holding capacity. The undisturbed soil structure progressively builds water buffering, providing the strongest drought protection among annual cropping systems — an effect confirmed in Schmidt et al. (2023), where conservation tillage was the only system showing a positive drought-buffering trend.

Agroforestry (High) — Multiple drought-buffering mechanisms operating simultaneously — canopy cover reducing evapotranspiration, deep roots accessing subsoil moisture, groundwater recharge, and microclimate regulation (Wilson & Lovell, 2016; Pancholi et al., 2023). However, the underlying conventional cropping practices (tillage, synthetic inputs) limit topsoil moisture retention compared to a no-till regenerative system, which prevents the score from reaching Very high.

Precision (4.0) (Very high) — Real-time thermal-drone monitoring detects crop water stress before visible yield loss occurs, enabling targeted irrigation (Haque et al., 2025). Variable Rate Irrigation (VRI) and precision tools reduce water use by 25–29 % (Sui & Yan, 2017; Hedley & Yule, 2009), and ML-driven decision support allows the system to adapt rapidly to drought conditions. The literature also nuances these gains: VRI primarily improves water productivity rather than absolute yield (Pasolli et al., 2024), so the Very high score reflects the magnitude of the adaptive and water-saving capacity rather than a guaranteed yield protection.

Flood and extreme rainfall resilience

Conventional (Very low) — Frequent tillage leaves soils compacted and bare during rainfall events. High erosion and runoff. No structural flood protection. Most vulnerable system to intense precipitation events.

Organic (Average) — Improved soil structure and organic matter increase water infiltration and reduce surface runoff (Borron, 2006). However, without trees or vegetated buffer strips, protection during the most intense events remains moderate.

Regenerative (High) — Permanent soil cover and no-till significantly reduce erosion and runoff. Crop residue acts as a physical barrier. Strong performance during excess-rainfall events documented in Zimbabwe (Michler et al., 2019); particularly effective on sloping terrain (Joshi et al., 2021).

Agroforestry (Very high) — Deepest roots, highest above-ground biomass, vegetative buffers and riparian zones combine for comprehensive flood protection. Wilson & Lovell (2016) document that perennial vegetation can trap up to 95 % of at-risk sediment. Hydrological regulation extends across the whole landscape, not just the field.

Precision (4.0) (Average) — GIS-based flood-inundation modelling and real-time rainfall and soil-water-content monitoring provide genuine early-warning capacity, enabling farmers to take protective action before peak events (Haque et al., 2025). This is a real contribution to damage mitigation, distinct from purely passive monitoring. The score remains Average rather than High because these tools do not structurally change soil hydraulic properties, runoff dynamics or erosion risk — they anticipate and help manage events rather than preventing them.

Soil health and long-term productivity

Conventional (Low) — Systematic degradation of soil organic matter, compaction from heavy machinery, and loss of microbial diversity. High erosion risk over time. Long-term productivity maintained only through increasing external chemical inputs, creating growing dependency.

Organic (Low) — Although organic amendments contribute organic matter (Azarbad, 2022), the absence of synthetic herbicides forces frequent mechanical tillage to control weeds. This systematic soil disturbance disrupts soil structure, accelerates organic-matter mineralisation, breaks fungal networks and exposes bare soil to erosion. Cooper et al. (2024) document that, after transition to organic management, soil organic carbon remained unchanged under conventional tillage and gained meaningfully only when organic was combined with minimum tillage — confirming that the biological gains from organic inputs are largely offset by repeated mechanical disturbance.

Regenerative (High) — Strong soil-carbon sequestration and protection of physical structure through permanent cover and no-till. Undisturbed soil supports stable microbial networks and continuous aggregate formation. Haddaway et al. (2017) quantify topsoil SOC gains of 4.6 Mg/ha (95 % CI: 0.78–8.43) under no-till compared to high tillage over 10+ years, and the MSU KBS LTER 30-year experiment (Robertson et al.) shows that protecting large soil aggregates is the primary mechanism for SOC accumulation, while a single tillage pass can erase years of accumulated gains. South-Asian meta-analyses (Joshi et al., 2021) report up to 480 kg SOC ha^{-1} yr^{-1} under no-tillage with residue retention.

Agroforestry (Very high) — Superior long-term soil-building through continuous litter, deep root activity and nitrogen-fixing tree species. Pancholi et al. (2023) report up to 40 % overall soil-quality improvement compared to conventional systems. Improvement occurs across multiple soil horizons over decades; the combination of biological, physical and chemical soil improvement is unmatched by annual systems (Wilson & Lovell, 2016).

Precision (4.0) (Average) — Real-time soil mapping through hyperspectral imaging and Variable-Rate Technology reduces over-fertilisation, documented at 25 % fertiliser savings (Haque et al., 2025). This prevents further degradation but does not actively rebuild soil organic matter or biological activity. Net soil-health outcome depends on the base farming system.

Yield stability under climate variability

Conventional (Low) — Yield highly sensitive to weather shocks. No structural buffers against rainfall variability. High external-input dependency amplifies exposure to supply-chain disruptions during climate events. Catastrophic partial or total crop losses possible during extreme years.

Organic (Average) — Crop diversification, longer rotations, organic amendments and the use of local landraces (Borron, 2006; Milestad & Darnhofer, 2003) contribute to more stable yields than conventional monocultures by spreading risk across species and varieties. Average rather than High reflects that organic yields remain sensitive to extreme events — the soil-based water-buffering benefits often attributed to organic management materialise only when combined with reduced tillage (Schmidt et al., 2023; Cooper et al., 2024), which is not the case in standard organic systems.

Regenerative (High) — Directly documented yield stabilisation during rainfall shocks in a rigorous panel study (Michler et al., 2019). The trade-off — neutral or slightly negative impact on yield in normal years — is acceptable given the clear climate-resilience benefit during stress years.

Agroforestry (Very high) — Multiple crops, multiple species, multiple time horizons and multiple ecosystem buffers combine to produce the highest interannual yield stability (Wilson & Lovell, 2016). Failure of any single component does not compromise the system as a whole. Income diversification from tree products further stabilises farm revenues.

Precision (4.0) (Very high) — ML-powered yield prediction and early climate-stress detection enable highly proactive management that strongly compensates for weather variability. An 18 % improvement in yield-prediction accuracy (Haque et al., 2025), combined with continuous monitoring of soil moisture, canopy temperature and vegetation indices, supports rapid adaptive decisions on irrigation, fertilisation and pest control. The integration of IoT, drones and variable-rate technology turns climate variability into a manageable signal rather than an exogenous shock. The Very high score is justified by the magnitude of this adaptive capacity, even though the literature on Variable Rate Irrigation shows that gains are mainly in water productivity rather than in absolute yield (Pasolli et al., 2024).

Composite score

Mapping the qualitative scores to the 1–5 numerical scale yields the following criterion scores: drought resilience = 1 / 2 / 4 / 4 / 5; flood and extreme rainfall resilience = 1 / 3 / 4 / 5 / 3; soil health and long-term productivity = 2 / 2 / 4 / 5 / 3; yield stability under climate variability = 2 / 3 / 4 / 5 / 5 (in the order Conventional / Organic / Regenerative / Agroforestry / Precision (4.0)). Averaging across the four criteria produces the composite resilience scores reported in the Values table below: 1.5 (Conventional), 2.5 (Organic), 4.0 (Regenerative), 4.75 (Agroforestry) and 4.0 (Precision (4.0)). The composite score is constant across crops, since the underlying climate-resilience mechanisms are properties of the farming system rather than of the crop.

Values

Table 4 — Resilience composite score per crop and farming system — 1–5 scale

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	1.5	1.5	1.5	1.5	1.5
Organic	2.5	2.5	2.5	2.5	2.5
Regenerative	4.0	4.0	4.0	4.0	4.0
Agroforestry	4.75	4.75	4.75	4.75	4.75

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Precision (4.0)	4.0	4.0	4.0	4.0	4.0

4.2 Environmental criteria

4.2.1 Water use efficiency – *Water consumption (mm/t)*

Water consumption expressed per tonne of product. Derived from water consumption (mm/ha) and yield (t/ha). Blue water was prioritised because irrigation pressure is the principal water-management issue in Mediterranean agriculture. The exclusion of green water may underestimate ecosystem-level water efficiency benefits of agroforestry and regenerative systems.

Description

This indicator quantifies blue-water consumption (irrigation water applied) per tonne of harvested product. It is expressed in mm per tonne, where 1 mm corresponds to 10 m^3 per hectare. Only blue water is considered; green water (rainfall) is excluded as it is not modulated by the choice of farming system. Reporting per tonne (rather than per hectare) integrates the yield effect of each system, providing a direct measure of water-use efficiency: the volume of irrigation water required to produce one tonne of output.

Quantification method

Conventional baselines are derived crop by crop from expert communications.

Each alternative system is then derived by applying a percentage reduction to the conventional per-hectare baseline. The convention adopted is that conventional uses centre-pivot, organic uses drip irrigation (“gota a gota”), and the other systems layer additional savings on top. Retained increments vs. conventional are: −4.8 % for organic (the model assumes a higher prevalence of drip irrigation in organic systems for the purpose of the scenario construction) (drip vs. pivot efficiency gain measured on the corn data, Agroportal); −9.8 % for regenerative used here as a proxy for conservation agriculture combining drip irrigation and organic mulch (Chukalla et al., 2015, blue-water-footprint review); −15 % for agroforestry (windbreaks reduce on-farm water consumption by 10–20 %, midpoint retained). Note that these water savings may be partially offset by tree water uptake depending on density, species and climat. For Agriculture 4.0, −23.4 % on rice (mild alternate wetting and drying, Carrijo et al., 2017) or −30 % on the other crops (smart-irrigation midpoint of the 20–46 % range reported in Ali et al).

The final per-tonne value is obtained by dividing the system-specific consumption (mm/ha) by the corresponding yield (t/ha) of Section 3.6: water (mm/t) = baseline_crop × (1 − reduction_system) / yield_system. This step propagates the yield differential across systems — in particular, organic loses part of its irrigation-efficiency advantage when expressed per tonne, due to the lower yields documented in Section 3.6, while Agriculture 4.0 benefits from both lower water use and higher yields.

Values

Table 5 — Water consumption per crop and farming system — mm/t

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	49.2	0	190.5	13.2	26.7 / 19.6

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Organic	67	0	266.7	13.9	28.2 / 20.8
Regenerative	45.6	0	NA	11.9	24.1 / 17.7
Agroforestry	45.2	0	175	11.8	25.2 / 18.5
Precision (4.0)	32.8	0	145.9	7.7	18.7 / 13.7

4.2.2 Water quality preservation – *Water pollution (kgNO$_3$/ha)*

Nitrate emissions to groundwater associated with eutrophication, expressed per hectare.

Description

This indicator quantifies nitrate (NO_3) leaching to groundwater, the dominant agricultural pathway to aquatic eutrophication. It is expressed in kg NO_3 per hectare and per year, and reflects how much reactive nitrogen is lost from the cropping system to water bodies. Phosphate runoff to surface waters is the other main eutrophication pathway but is not retained here, as soil-phosphorus dynamics are highly site-specific (binding capacity, pH, soil texture) and the literature comparing farming systems on this criterion is sparse and inconsistent.

Quantification method

The conventional baseline is taken from the Ecoinvent 3 database (cut-off, allocation by classification) accessed via Simapro, reading the "Nitrate, ground water" emission flow of each crop process. The five reference values are 1.1919×10^{-2} (maize), 2.1953×10^{-2} (wheat), 4.6977×10^{-2} (rice), 1.1945×10^{-2} (olive) and 2.6616×10^{-3} kg NO_3 per kg of harvested product. To express them on a per-hectare basis, each value is multiplied by the system-specific yield (t/ha, from Section 3.6) and by 1 000 (kg/t), giving the formula: leaching (kg NO_3/ha) = Simapro_value × yield × 1 000.

The four alternative farming systems are derived from the conventional baseline using percentage-reduction increments sourced from the literature, applied uniformly across crops in line with the working assumption that nitrate leaching is primarily driven by the farming system rather than by the crop. The retained increments vs. conventional are: −57.2 % for organic (Mondelaers et al., 2009, meta-analysis of 12 studies); −45 % for regenerative, used here as a proxy for conservation agriculture with cover crops (Thapa et al., 2018, meta-analysis of 27 studies); −50 % for agroforestry (Zhu et al., 2019); and −40 % for Agriculture 4.0, taken as the central value of the 28.77–53.98 % range reported for variable-rate fertilisation by site-specific management zones (Wang et al., 2023).

The final per-hectare leaching value for each (crop × system) combination is therefore: leaching = Simapro_value × yield_system × 1 000 × (1 − reduction_system). The Ecoinvent flow is reported as kg NO_3 (mass of nitrate ion); to convert to kg NO_3-N as used in part of the agronomic literature, multiply by 14/62 ≈ 0.2258.

Values

Table 6 — Nitrate leaching per crop and farming system — kg NO_3/ha

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	157.3	76.8	296	24.2	89.6 / 188.7
Organic	47.1	16.4	86.1	9.3	34.5 / 72.7
Regenerative	84.4	41.2	NA	13.3	49.3 / 103.8
Agroforestry	72.8	35.5	136.9	11.5	40.3 / 84.9
Precision (4.0)	99.1	49.8	177.6	17.4	53.8 / 113.2

4.2.3 Biodiversity (composite)

Composite biodiversity indicator aggregating four management-based sub-criteria, scored with the Cool Farm Tool.

Description

This indicator captures the effect of each farming system on on-farm biodiversity, expressed as a single composite score in which higher values denote stronger support for wildlife. It is built from the Cool Farm Biodiversity metric, an action-based assessment scored using expert judgements and expert assessment of experimental evidence, rather than from direct field measurement of species abundance. This is a deliberate methodological choice: standardised field surveys are not feasible across the five modelled systems and would be highly site-dependent, whereas a management-based proxy can be applied consistently to each system. The composite aggregates four sub-criteria: diversity of farmed products, farming practices, small (semi-)natural habitats, and large habitats.

Quantification method

Biodiversity is assessed with the Cool Farm Biodiversity metric (Crowther et al., 2024), the biodiversity module of the Cool Farm Tool. The Mediterranean and semi-arid biome calibration was used, as it is the one relevant to Portuguese conditions.

Each of the five farming systems (conventional, organic, regenerative, agroforestry, Agriculture 4.0) was modelled by completing the questionnaire once per system, with answers chosen to reflect the practices characteristic of that system. These responses were reviewed and validated by two researchers, Filipa Grilo and Joana Portugal Pereira, providing an expert-judgement check on the modelling. The four sub-criteria scores returned by the tool were then aggregated into a single composite biodiversity score for each system. Because the questionnaire was answered at the level of the farming system and not the individual crop, the resulting composite score is identical across all five crops for a given system, as shown below.

Values

Table 7 — Biodiversity composite score per crop and farming system

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	8.3	8.3	8.3	8.3	8.3
Organic	53.3	53.3	53.3	53.3	53.3
Regenerative	67.5	67.5	67.5	67.5	67.5
Agroforestry	55.0	55.0	55.0	55.0	55.0
Precision (4.0)	13.8	13.8	13.8	13.8	13.8

4.2.4 Climate mitigation potential – *GHG emissions (kgCO_2e/t)*

Greenhouse gas emissions expressed per tonne of product.

Description

This indicator quantifies the on-field net greenhouse-gas balance of each (crop × system) combination, expressed in kg CO_2e per tonne of product. Positive values denote net emissions to the atmosphere; negative values denote net removals (sequestration in soil organic carbon and perennial biomass). Reporting per tonne integrates the yield effect of each system, the climate cost (or benefit) per unit of useful output, and is the most relevant metric for product-level comparisons.

Quantification method

GHG balances are computed with a custom Tier 1 calculator implementing the 2019 Refinement to the 2006 IPCC Guidelines (Volume 4, Chapters 2, 5 and 11). Five emission and removal categories are aggregated: direct and indirect N_2O from crop residues (Eq. 11.6, 11.1, 11.10), direct and indirect N_2O from synthetic and organic N fertilisers (Eq. 11.1, 11.9, 11.10), CO_2 from diesel and electricity, soil organic-carbon stock change (Eq. 2.25, F_LU × F_MG × F_I, 20-year amortisation), and perennial above-ground biomass for vineyard and olive yard (Table 5.3). For paddy rice, CH_4 emissions from continuous flooding are added (Eq. 5.1–5.3). All gases are converted to CO_2e using AR6 100-year GWPs (N_2O = 273, CH_4 = 27). Emission factors and stock-change multipliers are taken from IPCC default tables for the warm-temperate-dry climate zone.

Activity data per (crop × system) are derived from a structured set of assumptions. Synthetic N rates follow crop-specific agronomic optima reported by expert communications. Organic N rates are capped at 170 kg N/ha (EU Nitrates Directive). Conventional diesel consumption is taken from expert communications. Electricity consumption is derived from irrigation water use via a constant 4.1 kWh/mm (Rodríguez Díaz et al., pressurised-irrigation networks of southern Spain).

Alternative systems are then derived by applying multipliers vs. the conventional baseline: regenerative (no-till) reduces diesel by 31 % (tillage-systems comparison study); Agriculture 4.0 reduces synthetic fertilisers by 25 % (variable-rate technology, Dutch potato study) and diesel by 8 % (optimised in-field route planning); organic increases diesel by 20 % on arable crops (mechanical weeding) and is unchanged on perennials; agroforestry increases diesel by 30 % (additional tree-management passes) and adds 1.5 tC/ha/yr of perennial biomass sequestration (Cardinael et al., 2018;

Kay et al., 2019). Soil-carbon factors (F_MG, F_I) are tagged per system following IPCC Table 5.5: full / reduced / no-till and medium / high / high+manure inputs.

Per-tonne values are obtained by dividing the per-hectare net balance by the system-specific yield (t/ha) of Section 3.6. The dual sign convention is preserved: a negative kg CO_2e/t indicates that the system is a net carbon sink at the on-field level, dominated by soil-carbon and biomass sequestration. The reported figures are on-field IPCC balances; upstream emissions (fertiliser manufacturing, diesel refining) and downstream emissions (winery, mill, transport, packaging) are out of scope.

Values

Table 8 — GHG emissions per crop and farming system — kg CO_2e/t

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	157.2	240.3	1100	41.8	105 / 71.3
Organic	51.6	−243.4	1639	−90	−53 / -0.8
Regenerative	119.2	132.4	n/a	8.8	54.4 / 42.4
Agroforestry	15.3	−325	846	−177	−163 / -50.7
Precision (4.0)	120.1	192.3	1091	29	86.6 / 58.3

Note on rice GHG balances. The high kg CO_2e/t values reported for rice across all farming systems reflect the dominant role of methane (CH_4) emissions from continuous flooding, computed via IPCC Eq. 5.1–5.3 with an AR6 GWP100 of 27. Methane from anaerobic decomposition of soil organic matter under flooded conditions structurally dominates the rice GHG balance. This mechanism explains why organic rice (1639 kg CO_2e/t) is **worse** than conventional: substituting synthetic fertilisers with organic inputs (compost, manure) increases the substrate available for methanogenesis in flooded paddies, which more than offsets the reduction in N_2O emissions.

Screenshots of every dashboard are available in annex at the end of this document.

4.3 Social criteria

Description

The Social pillar of the framework captures the human and societal dimensions of each farming system: how a system affects the people who practise it (farmers and farm workers), the rural communities that surround it, and the next generation of potential entrants into agriculture. Whereas the Economic pillar measures monetary flows and the Environmental pillar measures biophysical impacts, the Social pillar reflects dimensions that economic and environmental indicators do not capture but that are decisive for the long-term viability of any farming system.

The Social pillar is operationalised through four criteria: (i) Job satisfaction and acceptability of the work; (ii) Attractiveness to young people; (iii) Job creation in the rural territory; and (iv) Human health. Each criterion is treated as a stand-alone indicator (sub-sections 4.3.1 to 4.3.4) with its own definition, qualitative assessment and intermediate scoring table. Sub-section 4.3.5 reports the composite Social score obtained by averaging the four criterion scores.

Quantification method

Each of the four social criteria is scored on the same five-level qualitative scale used elsewhere in the framework: Strong negative impact (Very low = 1), Negative impact (Low = 2), Neutral (Average = 3), Positive impact (High = 4), Strong positive impact (Very high = 5). Scores are assigned by structured review of the empirical literature (peer-reviewed articles, EU and FAO statistical briefs, and case studies). For consistency with the rest of the report, the system labelled "Regenerative" is assessed on the basis of the conservation-agriculture literature (no-till, permanent soil cover, long rotations), which is the closest documented proxy. Each sub-section provides a category-by-category justification, an intermediate scoring table reporting both the qualitative grade and its numerical mapping, and a focused set of references. The composite Social score (sub-section 4.3.5) is the simple arithmetic mean of the four criterion scores. As the underlying social mechanisms are properties of the farming system rather than of the crop, social scores are constant across the five crops considered (corn, wheat, rice, vineyard, olive yard).

4.3.1 Job satisfaction / Acceptability

Description

This criterion assesses the degree of satisfaction and fulfilment of farmers in their daily work, taking into account physical workload, decision-making autonomy, sense of purpose and connection to the land. It captures not only objective working conditions but also the subjective dimension of professional well-being, which shapes the long-term appeal of a farming system. A satisfied farmer is more likely to sustain their practices, pass them on, and commit to a long-term sustainability logic. Conventional agriculture is treated as the neutral median rather than as an extreme, since job satisfaction is highly subjective and depends on the farmer's profile; other systems are scored relatively to this baseline.

Justifications by category

Conventional (Average) — Neutral reference system. Satisfaction is acceptable when economic conditions are favourable, but is often undermined by financial pressure, input dependency and the physical strain associated with chemical applications. The literature does not systematically demonstrate particularly high or low satisfaction levels, justifying the median score.

Organic (High) — Several French studies cited in the European review by Orsini, Padel & Lampkin (2018) (Nettier et al.; Dupré et al.; Navarrete et al.) report higher satisfaction levels among organic compared to conventional farmers, driven by greater personal fulfilment, social recognition and alignment with environmental values. Reduced pesticide exposure also contributes to overall well-being.

Regenerative (High) — Conservation-agriculture practitioners develop a strong connection to the land and a professional identity built around innovation and environmental stewardship (Topp et al., 2024). The reduction of physical workload (no tillage) and the alignment with a long-term sustainable management ethic act as positive drivers. Gao & Arbuckle (2024) confirm on Iowa farmer survey data that satisfaction with conservation practices is a significant positive predictor of overall job satisfaction, independently of farm financial health.

Agroforestry (Very high) — The integration of trees brings activity diversity, landscape aesthetics, and a sense of contributing to long-term climate resilience and cultural heritage. Farmers surveyed by Rois-Díaz et al. (2018), mostly operating non-organic agroforestry systems, express strong pride in managing their tree-based systems, with improved quality of life explicitly cited as a key motivation for adoption. The diversity of tasks and the meaningful relationship with the trees and landscape sustain a high level of professional fulfilment, independently of the use of synthetic inputs on the cropping component.

Precision (4.0) (High) — Precision agriculture reduces physical strain and provides a sense of technological mastery (UTAUT-based study on Chinese farmers). However, satisfaction may be limited by dependency on digital tools, high upfront costs and a steep learning curve. The score is High rather than Very high because the emotional connection to the land and the ethical dimension are less prominent than in agroecological systems. However, high technological attractiveness may be partly constrained by high investment requirements and unequal digital access.

Intermediate scoring table

Table 9 — Job satisfaction score per crop and farming system — 1–5 scale

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	3	3	3	3	3
Organic	4	4	4	4	4
Regenerative	4	4	4	4	4
Agroforestry	5	5	5	5	5
Precision (4.0)	4	4	4	4	4

4.3.2 Attractiveness to young people

Description

This criterion assesses a farming system's ability to attract new entrants, particularly young farmers. It considers the system's image, economic prospects, alignment with the aspirations of the new generation (technology, sustainability, sense of purpose), and ease of access. Generational renewal is a key challenge for the long-term viability of European farming, and some systems are objectively better positioned than others in this regard.

Justifications by category

Conventional (Low) — Conventional farming has a low appeal for young people. High setup costs, limited differentiation, dependence on commodity markets, and an image associated with chemical-intensive production make it an unattractive entry point for new entrants seeking purpose and innovation.

Organic (High) — Organic farming consistently attracts younger farm managers in the EU. According to the European Commission market brief (EC, 2023), 21 % of organic farm managers in the EU are under 40, versus only 12 % in conventional farming, and organic farmland increased by more than 50 % between 2012 and 2020. Its alignment with environmental values, growing market demand, and meaningful connection to nature resonate strongly with young people's aspirations.

Regenerative (Average) — Conservation/regenerative agriculture is relatively neutral in attracting young people. It reduces strenuous physical tasks (no tilling) and is intellectually stimulating — it requires a deep understanding of ecological processes, biodiversity and crop sequences (Topp et al., 2024) — but it lacks the visible technological dimension of Agriculture 4.0 and the strong nature/landscape narrative of agroforestry. This justifies a median score.

Agroforestry (High) — The tree-based component is what drives appeal among young people: climate resilience, biodiversity, landscape stewardship and product diversification (timber, fruit, honey) align with the aspirations of environmentally conscious new entrants (Rois-Díaz et al., 2018). The growing recognition of agroforestry as a climate-adaptation strategy under the CAP and EU green policies further strengthens its visibility and attractiveness, independently of whether the cropping system is organic or conventional.

Precision (4.0) (Very high) — Agriculture 4.0 is the most attractive system for young people seeking technology-driven careers. The use of drones, IoT, AI and data platforms aligns directly with digital-native skills and aspirations (Thailand Young Smart Farmer programme case study; AI/ML review on smart and precision agriculture). The smart-farming approach is actively promoted in agricultural programmes targeting youth, providing a concrete pathway into modern agriculture.

Intermediate scoring table

Table 10 — Attractiveness to young people score per crop and farming system — 1–5 scale

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	2	2	2	2	2

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Organic	4	4	4	4	4
Regenerative	3	3	3	3	3
Agroforestry	4	4	4	4	4
Precision (4.0)	5	5	5	5	5

4.3.3 Job creation

Description

This criterion assesses a farming system's ability to generate or sustain on-farm jobs and employment in the immediate rural territory. The analysis remains focused on the agricultural sphere: even if systems like Agriculture 4.0 may create jobs in adjacent digital or agri-tech sectors, what matters here is the net effect on on-farm employment. A system that displaces farm labour is scored negatively, regardless of jobs potentially created upstream or downstream in the supply chain.

Justifications by category

Conventional (Average) — Serves as the neutral baseline. Conventional agriculture relies heavily on mechanisation, keeping on-farm employment stable but without notable job creation. Family labour is predominant and limited diversification constrains employment growth.

Organic (Average) — Orsini et al. (2018) show that organic farms tend to employ more non-family labour and generate on-farm diversification activities, with positive rural-development implications. However, the European review concludes that the labour-intensity differential is not systematic and reflects business configuration as much as the organic practice itself (Lobley et al., cited in Orsini et al., 2018). The evidence is therefore not strong enough to warrant a score above Average.

Regenerative (Average) — Regenerative agriculture is neither particularly job-creating nor job-destroying. The growth of green jobs may foster opportunities in ecosystem management and sustainable agricultural extension services. However, heavy mechanisation of no-till operations reduces labour requirements compared to organic farming or agroforestry — though less drastically than Agriculture 4.0 — supporting a neutral score.

Agroforestry (High) — Agroforestry generates significantly more on-farm employment through diverse productive activities — tree management, fruit and timber harvesting, honey production, nursery work — and creates new markets for rural communities. The systematic review by Singh et al. (2025) on the socio-economic and environmental benefits of agroforestry confirms higher employment rates compared to monoculture systems and highlights the role of agroforestry in reducing rural-to-urban migration through sustainable income sources.

Precision (4.0) (Low) — Agriculture 4.0 systematically substitutes technology (drones, automated machinery, sensors) for human labour on the farm. Eastwood et al. warn that previous technology revolutions have caused mass rural unemployment, and call for careful governance of AI-driven automation. While Agriculture 4.0 may create tech-sector jobs outside the farm gate, the net on-farm employment effect is negative.

Intermediate scoring table

Table 11 — Job creation score per crop and farming system — 1–5 scale

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	3	3	3	3	3
Organic	3	3	3	3	3
Regenerative	3	3	3	3	3
Agroforestry	4	4	4	4	4
Precision (4.0)	2	2	2	2	2

4.3.4 Human health

Description

This criterion assesses the impact of a farming system on the health of agricultural workers. Two main dimensions are considered: (i) exposure to pesticides and other chemical inputs, which carries well-documented short- and long-term health risks (cancers, neurological diseases, endocrine disruption); and (ii) physical strain, i.e. the musculoskeletal constraints linked to repetitive tasks, load carrying and prolonged postures. A system that simultaneously reduces both risks receives a high score.

Justifications by category

Conventional (Very low) — Cumulates both risk dimensions: high pesticide exposure (cocktails of residues documented by Riedo et al. (2021)) and heavy physical workload linked to repeated tillage. The literature consistently identifies conventional farming as the system with the greatest occupational health risks.

Organic (Very high) — Eliminates synthetic pesticide exposure entirely, reducing long-term health risks substantially. Riedo et al. (2021) measure 70–90 % lower pesticide-residue concentrations in organic soils compared to conventional counterparts. The physical workload may be higher for some tasks (mechanical weed control), but the absence of chemical exposure is the dominant factor for this criterion.

Regenerative (Low) — While no-till practices reduce physical workload and soil erosion, conservation/regenerative agriculture typically depends on total herbicides (e.g. glyphosate) to control weeds in the absence of tillage. Operator pesticide exposure remains significant, only marginally lower than in conventional systems. The reduced physical strain partially offsets this risk, justifying a Low rather than low score.

Agroforestry (Low) — Understood here as conventional cropping with added trees rather than as an organic system, agroforestry retains the same pesticide use as conventional agriculture — trees do not reduce chemical exposure on the cultivated plots. In addition, tree management adds further physically demanding tasks (pruning, harvesting, hedge maintenance) on top of standard cropping operations, cumulating chemical exposure with a high physical workload. Because a fraction of the area is dedicated to trees and is therefore not treated, the score is set to Low rather than Very low.

Precision (4.0) (High) — Drone-based pesticide application reduces operator exposure by 90–99 % compared to handheld spray equipment (Wang et al., 2022). Automation and precision tools also significantly reduce physical strain. However, pesticides remain present on plots, and the long-term effects of newer inputs (nanoparticles, novel chemicals) are not yet fully assessed, justifying a High rather than Very high score.

Intermediate scoring table

Table 12 — Human health score per crop and farming system — 1–5 scale

Farming System	Corn	Wheat	Rice	Vineyard	Olive yard
Conventional	1	1	1	1	1
Organic	5	5	5	5	5
Regenerative	2	2	2	2	2
Agroforestry	2	2	2	2	2
Precision (4.0)	4	4	4	4	4

4.3.5 Social (composite)

Description

The Social composite is the simple arithmetic mean of the four criterion scores reported in sections 4.3.1 to 4.3.4. By construction, it summarises the overall social performance of each farming system on a 1–5 numerical scale, and is constant across the five crops since the underlying social mechanisms are properties of the farming system.

Computation and values

Mapping the qualitative scores to the 1–5 numerical scale yields the following criterion scores in the order Conventional / Organic / Regenerative / Agroforestry / Precision (4.0): Job satisfaction = 3 / 4 / 4 / 5 / 4; Attractiveness to young people = 2 / 4 / 3 / 4 / 5; Job creation = 3 / 3 / 3 / 4 / 2; Human health = 1 / 5 / 2 / 2 / 4. The simple arithmetic mean across the four criteria gives the composite Social scores reported in the table below: 2.25 (Conventional), 4.00 (Organic), 3.00 (Regenerative), 3.75 (Agroforestry) and 3.75 (Precision (4.0)). Organic ranks first on the social pillar, driven principally by its very high score on Human health and its strong attractiveness to young people. Agroforestry and Precision (4.0) are tied in second position but on very different grounds: Agroforestry combines the highest Job satisfaction and a positive Job-creation effect, while Precision (4.0) draws its strength from the highest Attractiveness to young people and a strong Human-health score, but is penalised by a negative Job-creation effect.

Table 13 — Social composite score per farming system — 1–5 scale

Indicator	Conventional	Organic	Regenerative	Agroforestry	Precision (4.0)
Social composite score	2.25	4.0	3.0	3.75	3.75

Section 5 – Scoring

This section explains how the raw criterion values presented in Section 4 are converted into the normalised 1–5 scores used throughout the simulation, and details the four pre-defined weighting profiles available under the Quick start mode.

Normalisation to a 1–5 scale

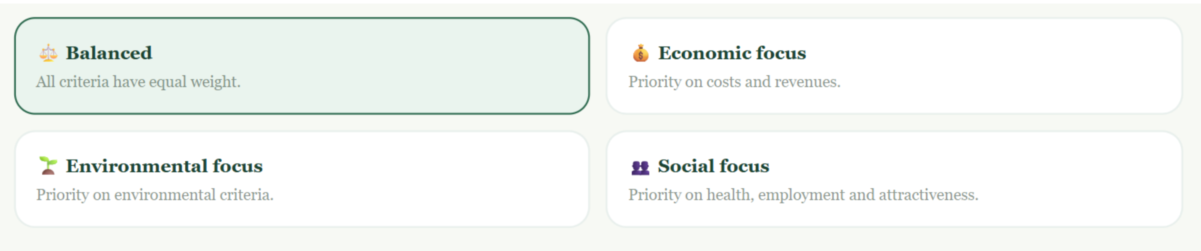
For a given crop, and independently for each of the eleven criteria, the raw values of the farming systems being compared, five for most crops, four for Rice, which has no Regenerative alternative (Section 3.6), are rescaled onto a common 1–5 scale. The system with the least favourable raw value for that criterion is assigned a score of 1, the system with the most favourable value is assigned a score of 5, and any intermediate systems are placed proportionally in between using linear min–max normalisation.

Because every criterion has already been reframed so that a higher raw value always corresponds to better performance (Section 2), the same rule, worst = 1, best = 5, applies uniformly across all eleven criteria, with no separate treatment needed for the four indicators originally expressed as costs to be minimised. Formally, for a given crop and criterion, and denoting by x the raw value of a farming system, and x_{min} and x_{max} the lowest and highest raw values observed among the alternatives being compared:

$$score = 1 + 4 \times (x - x_{min}) / (x_{max} - x_{min})$$

These 1–5 scores are the values shown in the Scores (1–5) tab of the Raw data view (Section 6) and are the figures combined with the criteria weights, described below, to compute each farming system's final AHP score.

Figure — The four pre-defined weighting profiles offered under Quick start.



Weighting profiles (Quick start)

The Quick start mode offers four pre-defined weighting profiles, each assigning a fixed percentage weight to every criterion (normalised to sum to 100 %), so that a first simulation can be run without going through the pairwise-comparison steps of the Hierarchical or Expert AHP modes. Table 14 reports the weight given to each criterion under each profile.

Table 14 — Criteria weights under each Quick start profile

Criterion	Balanced	Economic focus	Environmental focus	Social focus
Cost competitiveness	9.1 %	25 %	5 %	5 %

Criterion	Balanced	Economic focus	Environmental focus	Social focus
Gross revenue	9.1 %	25 %	5 %	5 %
Resilience	9.1 %	7 %	15 %	7 %
Climate mitigation potential	9.1 %	5 %	15 %	7 %
Biodiversity	9.1 %	5 %	15 %	7 %
Water use efficiency	9.1 %	5 %	10 %	5 %
Water quality preservation	9.1 %	5 %	10 %	5 %
Human health	9.1 %	7 %	8 %	18 %
Job satisfaction	9.1 %	7 %	5 %	15 %
Job creation	9.1 %	5 %	5 %	12 %
Attractiveness to young people	9.1 %	4 %	7 %	14 %

Balanced: every criterion receives an equal weight of 1/11 (≈9.1 %), reflecting no particular priority among the economic, environmental and social dimensions.

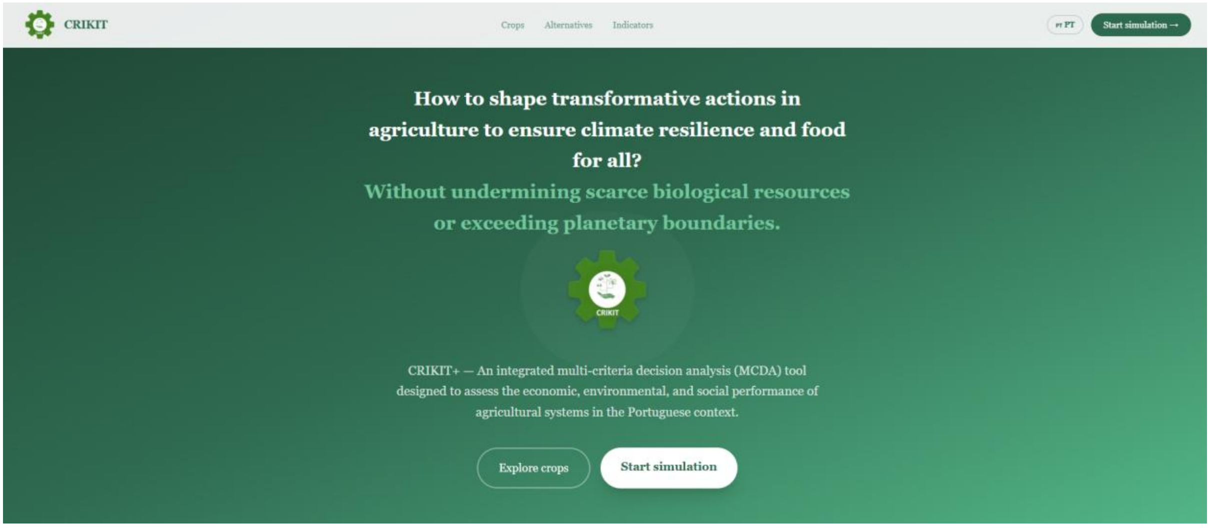
Economic focus: Cost competitiveness and Gross revenue are weighted most heavily (25 % each, 50 % combined), followed by a moderate weight on Resilience, Human health and Job satisfaction (7 % each); the remaining environmental and social criteria receive lighter weights (4–5 % each).

Environmental focus: Resilience, Climate mitigation potential and Biodiversity receive the highest weights (15 % each), followed by Water use efficiency and Water quality preservation (10 % each); the economic criteria and the remaining social criteria receive lighter weights (5–8 % each).

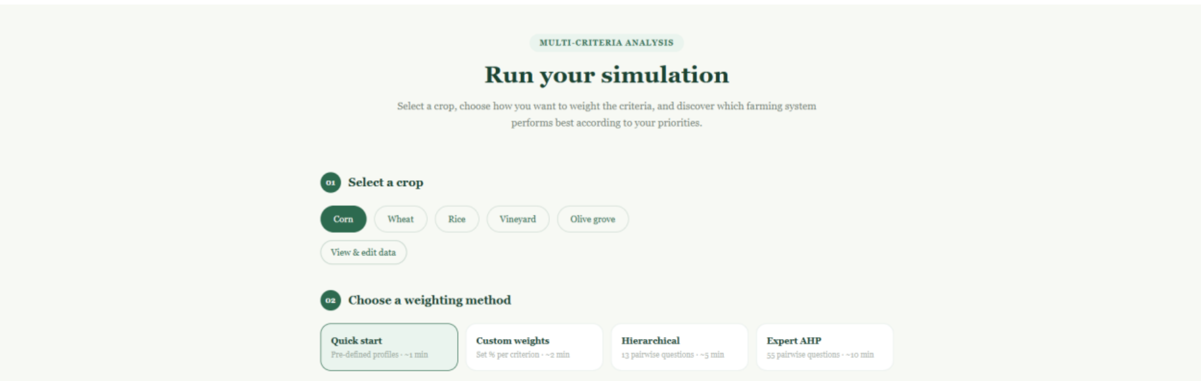
Social focus: Human health (18 %), Job satisfaction (15 %), Attractiveness to young people (14 %) and Job creation (12 %) dominate this profile; the economic and environmental criteria all receive a baseline weight of 5–7 %.

Section 6 – Tool WOP

When you first open the website, it appears as shown below, with a link in the centre to the CRIKIT project website. You can scroll down to browse the different crops, farming systems and indicators. Using the button in the top-right corner, you can switch the language and view the website in Portuguese.

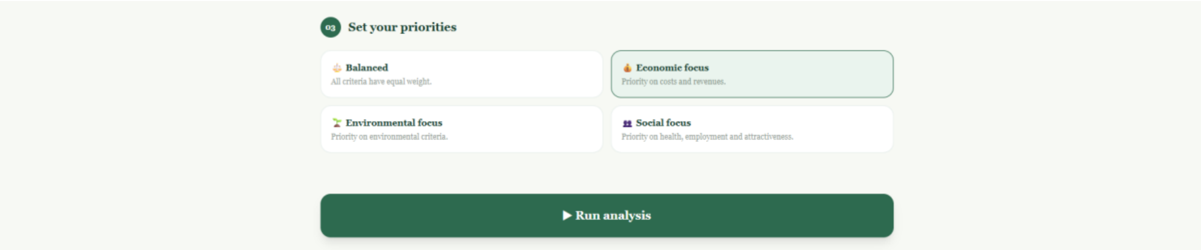


When you are ready to run a simulation, scroll down a little further or click the *Start simulation* button. The first step is to select one of the five available crops. You can then view and edit the data to match a specific farm or any figures of your own. Clicking *View & edit data* opens a first page showing the score of each criterion for each farming system, normalised on a scale from 1 to 5. A second page shows the raw data, which you can edit directly. Note that this second page uses the original indicators, so some of them are meant to be maximised and others minimised.

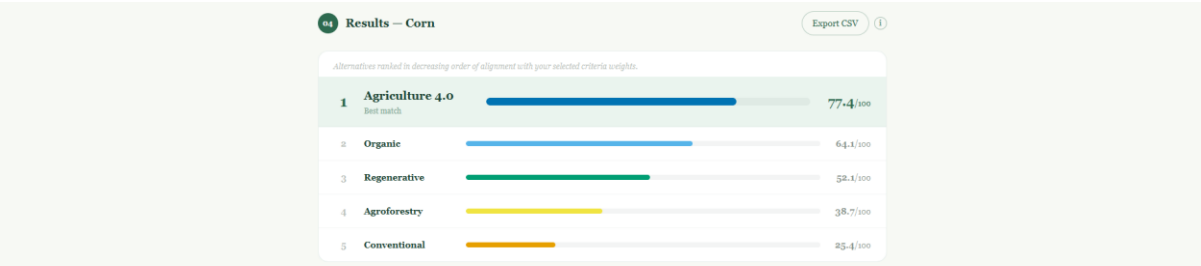


Once this is done, you choose a weighting method. Each method is designed for a different type of user. If you do not want to spend much time on the simulation, you can select the quick start or the custom weights. If you are an expert and want a simulation tailored precisely to your own judgements, you can use the Expert AHP method, which takes longer to complete (around 15 minutes).

Next, you set your priorities. In the example below, the economic focus has been selected within the quick start, which means the economic indicators are given greater importance than the others. Once your priorities are set, you can run the simulation.



Once the simulation has run, the ranking of the different farming systems is displayed just below. Several graphs are also provided to help you understand why some systems rank higher than others.



On this graph, each axis represents one indicator, normalised between 0 (worst performance) and 1 (best performance). Since every indicator is oriented so that higher always means better, a larger shaded area indicates better overall performance.

Section 7 – Bibliography

This section gathers all the references used throughout the report in a single bibliography. The entries are grouped by the criterion or topic they support, following the structure of Sections 3 and 4. Where a value in the report is based on direct exchanges with Portuguese farmers, it is cited in the text as “expert communication” and is therefore not listed here.

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Annex

This annex collects the screenshots of the GHG Balance dashboards generated with the Tier 1 IPCC 2019 calculator for each of the five crops considered in Section 4.2.4. Each dashboard reports the per-hectare and per-tonne emission and removal balances across the five farming systems (Conventional, Organic, Regenerative, Agroforestry, Precision (4.0)), broken down by IPCC category. Positive values denote net emissions to the atmosphere; negative values denote net removals (sequestration in soil organic carbon or perennial biomass).

A.1 GHG dashboards by crop

A.1.1 Maize (Grain Corn)

DASHBOARD — GHG Balance by Alternative (kg CO2e / ha / yr)						
Positive value = emission | Negative value = sequestration (removal from atmosphere)						
Crop:		Maize (Grain Corn)	Climate:	Warm temperate dry	Area (ha):	1
GHG Category	**IPCC Reference**	**1. Conventional**	**2. Organic**	**3. Regenerative (No-till)**	**4. Agroforestry**	**5. Agriculture 4.0**
Crop residues — N2O	Eq. 11.6 + 11.1 + 11.10	255,9485935	223,4280663	333,222485	316,1341524	287,7163307
Fertiliser inputs — N2O	Eq. 11.1 + 11.9 + 11.10	901,215315	633,7617	675,9114862	901,215315	675,9114862
Fuel & Energy — CO2	Tier 1 diesel + grid	694,43	728,89064	598,49314	713,2775	501,640247
Liming & Urea — CO2	Eq. 11.12 + 11.13	223,7209333	128,3876	199,8876	223,7209333	199,8876
Soil carbon change (ΔSOC) — CO2	Eq. 2.25	0	-1237,28	-272,8704	-133,76	0
Biomass (trees/hedges) — CO2	Agroforestry	0	0	0	-1833,333333	0
TOTAL NET BALANCE (kg CO2e/ha/yr)		**2075,314842**	**477,1880063**	**1534,644311**	**187,2545674**	**1665,155664**
TOTAL FOR FARM (kg CO2e/yr) — × area	× Parameters!$B$6	2075,314842	477,1880063	1534,644311	187,2545674	1665,155664
Per t grain produced (kg CO2e / t grain)	÷ yield (t/ha)	157,2208213	51,64372363	119,2419822	15,33616441	120,1411013
Ranking — per ha (1 = lowest emissions / best)		5	2	3	1	4
Ranking — per t grain (1 = lowest emissions / best)		5	2	3	1	4

Dashboard — GHG balance for Maize (Grain Corn) (kg CO_2e / ha / yr).

A.1.2 Winter Wheat

DASHBOARD — GHG Balance by Alternative (kg CO2e / ha / yr)						
Positive value = emission | Negative value = sequestration (removal from atmosphere)						
Crop:		Winter Wheat	Climate:	Warm temperate dry	Area (ha):	1
GHG Category	**IPCC Reference**	**1. Conventional**	**2. Organic**	**3. Regenerative**	**4. Agroforestry**	**5. Agriculture 4.0**
Crop residues — N2O	Eq. 11.6 + 11.1 + 11.10	97,18517669	60,13964527	125,0367086	118,6245697	112,7005007
Fertiliser inputs — N2O	Eq. 11.1 + 11.9 + 11.10	386,4861	410,0811	289,864575	386,4861	289,864575
Fuel & Energy — CO2	Tier 1 diesel + grid	193,76356	227,66425	157,006072	243,089026	167,513092
Liming & Urea — CO2	Eq. 11.12 + 11.13	183,3333333	132	170,5	183,3333333	170,5
Soil carbon change (ΔSOC) — CO2	Eq. 2.25	0	-1237,28	-272,8704	-133,76	0
Biomass (trees/hedges) — CO2	Agroforestry	0	0	0	-1833,333333	0
TOTAL NET BALANCE (kg CO2e/ha/yr)		**860,76817**	**-407,3950047**	**469,5369556**	**-1035,560304**	**740,5781677**
TOTAL FOR FARM (kg CO2e/yr) — × area	× Parameters!$B$6	860,76817	-407,3950047	469,5369556	-1035,560304	740,5781677
Per t grain produced (kg CO2e / t grain)	÷ yield (t/ha)	245,9337629	-232,7971456	137,5932471	-319,8641867	195,9201502
Ranking (1 = lowest emissions / best)		5	2	3	1	4

Dashboard — GHG balance for Winter Wheat (kg CO_2e / ha / yr).

A.1.3 Paddy Rice

DASHBOARD — GHG Balance by Alternative (kg CO2e / ha / yr)

Positive value = emission | Negative value = sequestration (removal from atmosphere)

Crop:		Paddy Rice	Climate:	Warm temperate dry	Area (ha):
GHG Category	**IPCC Reference**	**1. Conventional**	**2. Organic**	**3. Peripheral Agroforestry**	**4. Agriculture 4.0 (AWD)**
CH4 from rice cultivation	*Eq. 5.1 + 5.2 + 5.3*	5 181	7 448	5 181	2 849
Crop residues — N2O	*Eq. 11.6 + 11.1 + 11.10*	152	133	196	190
Fertiliser inputs — N2O	*Eq. 11.1 + 11.9 + 11.10*	302	330	302	258
Fuel & Energy — CO2	*Tier 1 diesel + grid*	1 249	1 306	1 274	942
Liming & Urea — CO2	*Eq. 11.12 + 11.13*	47	0	47	35
Soil carbon change (ΔSOC) — CO2	*Eq. 2.25*	0	-2 198	-238	2 596
Biomass (trees/hedges) — CO2	*Peripheral Agroforestry*	0	0	-1 833	0
TOTAL NET BALANCE (kg CO2e/ha/yr)		**6 931**	**7 019**	**4 929**	**6 871**
TOTAL FOR FARM (kg CO2e/yr) — × area	*× Parameters!$B$6*	6 931	7 019	4 929	6 871
Per t grain produced (kg CO2e / t grain)	*÷ yield (t/ha)*	1 100	1 638	846	1 091
Ranking — per ha (1 = lowest emissions / best)		3	4	1	2
Ranking — per t grain (1 = lowest emissions / best)		3	4	1	2

Dashboard — GHG balance for Paddy Rice (kg CO_2e / ha / yr).

A.1.4 Vineyard (grapes / wine)

DASHBOARD — GHG Balance by Alternative (kg CO2e / ha / yr)

Positive value = emission | Negative value = sequestration (removal from atmosphere)

Crop:		Grapes (wine)	*Climate:*	Warm temperate dry	*Area (ha):*	1
GHG Category	**IPCC Reference**	**1. Conventional**	**2. Organic**	**3. Regenerative**	**4. Agroforestry**	**5. Agriculture 4.0**
Pruning residues — N2O	*Eq. 11.6 + 11.1 + 11.10*	24	35	39	39	28
Fertiliser inputs — N2O	*Eq. 11.1 + 11.9 + 11.10*	99	130	99	99	74
Fuel & Energy — CO2	*Tier 1 diesel + grid*	243	270	186	276	204
Liming & Urea — CO2	*Eq. 11.12 + 11.13*	0	-	0	0	0
Soil carbon change (ΔSOC) — CO2	*Eq. 2.25*	-	(1)	49	28	-
Vine biomass — CO2	*Ch.4 Forest Land*	-	-	-	-	-
Agroforestry biomass — CO2	*Agroforestry only*	-	-	-	(60)	-
TOTAL NET BALANCE — on-field IPCC (kg CO2e/ha/yr)		**366**	**434**	**374**	**383**	**306**
Per tonne grapes produced (kg CO2e / t grapes)	*÷ yield (t grapes/ha)*	40	53	41	44	28
TOTAL FOR FARM (kg CO2e/yr) — × area	*× Parameters!$B$6*	366	434	374	383	306
Ranking IPCC (1 = lowest emissions / best)		**2**	**5**	**3**	**4**	**1**

Dashboard — GHG balance for Vineyard (grapes/wine) (kg CO_2e / ha / yr).

A.1.5 Olive yard intensive (olive oil)

DASHBOARD — GHG Balance by Alternative (kg CO2e / ha / yr)

Positive value = emission | Negative value = sequestration (removal from atmosphere)

Crop:		Olive (oil)	Climate:	Warm temperate dry	Area (ha):	1
GHG Category	**IPCC Reference**	**1. Conventional**	**2. Organic**	**3. Regenerative**	**4. Agroforestry**	**5. Agriculture 4.0 (SHD)**
Pruning residues — N2O	*Eq. 11.6 + 11.1 + 11.10*	24	35	39	39	28
Fertiliser inputs — N2O	*Eq. 11.1 + 11.9 + 11.10*	351	373	264	351	264
Fuel & Energy — CO2	*Tier 1 diesel + grid*	369	406	331	425	325
Liming & Urea — CO2	*Eq. 11.12 + 11.13*	44	-	33	44	33
Soil carbon change (ΔSOC) — CO2	*Eq. 2.25*	-	(1 172)	(259)	(127)	-
Olive biomass — CO2	*Table 5.3 / Ch.4 Forest Land*	-	-	-	-	-
Agroforestry biomass — CO2	*Agroforestry only*	-	-	-	(1 833)	-
TOTAL NET BALANCE — on-field IPCC (kg CO2e/ha/yr)		**788**	**(358)**	**408**	**(1 101)**	**649**
Per t olives produced (kg CO2e / t olives)	*÷ yield (t olives/ha)*	**105,10**	**(53,03)**	**54,44**	**(163,05)**	**86,59**
TOTAL FOR FARM (kg CO2e/yr) — × area	*× Parameters!$B$6*	**788**	**(358)**	**408**	**(1 101)**	**649**
Ranking — per ha (1 = lowest emissions / best)		**5**	**2**	**3**	**1**	**4**
Ranking — per hL oil (1 = lowest emissions / best)		**5**	**2**	**3**	**1**	**4**

Dashboard — GHG balance for Olive yard (olive oil) (kg CO_2e / ha / yr).

A.1.6 Olive yard super-intensive (olive oil)

DASHBOARD — GHG Balance by Alternative (kg CO2e / ha / yr)						
Positive value = emission | Negative value = sequestration (removal from atmosphere)						
Crop:		Olive (oil)	**Climate:**	Warm temperate dry	**Area (ha):**	1
GHG Category	**IPCC Reference**	**1. Conventional**	**2. Organic**	**3. Regenerative**	**4. Agroforestry**	**5. Agriculture 4.0 (SHD)**
Pruning residues — N2O	*Eq. 11.6 + 11.1 + 11.10*	24	35	39	39	28
Fertiliser inputs — N2O	*Eq. 11.1 + 11.9 + 11.10*	527	559	395	527	395
Fuel & Energy — CO2	*Tier 1 diesel + grid*	503	567	438	599	444
Liming & Urea — CO2	*Eq. 11.12 + 11.13*	73	-	55	73	55
Soil carbon change (ΔSOC) — CO2	*Eq. 2.25*	-	(1 172)	(259)	(127)	-
Olive biomass — CO2	*Table 5.3 / Ch.4 Forest Land*	-	-	-	-	-
Agroforestry biomass — CO2	*Agroforestry only*	-	-	-	(1 833)	-
TOTAL NET BALANCE — on-field IPCC (kg CO2e/ha/yr)		**1 127**	**(11)**	**669**	**(721)**	**922**
Per t olives produced (kg CO2e / t olives)	*÷ yield (t olives/ha)*	**71,35**	**(0,75)**	**42,36**	**(50,73)**	**58,32**
TOTAL FOR FARM (kg CO2e/yr) — × area	*× Parameters!$B$6*	**1 127**	**(11)**	**669**	**(721)**	**922**
Ranking — per ha (1 = lowest emissions / best)		**5**	**2**	**3**	**1**	**4**
Ranking — per hL oil (1 = lowest emissions / best)		**5**	**2**	**3**	**1**	**4**