D3.3

Social assessment of selected CARINA concepts

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ABBREVIATIONS

DCT	Data collection template
EU	European Union
FU	Functional unit
LC	Life cycle
GLS	Glucosinolates
PSILCA	Product Social Impact Life Cycle Assessment
SB	System boundaries
S-LCA	Social Life Cycle Assessment
VC	Value chain
WP	Work Package

1 Executive summary

This report presents the methodological foundations of the social assessment applied to the selected innovative bio-based value chains of the CARINA project, carried out within WP3 (Sustainability Assessment) and specifically linked to T3.3 (Social assessment of selected CARINA concepts). In this context, a set of social indicators was defined in T3.1 (Identification of sustainability indicators) as part of the overall project framework. To address these indicators comprehensively and ensure a holistic evaluation, the social risk and opportunities of the selected CARINA value chains were assessed through a simplified Social Life Cycle Assessment (S-LCA) methodology.

This document reports exclusively on those indicators examined from a life cycle perspective, presenting a first-round assessment. The preliminary results serve a dual purpose: (i) to identify social hotspots across the different phases of the selected CARINA value chains, thereby providing decision support for developing more sustainable process routes, and (ii) to refine both the data inputs and the methodological framework applied.

A second-round assessment will be presented in a forthcoming deliverable (D3.5), in which the full set of social indicators will be evaluated as part of a broader Integrated Sustainability Assessment (T3.5). This will be complemented by an economic (T3.2) and an environmental assessment (T3.4), ensuring a multidimensional perspective on sustainability performance.

In conclusion, this assessment represents an initial step for the evaluation of the social sustainability of CARINA concepts. Although results remain preliminary and constrained by data availability, they already provide some insights on social hotspots and performance within CARINA value chains. Future assessments, incorporating more comprehensive datasets and building on the know-how developed during the first two years of experimental trials, are expected to provide a more robust and consolidated analysis.

2 Social assessment in the CARINA project

The CARINA project is a four-year, cross-national EU-funded initiative under the Horizon Europe programme. It aims to boost sustainable diversification in agricultural production systems, through the introduction of two novel oilseed crops— camelina and carinata— and their use as feedstocks in bioeconomy value chains (VCs).

To ensure robustness and co-creative approaches, CARINA established a network of 9 Lighthouses, 5 Living Labs, and 9 Policy Innovation Labs across Europe, which play a central role in driving innovation and validating project actions. The project involves a broad consortium of countries, including Bulgaria, France, Germany, Greece, Italy, Morocco, Poland, Serbia, Slovakia, Spain, Switzerland, Tunisia, and the United Kingdom.

Within the project framework, the term “CARINA concepts” refers to innovative VCs based on camelina and carinata, encompassing the entire pathways from crop cultivation to the development of bio-based end products included within the project.

The project includes several case studies involving field trials, seed crushing tests, and industrial trials, designed to cover the full VC from agricultural production to a wide range of potential final bio-products (e.g. bioherbicides, bioplastics, etc). Trials are mainly held in Europe, but also in Morocco and Tunisia. The overarching aim is to contribute to the creation of European VCs with a strong cross-regional dimension. A selection of VCs relevant for the economic sustainability analysis, considering also the data availability was then performed. The economic assessment builds on a simplified life cycle-based methodology covering the three main phases of the VC: farming, seed crushing, and industrial manufacturing. It integrates primary data collected through dedicated templates with secondary datasets, enabling the identification of potential risks and opportunities

associated with the CARINA VCs under investigation. This approach is strengthened by a participatory approach, involving stakeholders from the early stages of the project, for example through the co-selection of relevant economic indicators. Preliminary results suggest potential economic risk at the field phase, whereas opportunities are mainly in the industrial phase. Some economic indicators, such as gross value added per person and income stabilization, could not be fully assessed due to a lack in suitable data and therefore warrant more in-depth analysis.

The social sustainability assessment of the selected CARINA concepts was tested in trials conducted in nine countries: Bulgaria, France, Greece, Italy, Morocco, Poland, Serbia, Spain and Tunisia.

Not in all the countries involved in the trials there are industrial facilities for the crushing and the processing of camelina-based or carinata-based bioproducts, nor consolidated VCs beyond the agricultural production. For these reasons, for countries where only the field phase is established, such as Bulgaria, Greece, Morocco, Poland, Serbia and Tunisia, scenarios ending at the seeds' sales stage are assessed. For the case studies developed in France, Spain and Italy, both the agricultural and industrial phases are well established and supported by infrastructure and companies. Data obtained for a French seed crushing plant (Saipol) was used to model crushing phases in Spain and Italy, as well as data coming from Spain, France and Italy pilot and industrial plants (Kimitec, Terres Inovia, Novamont, and Flanat) were used to model industrial phases in Spain, France and Italy.

2.1 Field trials

Concerning the field phase, a range of cropping systems was considered in the context of the CARINA project, called with a letter for differentiation purposes:

A. Camelina as a cash-cover crop in double cropping.
B. Camelina intercropping and relay cropping.
C. Camelina on marginal land.
D. Carinata as a cash-cover crop in double cropping.
E. Carinata intercropping and relay cropping.
F. Carinata on marginal land.

A detailed overview of the field phase scenarios is provided in Table 1, including information on location, the responsible project partner, and the campaign year. The scenarios are structured around two system types: reference scenarios, and CARINA scenarios. The latter are characterized by the integration of camelina or carinata in different ways: (i) as cash-cover crops in double cropping systems (scenarios A and D), (ii) through intercropping or relay cropping (scenarios B and D), and (iii) on marginal land (scenarios C and F).

Table 1: List of the field phase scenarios of the CARINA project.

Scenario	Sub-scenario code	Location	CARINA partner	Reference crop system	CARINA crop system	Campaign	Area (ha)
A	FR1_B-Cm	France (Centre-Val	TI	Barley	Barley & Camelina	2024	1

	FR1_P-Cm	de Loire, Bainvilliers)		Pea	Pea & Camelina	2024	1
	FR2_Sf-Cm	France (SW)	ARVALIS	Sunflower	Camelina & Sunflower	2023 & 2024	1 (2)
	FR2_So-Cm			Sorghum	Camelina & Sorghum	2024	1
	IT1_Sf-Cm	Italy (experimental site in Bologna)	UNIBO	Sunflower	Camelina & Sunflower	2023 & 2024	0.1314 0.285
	IT1_So-Cm			Sorghum	Camelina & Sorghum	2023 & 2024	0.1314 0.285 0.16
	RS1_Sf-Cm	Serbia (Rimski sancevi)	IFVCNS	Sunflower	Camelina & Sunflower	2024	0.1314
	RS1_So-Cm			Sorghum	Camelina & Sorghum	2024	0.1314
	SP1_Sy-Cm	Spain (Lleida)	CCE	Barley Soy	Camelina & Soy	2024	2.7
B	PL1_B-Cm	Poland (next to Poznan)	PULS	Winter wheat	Barley & Camelina	2023 & 2024	0.35 (2)
	FR1_Ba-Cr	France (centre, Boigneville)	ARVALIS	Barley	Barley & Carinata	2024	1
	FR1_B-Cm	France (centre, Boigneville)	ARVALIS	Barley	Barley & Camelina	2024	1
	RS2_P-Cm	Serbia (Rimski sancevi)	IFVCNS	Barley	Pea & Camelina	2023	0.1314
C	SP2_WBP-Cm	Spain (Ciudad Real)	CCE	Crop rotation: Wheat, barley & pea (with fallow)	Crop rotation: Wheat, barley & pea (with camelina)	2023	1.38
	SP3_SfBPW-Cm	Spain (Burgos)		Crop rotation: Sunflower, barley, pea & wheat (with fallow)	Crop rotation: Sunflower, barley, pea & wheat (with camelina)	2023	36

	PL2_CmML	Poland (next to Poznan)	PULS	NA (marginal land)	Camelina in marginal land	2023 & 2024	0.35 (2)
	IT2_CmML	Italy (Emilia-Romagna, Ozzano dell'Emilia)	UNIBO	NA (marginal land)	Camelina in marginal land	2023	0.168
	IT2_CmML			NA (marginal land)	Camelina in marginal land	2024	0.24
D	IT3_Cp-Cr	Italy (experimental site in Bologna)	UNIBO	Chickpea, Carinata (0.04)	Chickpea & Carinata	2024	0.076 0.162
	IT4_Cp-Cr	Italy (Lemmo rino)	Novamont	NA	Chickpea & Carinata	2024	1
	PL3_B-Cr	Poland (next to Poznan)	PULS	Barley, Carinata?	Barley & Carinata	2023 & 2024	0.35 (2)
E	PL4_CrML	Poland (next to poznan)	PULS	NA (marginal land)	Carinata in marginal land	2023 & 2024	0.35

2.2 Pilot and industrial Trials

Within the project, three main trial phases were conducted: the field phase, the crushing phase, and the industrial phase. During the field phase, camelina and carinata were cultivated in rotation with different food crops, as outlined above, to assess their agronomic performance under diverse conditions. In the crushing and industrial phase, the harvested seeds of both camelina and carinata underwent a crushing process (Saipol – France or Flanat – Italy), yielding two main fractions: oil and protein-rich cake. These intermediates can be further processed into a variety of bio-based products across different European countries, creating distinct VCs.

- Camelina Cake: can be directly used as animal feed (Saipol – France) or can be processed to develop a Carrier formulation designed to increase the bioavailability of food supplements (Flanat – Italy) or to produce Biostimulant (Kimitec – Spain);
- Camelina oil: can be consumed as such since it is edible or can be processed to produce biofuels, but both the final products are out-of-scope for the CARINA project, since they are not innovative VCs;
- Carinata Cake: due to high glucosinolates (GLS) content, it cannot be used directly as animal meal, but a GLS-free meal can be produced (Terres Inovia – France) or can be processed to produce Biostimulant (Kimitec – Spain). From GLS, Biopesticide can be obtained (Kimitec – Spain);
- Carinata oil: can be processed into Bioherbicide or Bioplastic (Novamont – Italy).

This integrated approach highlights the versatility of camelina and carinata as multipurpose crops, enabling the development of innovative, sustainable VCs that combine food, feed, and industrial applications.

As previously anticipated, the industrial VCs and facilities (WP5) for camelina- and carinata-based products are more consolidated only in France, Italy, and Spain, where specific processing routes and final applications were established. For the other countries involved in the project, less consolidated VCs have been identified at this stage.

2.3 Value Chains Co-Selection

Based on the considerations above, and to ensure comparable and realistic assessments across heterogeneous contexts, two distinct evaluation approaches were applied:

1. Crop-based products for countries with less consolidated VCs (Poland, Serbia, Morocco, Bulgaria, Tunisia and Greece);

2. Industrial products for countries with more consolidated VCs (France, Italy and Spain).

For the first assessment, comparisons were on the basis of the total impact generated at plot level, irrespective of whether one or multiple crops were cultivated.

For the second assessment, to focus on strategic products in countries with more consolidated VCs, national project partners were asked to select up to three bio-based final products of interest (Fig 1. and Fig. 2). The social sustainability assessment was therefore performed on a maximum of three complete VCs per country (including field phase, crushing phase, and, where applicable, the industrial phase).

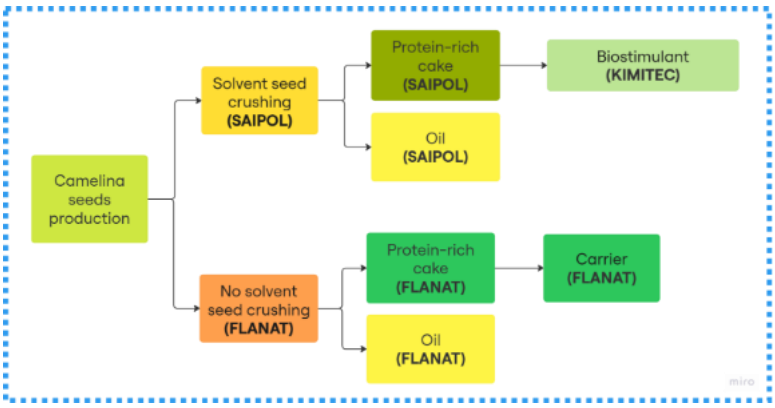

Figure 1: All possible camelina VCs for France, Italy, and Spain.

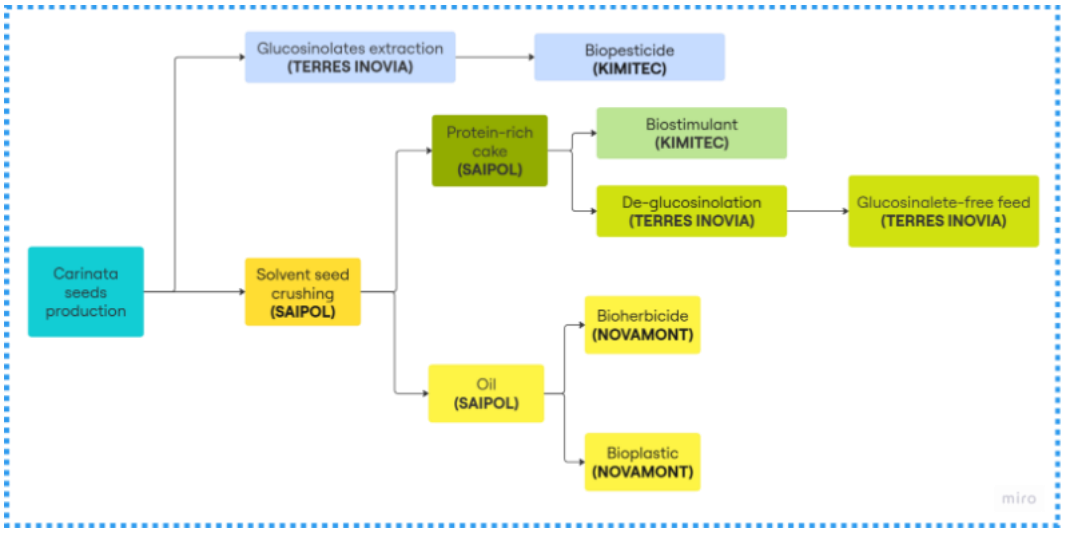

Figure 2: All possible carinata VCs for France, Italy, and Spain.

As a result of this joint selection process, three final products per country were defined as follows (and as resumed in Fig. 3):

1. France: Protein-rich Cake from camelina; GLS-free feed from carinata; Bioherbicide from carinata;
2. Italy: Carrier from camelina; Bioherbicide from carinata; Bioplastic from carinata;
3. Spain: Protein-rich Cake from camelina; Biopesticide from carinata; Biostimulant from carinata.

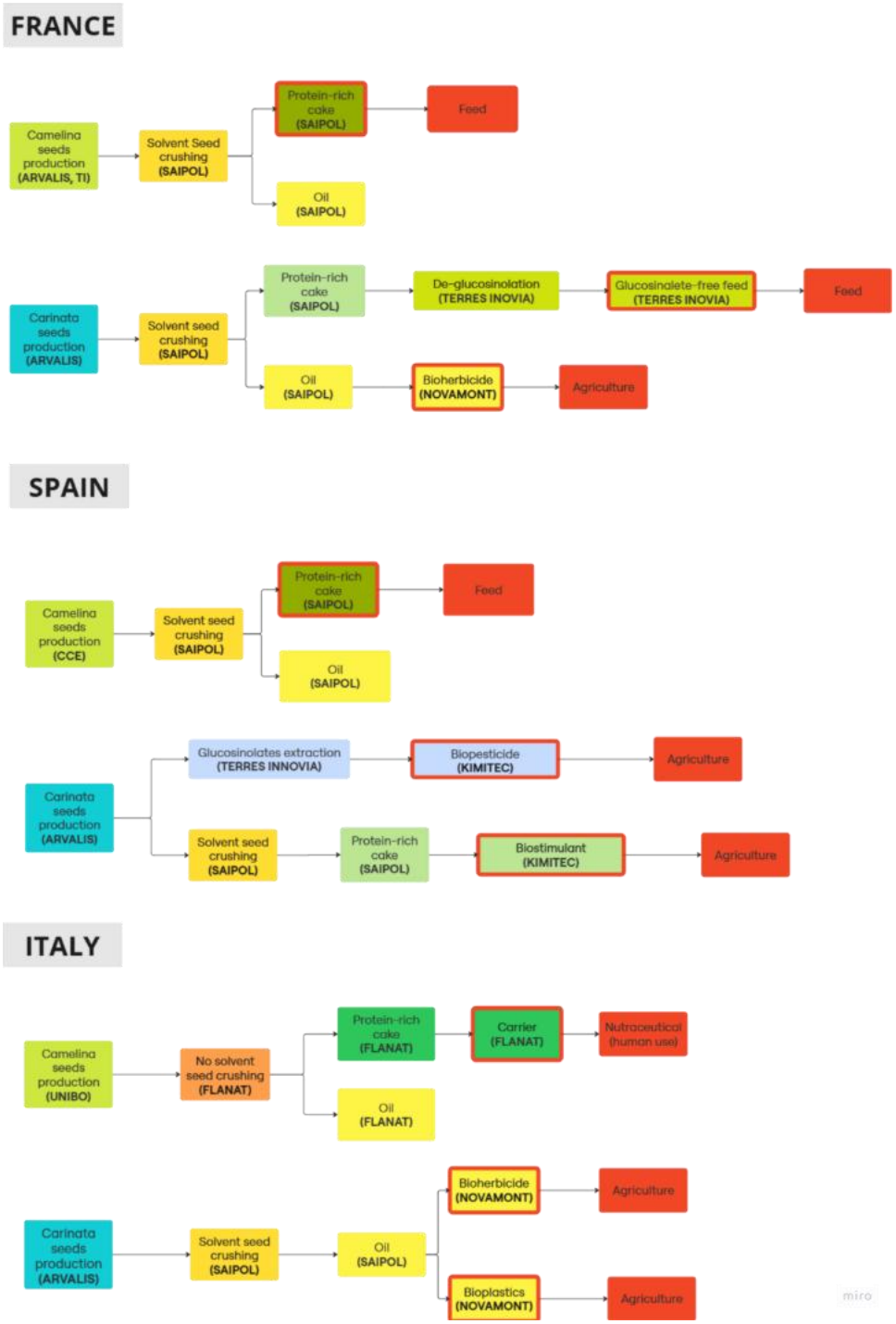

Figure 3: France, Italy, and Spain CS of VC selection (the selected final products are circled in red).

To summarize, the nine scenarios whose final products include the field phase, the crushing phase, and the industrial phase (or the whole VC) are:

1. France Cake
2. France GLS-free feed
3. France Bioherbicide
4. Italy Carrier
5. Italy Bioherbicide
6. Italy Bioplastic
7. Spain Cake

8. Spain Biopesticide
9. Spain Biostimulant

3 Methodology

To assess the potential social risks and benefits of the VCs selected in the CARINA project, an approach based on a simplified Social Life Cycle Assessment (S-LCA) methodology was applied.

The S-LCA is a methodology to assess the social impacts of products and services across their life cycle (e.g. from extraction of raw material to the end-of-life phase, e.g. disposal) (UNEP, 2020). It has been standardised in the ISO 14075:2024 while the UNEP published methodological guidance (UNEP, 2020). These two documents are the two main references. While its most common application is at product level, it can also be used at macro-scale level, e.g. for the evaluation of social risk in VCs analysis (Mancini et al. 2023; Iribarren et al. 2022; Martín-Gamboa et al. 2025).

S-LCA differs from other life cycle-based methodologies since it includes the perspectives of various stakeholders. Therefore, impacts are organized according to different stakeholder categories which may experience a certain impact and impact subcategories. The UNEP guidelines recommend scrutinising a list of stakeholder categories and impact subcategories to select the most relevant ones for the object under investigation (Fig. 4). Relevant stakeholders are those influencing or being influenced by the analysed product, process, or service. Similarly, impact subcategories with a potential impact on the stakeholders are selected for the impact assessment phase (UNEP 2020).

As for other life cycle thinking-based methodologies, S-LCA is carried out in four main steps:

1. Goal and scope definition: where the purpose, the object, the functional unit (FU) and the system boundaries (SB) are determined; moreover, in this phase it should be described the social impact categories and stakeholder categories included in the study;
2. Life cycle inventory: which implies the data collection for all the processes and life cycle stages included in the SB;
3. Impact assessment: which aims at calculating, understanding and evaluating the magnitude and significance of the potential social impacts of the system under investigation throughout its life cycle;
4. Interpretation: in which all the previous phases are reviewed, the results are checked and discussed in depth. This discussion forms a basis for conclusions, recommendations, and decision-making in accordance with the goal and scope definition.

WORKERS	LOCAL COMMUNITY	VALUE CHAIN ACTORS	CONSUMERS	SOCIETY	CHILDREN
Child labour	Access to material resources	Fair competition	Health and Safety	Contribution to economic development	Education provided in the local community
Forced labour	Access to immaterial resources	Promoting social responsibility	Transparency	Public commitment to sustainability issues	Health issues for children as consumers
Fair salary	Respect of indigenous rights	Supplier relationships	End of life responsibility	Prevention and mitigation of armed conflicts	Children concerns regarding marketing practices
Working hours	Safe and healthy living conditions	Respect of intellectual property rights	Feedback mechanism	Technology development	
Equal opportunities / discrimination	Local employment	Wealth distribution		Corruption	
Health and Safety	Delocalization and migration			Ethical treatment of animals	
Social benefits / social security	Cultural heritage			Poverty alleviation	
Freedom of association and collective bargaining	Community engagement				
Employment relationship	Secure living conditions				
Sexual harrassment					
Smallholders including farmers					

Figure 1: List of stakeholders' categories and impact subcategories recommended in the UNEP Guidelines (UNEP, 2020).

In the next section, the four phases of the methodology and how they have been applied to the CARINA VCs are illustrated.

3.1 Goal and scope definition

In S-LCA, the goal and scope phase includes several steps, which entails establishing the aim of the intended study, defining the FU, the reference flow, the product system(s) under study and the breadth and depth of the study in relation to its aim. Moreover, in this phase the social impact categories and stakeholder categories included in the study should be defined.

The aim of this assessment was to identify potential social hotspots in the various VCs explored under the CARINA project and presented in section 2. The analysis aims to assess the level of risk and opportunity related to social aspects, measured through a set of indicators prioritised during previous project phases (D3.1) using a participatory approach. As noted in the UNEP guidelines, the involvement of stakeholders in the selection of relevant impact categories and in the validation of the results is an important requirement, allowing for the consideration of different perspectives and resulting in more grounded and credible outcomes.

The SB of the studies were set on a "cradle-to-gate" approach, where the various countries and sectors potentially involved in the VC are considered.

As previously specified, in the CARINA project different countries with different readiness of the VC are considered. For this reason, for those countries with less consolidated VC only the field phase is considered, for those countries with more consolidated VC, field phase, crushing and in some cases also industrial phase are considered, depending on the final product.

Therefore, for Poland, Bulgaria, Greece, Morocco, Serbia and Tunisia, a cradle-to-farm gate was set as SB (Fig. 5). Differently, for France, Italy and Spain, SB were set as cradle-to-crushing phase gate when camelina's Cake is considered as final product (Fig. 6), for all the other final products, cradle-to-industrial gate is set (Fig. 7).

Figure 2: Cradle-to-(farm)gate as SB for countries with less consolidated VC.

Figure 3: Cradle-to-seed crushing gate as SB for protein-rich Cake from camelina.

Figure 4: Cradle-to-(industrial)gate as SB for all the other CARINA final products.

Concerning the FU, the assessment considered the activities of the organization in one year, as the selected social indicators are not specific for a product output, but refer to organisational and corporate aspects.

For what concerns the selection of relevant impact categories and indicators, stakeholder engagement is recommended in S-LCA to ensure appropriate context-based social impact assessment.

The involvement of relevant stakeholders for the selection of sustainability indicators is described in detail in D3.1 and Table 2 presents the selected indicators for the assessment.

What must be noted, is that not all the 10 selected indicators are indicators themselves, since some of them can be considered more as impact categories (i.e. “Local employment”), for this reason, the term “Social aspects” would be used instead.

Furthermore, few minor adjustments were performed:

- “Average wage per person”: it was calculated per month, instead of weeks, to align with the data reported in PSILCA

- “Working hours per week” description was originally intended to compare the actual working hours with the contractual working hours (%). However, during implementation it was decided to use the absolute value of the average number of hours per week instead (n).

- “Income stabilization” was meant to consider the average income gap of two years between scenario a and b, where scenario a is intended for monocultures without the cover crop included in the rotation, while b is intended for the whole rotation food crop and cover crop, but due to limited data availability at this stage of the project, it was decided to calculate the average income gap of just one year. This indicator, as specified, also considers only rotations (double cropping, relay cropping and intercropping) and excludes marginal lands results.

Furthermore, "Local employment” risk was calculated with national data for unemployment % from PSILCA for the field and the crushing phase, while for the industrial phase the rational was kept similar as originally described, such as not the number of local (from the region) employees hired, in % of the total number of employees hired, but the % of non-local (from the region) employees hired, in % of the total number of employees hired.

Lastly, for “Equal opportunities” no rate of female employees in managerial position was considered, but just the share of female employees.

Table 2: Set of selected indicators/impact categories for the social dimension.

Social impact category	Indicators	Unit
Fair wage	Average wage per person for each category (supply chain stage) / national average wage per person for each category	€
Working time	Working hours per week per person (relative to working hours per week as indicated in the contract)	n
Equal pay (gender)	Gender wage gap (%) potentially to be compared to the national average	%
Equal opportunities	Share of female employees	%
Local employment	Number of non-local (from the region) employees hired, in % of the total number of employees hired	%
Measures to improve gender equality	Existing/implemented measures to improve gender equality	yes/no
Income stabilisation	Average income gap (per year) between scenario a and b, where a is without cover crop and b is with cover crop	%/year
Equal distribution of the generated value	Equity in distribution of generated value (or profit) among the FSC actors (i.e. how much of the profit is generated within each of the FSC stages) calculated as Gini index	%/year
Number of employees trained	Number of employees trained as % of the total number of employees	%/year
Training and re-qualification of the workforce	Number of people belonging to the workforce trained and/or re-qualified	%/year

3.2 Data collection

For both the CARINA VCs, primary data were collected with the contribution of project partners. Inventories covering social aspects were filled with data by partners. Specifically, an Excel-based data collection template (DCT) was developed (Annex). The DCT included a general information sheet, requesting details about the company (e.g. location, stage of implementation, subsidies received) and the product (e.g. type of product and sub-product, total production, etc.). A separate sheet was dedicated to social-related data, including wages, working hours, and gender balance information. Prior to distributing the DCT to partners, bilateral meetings were organized to validate

the information requested and, where specific data could not be provided, alternative approaches were agreed. These datasets enabled a comprehensive assessment of the social impacts associated with each case study. Where primary data was not available, secondary sources and proxy data from the PSILCA database (Ciroth & Eisfeldt, 2016) were used.

Box: The Product Social Impact Life Cycle Assessment (PSILCA) database

PSILCA - the Product Social Impact Life Cycle Assessment database, developed by GreenDelta GmbH, is one of the available commercial databases for Social LCA. It provides information on social aspects of products over their life cycles. It integrates social indicators with also a global input/output model representing the structure of the world economy.

The EORA Multi-Regional Input/Output (MRIO) database is used as input–output model. It represents the interdependencies between different branches of a national economy or different regional economies (Lenzen et al., 2013). Eora database covers 187 countries with a list of 15,909 sectors and uses monetary flows, expressed in US dollars, to link processes among different sectors and countries.

Since PSILCA provides comprehensive data for a broad range of industry sectors worldwide it is applied for VCs sustainability analysis. It provides social indicators for a set of stakeholders and impact subcategories, based on the list from the UNEP Guidelines. A total of 88 qualitative and quantitative social indicators is applied to the whole set of Country-Sector combinations available in the Eora database. Definitions, units of measurement, data sources of each indicator are described in detail in a documentation of PSILCA (Ciroth and Eisfeld, 2016).

The database gathers data from a variety of sources, e.g. international organizations like World Bank, International Labour Organization, World Health Organization and Organization for the Economic Cooperation and Development. For all indicators, the raw, unassessed values are provided, together with an indication of its quality.

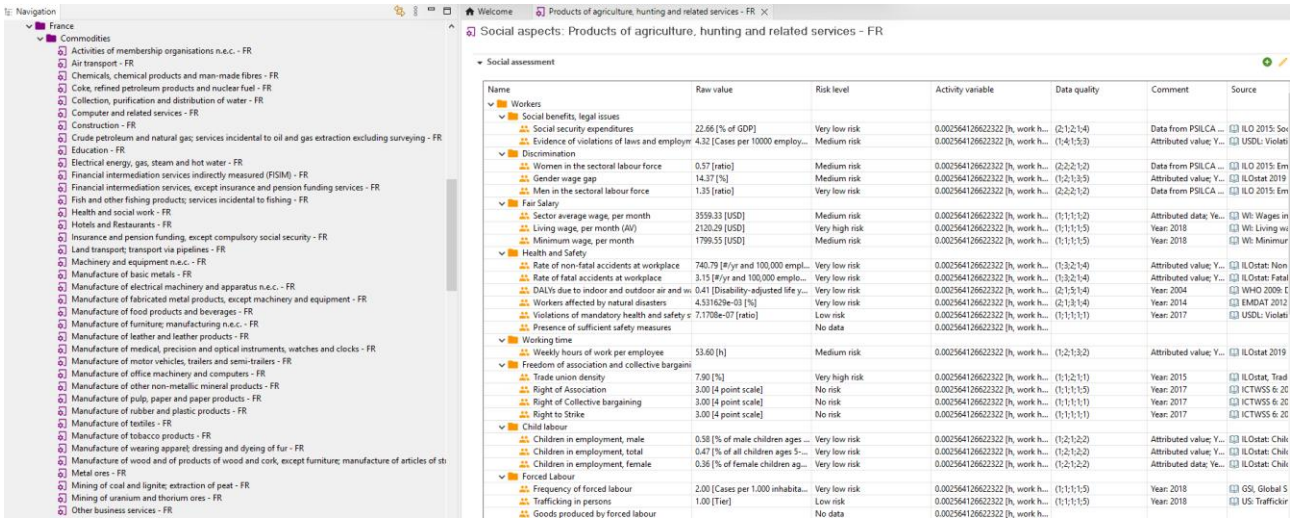

Figure 8: screenshot from PSILCA

Partners contributed to completing inventories on social aspects or sharing relevant databases. In some instances, when data could not be obtained through questionnaires, bilateral meetings were organized to fill the gaps

The data collection strategy is developed including guidelines to facilitate the data gathering process and ensure consistency throughout the assessment steps. Data collection protocols are developed in synergy with the Systerre software.

3.2.1 Field phase data collection

For the analysis of the field phase, primary data were collected through questionnaires including the following questions related to the organisations involved in the project:

1) Are there any existing or implemented measures to improve gender equality? (Please answer "Yes" or "No")
2) What percentage of employees are trained annually, based on the total number of employees? (Please answer in %/year.)
3) What percentage of the workforce is trained or requalified every year, based on the total workforce? (Please answer in %/year)

From PSILCA database, this following national and sector-specific information was collected:

1) Sector-specific data, such as "Average wages per person", "Working hours per week", "Equal opportunities" and "Equal pay (gender)" for the sector "Agriculture, hunting and related service activities" for Italy, France, Poland and Greece, for the sector "Agriculture, livestock and hunting" for Spain and for the sector "Agriculture" for Bulgaria, Morocco, Serbia and Tunisia.
2) Country-specific data, such as "National living wage" and "Local employment"

The PSILCA country-specific sectors used for this phase were the following:

- Products of agriculture, hunting and related services for France, Greece, Poland and Italy

- Agriculture, livestock and hunting for Spain

- Agriculture for Bulgaria, Greece, Morocco, Serbia and Tunisia

Even though not all the indicators risk level can be obtained from the PSILCA database (Serbia, Morocco and Tunisia are missing national data for the Agricultural sector to calculate "Equal pay gender" and Morocco and Tunisia also "Local employment"), most of them could be calculated. Unfortunately, since much information is missing to calculate the opportunity-associated indicators for the field phase, for the comparison across all the countries involved in the project having field trials, just the negative impact comparison is performed.

Lastly, from the economic analysis performed in T3.2 economic primary data was used to calculate "Income stabilisation" indicator, but this indicator is calculated only for trials based on a double cropping system, since the indicator is calculated by comparing a monoculture system and a double cropping system. Finally, economic primary and secondary data was used also to calculate "Equal Distribution of the generated value" indicator, by using the net revenue for each phase of the VC to obtain the Gini index.

Table 3: Share of primary and secondary data used for the assessment of the field phase.

	Data type
Risk indicators	Secondary
Opportunity indicators	Primary

3.2.2 Crushing phase data collection

Primary data on the social aspects related to gender and training was not available for the crushing phase, and therefore was not available:

1) the following country and sector-specific information was collected from PSILCA:

1) Sector specific data, such as “Average wages per person”, “Working hours per week”, “Equal opportunities” and “Equal pay (gender)for the sector “Manufacture of food products and beverages[1]”

2) Nation-specific data, such as “National living wage” and “Local employment”

Lastly, from as for the field phase, the primary and secondary data collected for the economic assessment was used to calculate “Equal Distribution of the generated value” indicator.

Table 4: Share of primary and secondary data used for the assessment of the crushing phase.

	Data type
Risk indicators	Secondary
Opportunity indicators	Secondary

3.2.3 Industrial phase data collection

For the analysis of the industrial phase, the following primary data were through questionnaires including the following questions related to the organisations involved in the project:

1) Are there any existing or implemented measures to improve gender equality? (Please answer “Yes” or “No”)
2) What percentage of employees are trained annually, based on the total number of employees? (Please answer in %/year.)
3) What percentage of the workforce is trained or requalified every year, based on the total workforce? (Please answer in %/year)
4) What is the total number of workers?
5) What is the total number of local (from the region) workers employed?
6) What are the average working hours per day per worker?
7) What is the total number of female workers?

When primary data was not available, sector-specific data from PSILCA were used.

Table 5: Share of primary and secondary data used for the assessment of the industrial phase.

	Data type

[1] In the classification of sectors used in PSILCA does not detail the sector of seed crushing for non-food oil production, therefore the higher level of the classification was chosen.

Risk indicators	Primary*
Opportunity indicators	Secondary

*Apart from “Local employment” for France VCs (secondary data from PSILCA, country-specific for France).

3.3 Risks and opportunities assessment

The Impact Assessment aims at “calculating, understanding and evaluating the magnitude and significance of the potential social impacts of a product system throughout the life cycle of the product” (Norris et al., 2020). Nevertheless, the adopted methodology only associated risks and opportunities levels to each social concept, without converting them into impacts.

The UNEP (2020) guidelines and the ISO 14075 propose two different approaches to perform a Social Life Cycle Impact Assessment, namely reference scale assessment (Type I) and impact pathways or Social Life Cycle Impact Assessment (Type II).

The reference scale assessment is aimed at measuring the positive or negative social performance of the product, service, or process, based on specific reference scales, i.e. by comparing indicators values to baseline and reference values. The reference scales are ordinal scales comparing several levels where each level corresponds to a performance reference point (PRP). The levels used in the reference scales should be defined according to international and/or national norms, or according to best practices.

In the Social Life Cycle Impact Assessment (S-LCIA) method, the cause effect mechanism is modelled, and characterisation factors are used to relate the results of the inventory with impact categories results.

For the assessment of the CARINA VCs, the reference scale assessment method was chosen to assess the social performance both in terms of risks and opportunities, using both primary data and secondary data from PSILCA.

The indicators selected through the participatory approach have been classified as:

- risk indicators, assessing possible social risks as outcome of specific activities from the organisations

- opportunity indicators, assessing potential benefits arising from organisation’s activities.

The reference scales have been retrieved from PSILCA for the risk indicators, while those related to opportunities have been developed by the authors based on available literature in the topics (table 3).

Table 6: Reference scales of selected social risk indicators.

Impact category	Indicator:	Reference scale:	Reference:
Fair wage	Average wages per person/national leaving wage (ratio)	very low risk: >2.5; low risk: 2-2.5; medium risk: 1.5-2; high risk: 1-1.5; very high: 0-1	PSILCA
Working time	Working hours per week (h)	very low risk: n.a.; low risk: 40-48; medium risk: 30-40; high risk: 20-30, 55-60; very high: <20, >60	PSILCA
Discrimination	Women in the sectoral labour force (ratio)	very low risk: 0.8-1, 1-1.5; low risk: 0.6-0.8, >1.5; medium risk: 0.4-0.6; high risk: 0.2-0.4; very high: <0.2	PSILCA
	Gender wage gap (%)	very low risk: 0-5%; low risk: 5-10%; medium risk: 10-20%; high risk: 20-30%; very high: >30%	PSILCA
Local employment	Unemployment rate (%)	very low risk: 0-3%; low risk: 3-8%; medium risk: 8-15%; high risk: 15-25%; very high: >25%	PSILCA

Table 7: Reference scales of selected opportunity indicators

Impact category	Indicator:	Reference scale:	Reference:
Gender balance	Measures to improve gender equality (yes/no)	yes = very high opportunity; no = very low opportunity	Authors' to be validated by experts
Income stabilisation	Rotation income/monoculture income x100 (%)	very high opportunity = 100-80%; high opportunity = 80-60%; medium opportunity = 60-40%; low opportunity = 40-20%; very low opportunity = 20-0%	Authors' proposal to be validated by experts
Equal distribution of the generated value	Gini index (%)	very high opportunity = 0-20%; high opportunity = 20-40%; medium opportunity = 40-60%; low opportunity = 60-80%; very low opportunity = 80-100%	Authors' proposal to be validated by experts
Skills and trainings	Number of employees trained/total employees (%)	very high opportunity = 100-80%; high opportunity = 80-60%; medium opportunity = 60-40%; low opportunity = 40-20%; very low opportunity = 20-0%	Authors' proposal to be validated by experts
	Training and re-qualification of the workforce /total employees (%)	very high opportunity = 100-80%; high opportunity = 80-60%; medium opportunity = 60-40%; low opportunity = 40-20%; very low opportunity = 20-0%	Authors' proposal to be validated by experts

Finally, Performance Reference Points were developed to translate social performance into semi-quantitative results. The following scheme was applied:

Table 8: Performance Reference Points associated with risk levels

Risk level	Performance Reference Points
Very low risk	1

Low risk	2
Medium risk	3
High risk	4
Very high risk	5

Table 9: Performance Reference Points associated with opportunity levels

Opportunity level	Performance Reference Points
Very low opportunity	1
Low opportunity	2
Medium opportunity	3
High opportunity	4
Very high opportunity	5

As suggested by the UNEP guidelines risk categories (negative impacts) and opportunity categories (positive impacts) should not be aggregated, to avoid compensation effect. Indeed, favourable conditions in one area cannot compensate for severe violations in another. For this reason, an overall risk score and an overall opportunity score were calculated separately. These scores were calculated by computing the average of the diverse impact categories and by considering the same weight for each of them.

3.4 Interpretation

In S-LCA, the interpretation phase comprises several elements, including:

- the identification of the significant issues based on the results of the impact assessment;
- the evaluation of the completeness, sensitivity and consistency of the study, including the acknowledgement of the study's limitations;
- the development of conclusions and recommendations.

In the context of the CARINA project, the results interpretation phase aims at deriving meaningful insights on the potential social risks and opportunities related to the VCs based on carinata and camelina crops. The results of this social assessment will be integrated with the economic and environmental assessment results in a dedicated project task, to comprehensively evaluate possible trade-offs and win-win solutions in the VCs under investigation. These results will then feed and support the development of policy recommendations, complementing the outcomes of the WP4.

4 Results

As previously explained, not all the indicators could be calculated for every country, final product, or specific phase of the VC. To date, according to data availability, two main types of comparisons have been performed. The main results are listed in the next sub-paragraphs and resumed as follows:

1. Intra-phase comparison:
    a. Field phase: only for risk indicators;
    b. Crushing phase: no comparison is performed for now since data for risk indicators are the same for each process and final product, and since no data availability is available for opportunity indicators;
    c. Industrial phase: no comparison is performed for now since there is data availability to compare only bioherbicide and bioplastic, but the company is the same and so are the results;
2. Whole VCs comparison:
    a. In Italy: Bioplastic and Bioherbicide VCs;
    b. In France: camelina Cake and Bioherbicide VCs.

4.1 Intra-phase comparison

The results of the impact assessment enable a comparison for the risk indicators related to the field phase of all the nine countries involved in the project.

Fig. 9 shows the levels of risk for the field phase in the countries under investigation. Despite some data gaps for Morocco, Serbia and Tunisia (where national data for the Agricultural sector to calculate equal pay gender is missing and Morocco and Tunisia where also local employment is missing), most of risk indicators could be calculated. Instead, opportunity-indicators could not be calculated due to lack of data.

The heatmap shows that the highest social hotspot (detected through secondary data from PSILCA) is the Equal pay (gender) in Bulgaria, which is the only 5 score result. This is due to a gender pay gap of 30% in the country (based on data from International Labour Organization, ILO), which is likely representative of the agricultural sector. Spain shows a high risk in terms of equal pay, with a gender wage gap of 21%.

Concerning the average wage in the agricultural sector, the risk that the average wage is too low to permit a dignified life is higher in France, Italy and Serbia, than in Morocco and Tunisia. The background data source used in PSILCA is the Wage indicator foundation. Risk of excessive working time (working hours per week) is instead high in Greece, Italy and Poland.

The risk related to local employment is higher in Greece and Spain. However, the data available in PSILCA refer to general unemployment levels and is not considered suitable to describe potential social impacts of CARINA VCs.

Considering the overall risk associated to the various impact categories, equal opportunities, which accounts for the share of women employed in the sector, shows the best performance (lower risk), while the equal pay category has the highest risk.

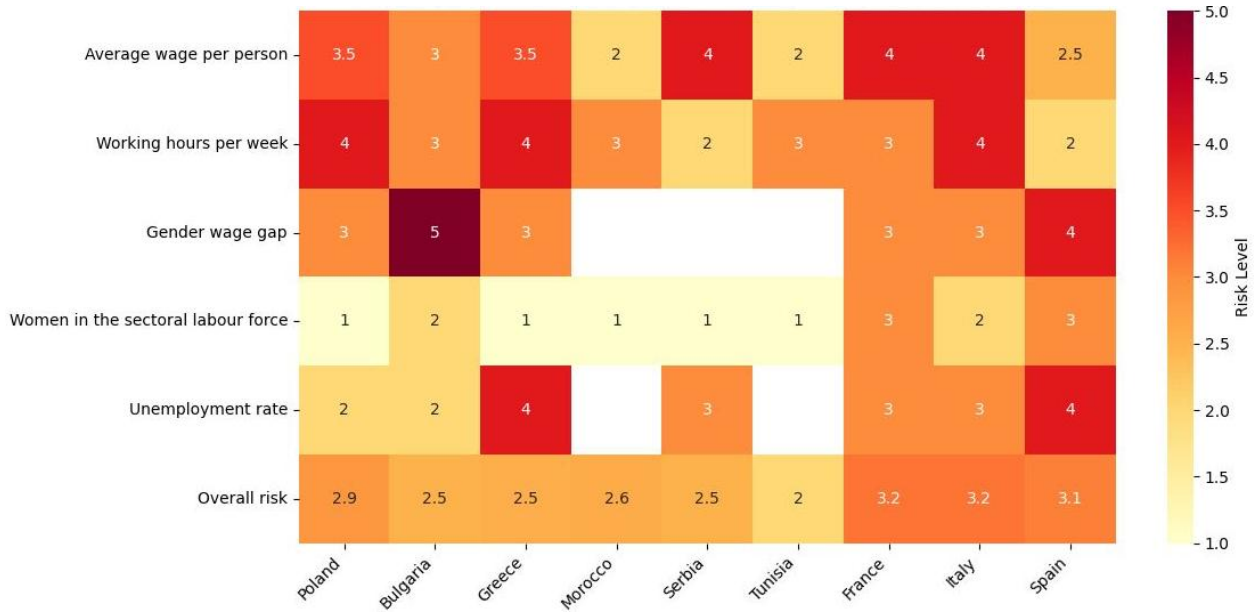

Figure 5: Risk levels at field phase by country.

4.2 Whole value chain comparison

Considering the nine whole VCs, the data gaps allow for a comparison of just four of them: Italy Bioplastic, Italy Bioherbicide, France Cake and France Bioherbicide.

In terms of social risk hotspots (Fig. 10), the impact category showing the best performance across the four VCs is equal pay (gender), while fair wage shows a high risk for the four VCs under investigation. The better performance of the equal pay category is influenced by the lowest risk score in the industrial phase, compared to the farm phase.

What also emerges is that the whole VC shows better performances for equal pay because of the better performances of the industrial phase with respect to the field phase for this social aspect. It must be noted that for the two phases there is a difference in terms of data quality: for the field phase secondary data are used, for the industrial one data is company-specific.

A key methodological consideration concerns the indicator “Local employment”. For this indicator, both primary and secondary data have been used to assess the whole VCs, but they lead to different interpretations. Primary data collected from partners for the industrial phase include information on the share of immigrant workers employed in their company. This data provides context-specific insights and allow “Local employment” to be interpreted as an opportunity indicator, reflecting the capacity of the VCs to create job opportunities for vulnerable or underrepresented groups. By contrast, the secondary data collected through PSILCA for the field and the crushing phase report only the national unemployment rate, which results to be a risk indicator and since it is country-specific, does not directly capture the dynamics of employment creation within CARINA VCs. This discrepancy highlights the need either to expand the availability of primary data also for the field and the crushing phase or to develop more accurate estimation methods. Only by doing so can the “Local employment” indicator fully reflect solid social impacts of the CARINA VCs.

Overall, the risk scores are very similar for the different VCs and is barely possible to spot differences among the VCs. This is due to the use of mostly generic and country-sector data, caused by the lack of specific primary data.

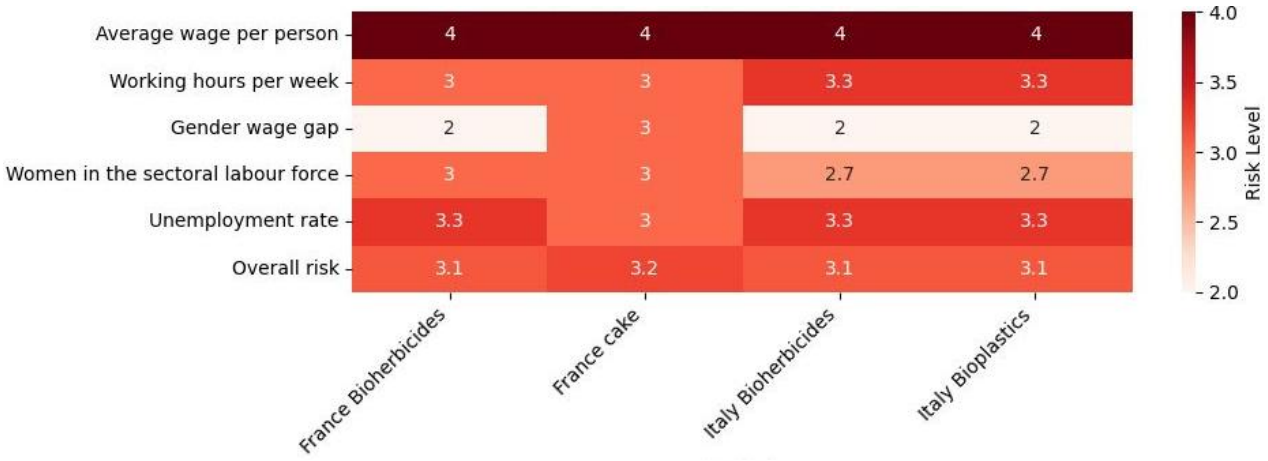

Figure 6: Whole VCs risk levels by final product and country.

The heatmap in Fig. 11 shows opportunity levels, i.e. potential positive impacts linked to the values chains under investigation. The impact category showing the best performances is measures to improve gender equality, while the one showing the lowest opportunity level is income stabilization, which is measured comparing the share of income from rotation with the income from monoculture. This impact category could not be calculated for the Italian VCs, where a carinata monoculture was used for the field phase. Finally, Overall, the two Italian VCs are the ones having the best performances (even though the average is calculated without the income stabilization contribution) and between the French ones, the Bioherbicide VC performs better than the camelina Cake.

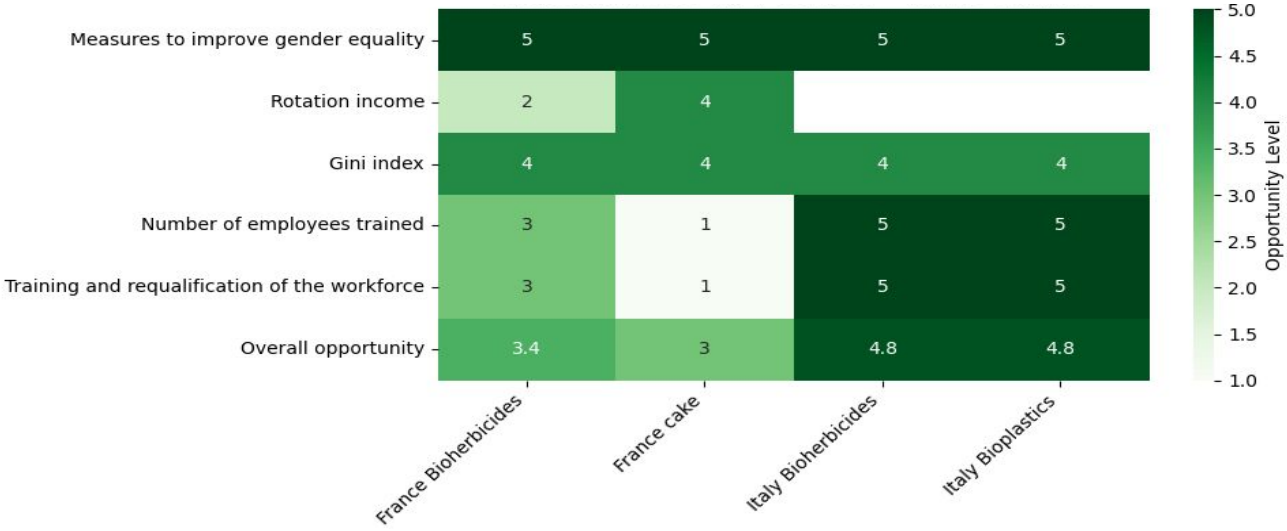

Figure 7: Whole VCs opportunity levels by final product and country.

Fig. 12 shows the overall social risk comparison between the three phases of the four VC. For all of them, the field and crushing phases are associated with the highest risks while the industrial phase has the lowest risk.

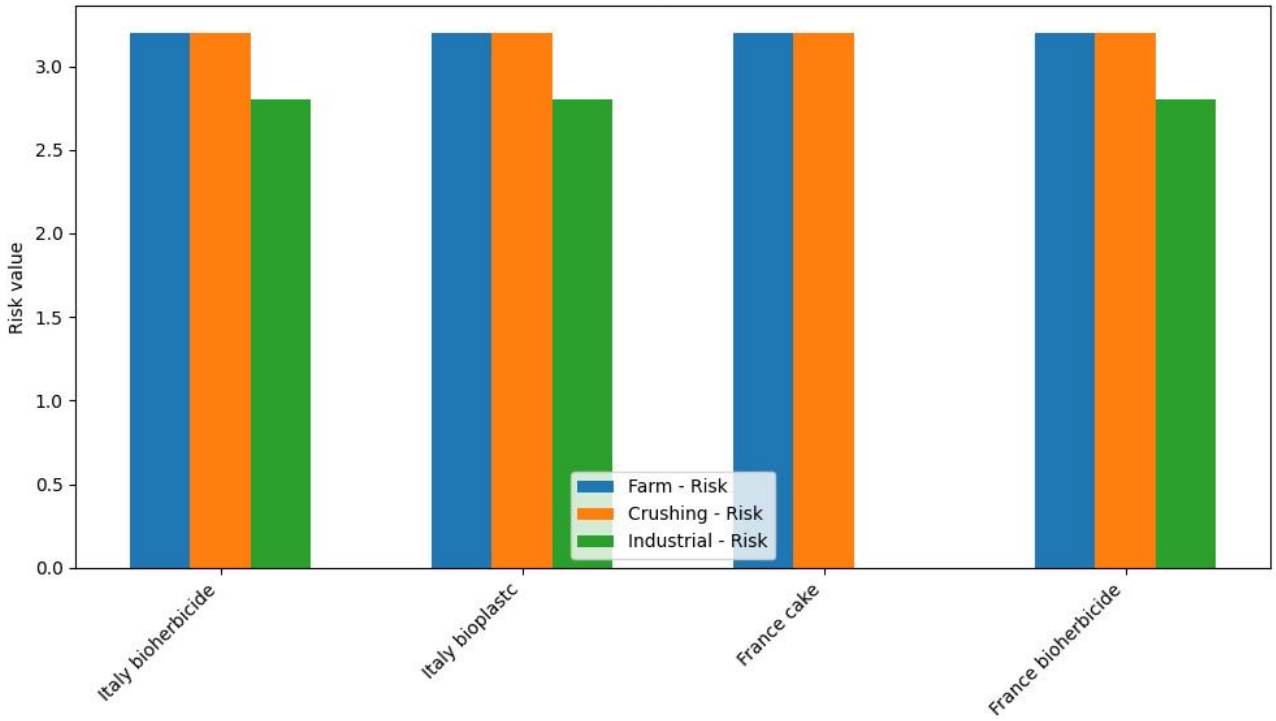

Figure 8: Overall risk by phase, final product and country.

Concerning the overall positive performances of the VCs, results are shown in Fig. 13. These results don't include the crushing phase's positive performances due to lack of data for this phase, as specified earlier.

The comparison between the farm and the industrial phases differs: in the Italian context, both phases have a high opportunity level (scores between 4.5 and 5), but the field one is slightly better than the industrial one for the Bioplastic VC. Differently, in the French context the field phase has low opportunity levels (scores between 2 and 3) and where the industrial phase is also present, such as in the VC of the Bioherbicide, the latter shows a better performance and the highest opportunity score.

The reason behind these differences between the field phases of the two countries, is mainly explained by the much higher performance in the impact category related to training and requalification of the workforce. Indeed, both are associated with an opportunity score of 5 for Italy and 1 for France. Moreover, the category income stabilization for France, with an opportunity score of 2, decreases the overall average, while in Italy this category is missing.

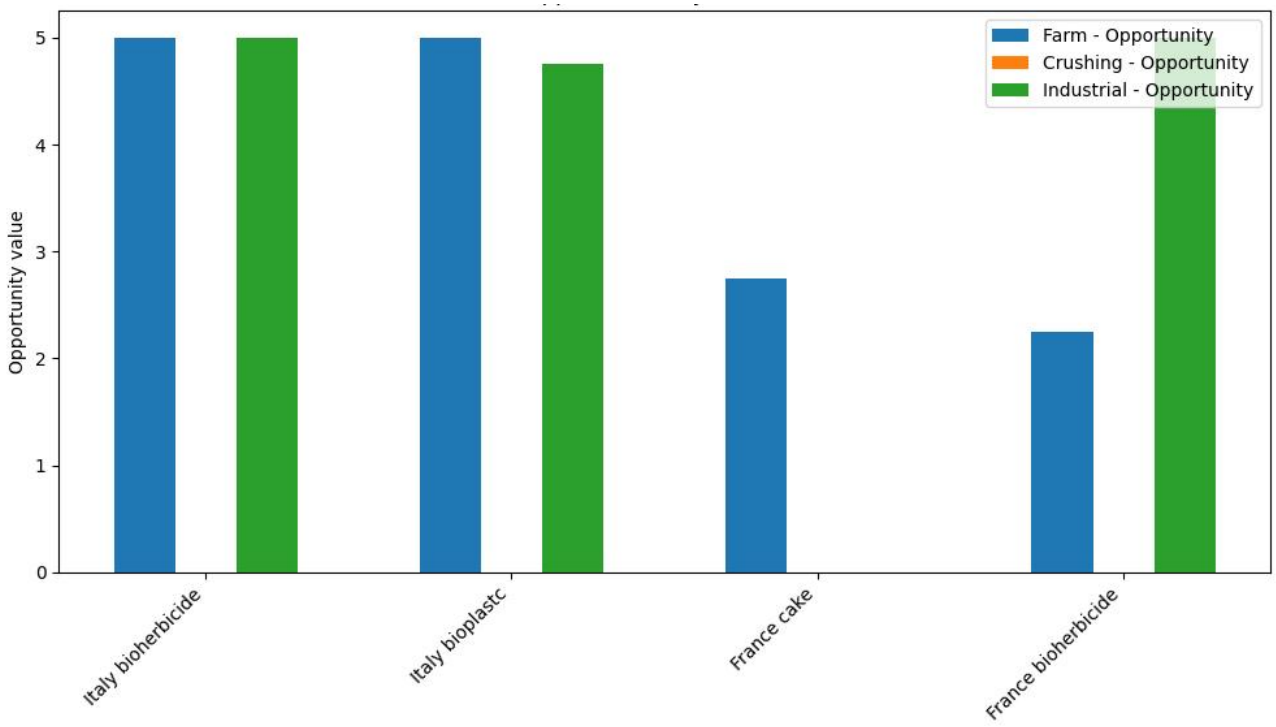

Figure 9: Overall opportunity by phase, final product and country.

4.3 Key messages

The main outcomes of this Deliverable are summarized below:

- The co-selection process has facilitated greater consensus among stakeholders; however, it has provided only partial coverage of the overall impacts and some of the selected indicators are not suitable for measuring aspects that can be influenced by different cropping systems or agricultural practices.
- Data availability remains a significant challenge. Consequently, much of the current analysis relies on secondary data, which often suffer from low granularity and limited significance.
- Primary data for the industrial phase are considered representative for the national level, since the companies involved are leaders in their sector; nevertheless, this further affects the robustness of the results.
- Company-specific data are also used as proxies for other countries with more consolidated VCs participating in the project. As above, this further limits the overall significance and comparability of the various VCs.
- This issue is particularly evident in relation to innovative VCs, where reliable and detailed datasets are scarce. As a result, the absence of established VCs introduces a higher degree of uncertainty in the sector-specific PSILCA data applied.
- The results shows that the CARINA VCs present social risk hotspots in terms of fair wage and working time, while for the field phase the main hotspot is on gender wage gap. The category related to local employment could not be assessed with the secondary data available in PSILCA and deserve further investigation.

- Opportunities can be envisaged in terms of gender equality measures and training, but the capability of stabilising income seems limited. This aspect requires further investigation and integration with the results of the economic analysis.
- The adopted methodology still requires validation by experts in the field, e.g. in the definition of reference scales which should also be validated considering existing regulatory frameworks and sustainability standards. This will be carried out in the coming months.
- Therefore, the current results represent an intermediate assessment, which will be progressively refined and consolidated as additional data and evidence become available.

5 Concluding remarks

The social analysis has identified several hotspots across the assessed VCs. In the field phase, risks hotspots are associated with equal pay in Bulgaria and Spain, fair wage in France, Italy, and Serbia, and working time in Italy, Greece, and Poland. At the level of the whole VCs, fair wage also emerges as a risk factor. On the other hand, opportunities are spotted for the VCs in Italy, in terms of number of employees trained as well as training and requalification of the workforce. An additional positive performance concerns the measures to improve gender equality, for all the 4 analysed VCs.

The methodology applied in this study combined a simplified S-LCA with a participatory process, from the early stage of indicators co-selection and a continue dialogue with stakeholders and project partners. The S-LCA methodology provided a framework and a structure for the reference scale impact assessment, and the related database PSILCA was used of a source for secondary data for the risk indicators. The participatory process allowed to gather more detailed information on the VC and to identify relevant issues of concern from the stakeholder perspective.

A key methodological issue concerns the indicator “Local employment”. Primary data from partners (industrial phase) provide information on the share of immigrant workers, allowing the indicator to be interpreted as an opportunity indicator linked to job creation for vulnerable groups. By contrast, secondary data from PSILCA (field and crushing phases) rely only on national unemployment rates, which act as a risk indicator and do not reflect employment dynamics within CARINA VCs. This inconsistency underlines the need to expand primary data collection also for the field and crushing phases or to develop more accurate estimation methods.

Lastly, the results presented in this Deliverable represent an initial screening step, providing a basis for further data collection and partner discussion. The discussion will also support the refinement of the methodology, acting as an opportunity towards a more holistic and robust assessment. Moreover, the integration of these results with those on environmental and economic sustainability will allow a better interpretation of the results in a more integrated manner. The final consolidated assessment will be part of D3.5, which is planned for Month 46 of the CARINA project.

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7 Annex

Due to its format and size, the data collection template is provided below as screenshots of the excel files. Screenshots include the main parts of the excel file showing most of the data and the most important information requested to project partners related to the analysis presented in this document. For additional information, please contact the organization.

This section collects general data on:

- General characteristics
- Product
- Type of production
- Structure

Please fill only the relevant sections. If some of the elements are not applicable to the specific case, leave them blank. **The cells to fill in are highlighted in yellow**.

Product			
Element	Unit of measure	Data	Type of data
Type of product	text		
Total production	kg/year		
Production loss	% (kg of losses/ total kg)		
By-products production	kg/year		
Type of by-product	text		
Other (specify, even adding rows/columns)			

General characteristics			
Element	Unit of measure	Data	Type of data
Place (region and/or city)	text		
Starting date of the evaluation	data		
Ending date of the evaluation	data		
Activity orientation	text		
Total revenue	€/year		
Sales from product	€/year		
Sales from by-products	€/year		
Sales from services	€/year		
Income from incentives	€/year		
Stage of implementation of systems	text		
Other (specify, even adding rows/columns)			

CARINA

This section collects data on:

- Working conditions
- Labour rights
- Gender balance
- Job opportunities
- Economic development
- Education and knowledge transfer

Please fill only the relevant sections. If some of the elements are not applicable to the specific case, leave them blank. **The cells to fill in are highlighted in yellow.**

Item	Targeted question	Data	Unit
Workers	Specify the total number of workers		n
Incidents	Specify the average number of occupational accidents per year		n/year
Gender equality	Are there already existing measures to improve gender equality in your company?		Y-N
	Are you willing to implement measures to improve gender equality?		Y-N
Local employment	Specify the number of local (from the region) workers employed		n
Tax exemptions	Are you benefitting from any tax exemptions for projects you are funding?		Y/N
	Which is the percentage of the tax exemption on your total tax payments?		n
Training	Specify the number of employees trained		n/year
Re-qualification	Specify the number of employees re-qualified		n/year

Item	Targeted question	Professional category	Gender	Data	Unit
Wage	If applicable, specify the average wage per hour per person for each category (see description in the textbox to the right)	Senior level managers			€
		Mid level managers			€
		Professionals			€
		Technicians			€
		Sales Workers			€
		Administrative support workers			€
		Craft workers			€
		Operatives			€
		Laborers and helpers			€
		Service workers			€
		Interns			€
Working hours	If applicable, specify the working hours per week per person (as indicated in the contract)	Senior level managers			h/week
		Mid level managers			h/week
		Professionals			h/week
		Technicians			h/week
		Sales Workers			h/week
		Administrative support workers			h/week
		Craft workers			h/week
		Operatives			h/week
		Laborers and helpers			h/week
		Service workers			h/week
		Interns			h/week
Contract typologies	If applicable, specify the number of fixed term contracts	Senior level managers			n
		Mid level managers			n
		Professionals			n
		Technicians			n
		Sales Workers			n
		Administrative support workers			n
		Craft workers			n
		Operatives			n
		Laborers and helpers			n
		Service workers			n
		Interns			n
	If applicable, specify the number of non fixed term contracts	Senior level managers			n
		Mid level managers			n
		Professionals			n
		Technicians			n
		Sales Workers			n
		Administrative support workers			n
		Craft workers			n
		Operatives			n
		Laborers and helpers			n
		Service workers			n
		Interns			n
	If applicable, specify the number of full time contracts	Senior level managers			n
		Mid level managers			n
		Professionals			n
		Technicians			n
		Sales Workers			n
		Administrative support workers			n
		Craft workers			n
		Operatives			n
		Laborers and helpers			n
		Service workers			n
		Interns			n
	If applicable, specify the number of part time contracts	Senior level managers			n
		Mid level managers			n
		Professionals			n
		Technicians			n
		Sales Workers			n
		Administrative support workers			n
		Craft workers			n
		Operatives			n
		Laborers and helpers			n
		Service workers			n
		Interns			n

Workers Category	Description
Senior-level managers	Chief operating officers, chief executive officers, chief financial officers, chief human resource officers, chief marketing officers
Mid-level managers	Vice presidents, operational managers, marketing managers, financial managers, education Administrators, human resource managers
Professionals	Training and development specialists, financial analysts, insurance underwriters, computer programmers, web developers, chemical engineers, sociologists, lawyers
Technicians	Civil drafters, mechanical engineering technicians
Sales Workers	Retail workers, telemarketers, product promoters, loan officers
Administrative support workers	Paralegals, file clerks, dispatchers, bank tellers, customer service representatives, receptionists
Craft workers	Carpenters, woodworkers, mechanics, electricians, tailors
Operatives	Loading machine operators, engine assemblers, truck drivers, tool grinders, printing press operators, gas plant operators
Laborers and helpers	Landscaping and groundskeeping workers, breeders, carpenter helpers, construction laborers, farm workers, vehicle cleaners
Service workers	Security guards
Interns	Students, trainees, first experience (in the sector) workers

Adapted from: https://resources.workable.com/tutorial/eeo-categories