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CEFoodCycle

Adapting Agri-food Data for Environmental Footprinting in Regional Contexts in the Alpine Region: Part 1 - Agriculture

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Adapting Agri-food Data for Environmental Footprinting in Regional Contexts in the Alpine Region: Part 1 - Agriculture.

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Key Takeaways

01

Standardized regional data collection approaches are needed:

Improving regional data collection and management for environmental footprinting helps businesses and governments make informed decisions for local food system developments.

02

Businesses need to be able to understand environmental assessments:

Enhanced knowledge of Life Cycle Analysis (LCA) helps agri-food businesses evaluate practices, reduce environmental impacts, and meet legal requirements.

03

Existing Data Networks should be used:

Expanding the Farm Accountancy Data Network (FADN) to include environmental data supports Europe-wide use of agricultural data for informed decision-making by businesses and policymakers.

04

Regional approaches to transregional systems have its limitations:

Further research is needed to determine how detailed regional agricultural data should be to effectively apply LCA tools, given the interconnected nature of European food systems.

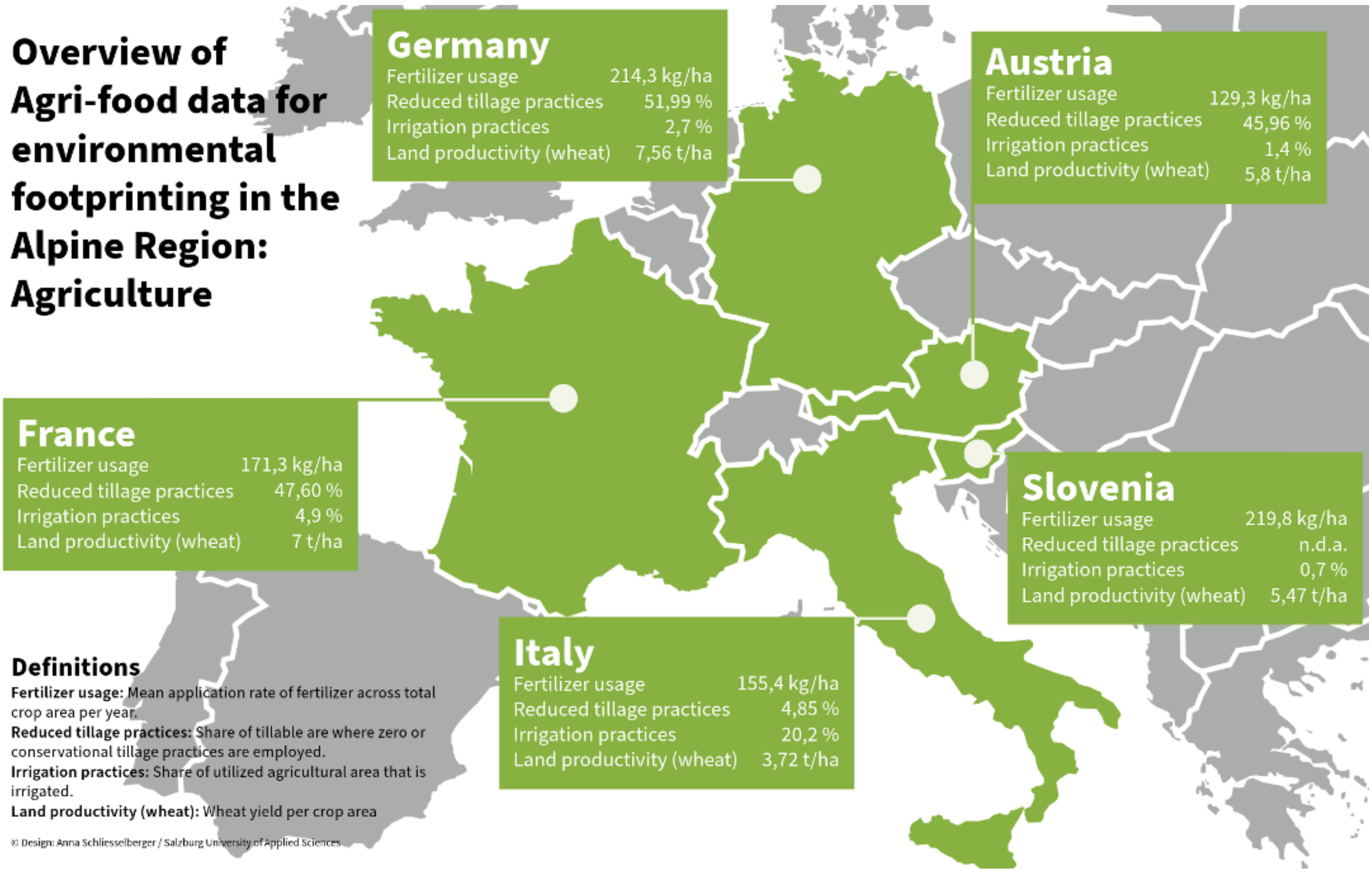

Fig. 1: Overview of agri-food data for environmental footprinting in the Alpine Region: Agriculture.

1. Introduction

On a global scale, one-third of food goes to waste (World Resources Institute, 2020).Food waste remains a critical issue in Europe, with staggering amounts of edible food being discarded at various stages of the supply chain (European Commission, 2019), agriculture being one of these stages. To foster the shift towards a Circular Economy in the agri-food sector, it is not only necessary to show food waste conversion pathways and related trade-offs and opportunities (Santagata et al., 2021) but also to measure the environmental burdens of food loss and waste (Gava et al., 2019). Only then relevant stakeholders are able to strategically tackle existing challenges, draft effective policy, and measure progress (Ibid.). Therefore, the efforts to express food waste and food system emissions in CO_2-emission equivalents and other factors through **Life Cycle Analysis (LCA) methods** have increased in the last decade (Voglhuber-Slavinsky et al., 2022; Kaltenbrunner et al., 2024). Recent EU policies such as the Corporate Sustainability Reporting Directive (CSRD) and the EU-Taxonomy have evoked strong interest in businesses to measure and monitor their environmental burdens (Sala et al., 2021).

This report is written as part of the project CEFoodCycle (2024a) and therefore focuses especially on the Alpine regions in Austria, France, Germany, Italy, and Slovenia. The **Alpine Space region** is a complex economic area with agroecosystems providing a large amount of ecosystem services (Faccioni et al., 2019). The preservation of provisioning services for resources such as food or water as one of them is highly dependent on the environmental burdens of our farming practices. To assess the different practices and contexts within agricultural systems, relevant for environmental footprinting, a comparison of national and regional data was conducted as part of the project CEFoodCycle (2024a). Further data as regards the value chain structure in the five Alpine Space regions and food initiatives / regulations can be found in our report '*Blueprint for an emerging sustainable circular future in the food sector*' (CEFoodCycle, 2024b).

Significant regional differences in environmental impact can be observed, both on national as well as on subnational (Wilting et al., 2021) levels. These regional differences depend on manifold factors such as production practices, local climate, cultural factors or available infrastructure. An exemplary study (Theurl, Haberl et al., 2014) shows that regional production is not always 'better' regarding the emitted greenhouse gases of a product, with tomatoes grown in Austrian heated greenhouses resulting in a higher environmental footprint than imported tomatoes grown in Italy or Spain. At the same time, if organic farming practices were applied, the tables turned in favor of the Austrian tomatoes.

While previous studies have highlighted the global significance of food waste (e.g. United Nations Environment Programme, 2021) and the multiple benefits of transitioning to a Circular Economy (e.g. Ellen MacArthur Foundation, 2024a), there is a lack of detailed analysis focusing on how regional variations in the food value chain impact LCA metrics within the Alpine region. Therefore, we conducted a targeted, mixed-methods investigation with the aim to uncover national differences of key factors responsible for variations in environmental impacts within the agri-food sector in Austria, Germany, Italy, France and Slovenia applicable for LCA assessments. The key findings are made available in this report to support decision makers in the food sector (e.g. managers, policymakers, research institutions).

Furthermore, the findings of this study are used in order to tailor regional differences in the AI LCA-tool that is developed within the project (CEFoodCycle, 2024a). The tool is designed to connect companies to find solutions for their surplus food and food waste and compare them based on LCA metrics.

2. Methodology

The work described here encompasses the explorative research for national and regional differences in agri-food systems and the deduction and attempted quantification of possible impact factors, which could be integrated into LCA market data for the respective Alpine countries. The validation of the suggested factors and the integration into an LCA-tool might reveal more information about the applicability of the selected impact factors. However, this is out of scope for this study within the necessary process for the final integration into LCA-tools (see fig. 2).

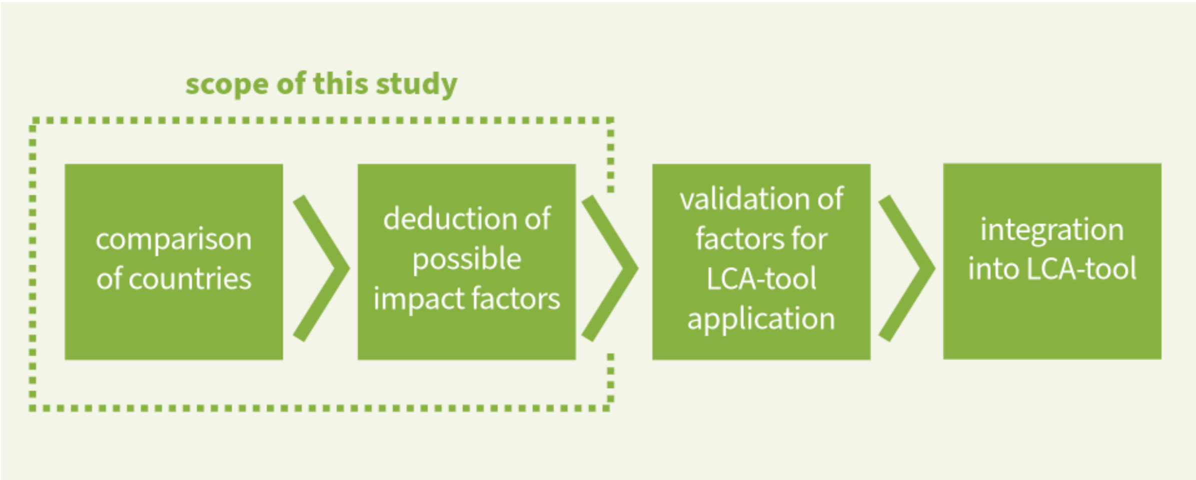

Fig. 2: Scope of this study.

Qualitative Approach

The majority of current LCA studies on agri-food products and processes rely on emission calculations derived from the extensive Agribalyse database, which is based on French market data and accessible free of charge. The international scientific community and governmental agencies are working to adapt the available data from Agribalyse to the context of other countries and regions.

Based on extensive research on national food industry data in the five countries and related food waste (CEFoodCycle, 2024b) as well as on LCA calculations in food streams (Kaltenbrunner et al. 2024), two exploratory interview guidelines were developed: One guideline focused on agricultural challenges and practices, addressing experts within the field of agriculture. The second guideline was established with the intent to gain knowledge on processing and retail, and thereby covering central steps in the food value chain. Specifically, the questions evolved around current practices in and use of key agricultural resources, the commonness of frontrunner methods, regional efficiency, and the existence and implementation of resource-relevant strategies in the food sector.

Feedback on the interview guidelines was collected from the transregional project consortium to make sure it was applicable for the different contexts. Regional agriculture experts, in total 5 experts (3 male, 2 female) from universities, ministries and interest groups in Italy and Slovenia were selected based on their extensive knowledge and experience in the local agricultural sector. The interviews were conducted online between March and May 2024. They were recorded and transcribed in national language and then translated to English to facilitate the following systematic interview analysis.

Quantifying National Differences

Based on the information given by expert interviews, desk research was conducted to find available national data that is relevant for LCA -factors and could be implemented into the structure of existing LCA-tools.

Based on information derived from international comparative studies (e.g. Crippa et al. 2021; Finnegan et al. 2018; Lam et al. 2018), an extensive list of 30 impact categories for both agricultural and processing to retail value-chains was compiled. This catalogue was reduced to a list of 9 factors with the highest environmental relevance (considered aspects: environmental burdens, anticipated national differences, impact on CO_{2eq}-emissions, water use, land use) and promising comparability (considered aspects: measurability, availability). In order to be applicable for the impact factor catalogue, the existing data had to fulfill the following prerequisites:

- availability for at least 4 out of the 5 selected countries
- suitability with the structure of existing LCA databases (e.g. Agribalyse)
- comparability of used methodology in compiling country data

This resulted in four final impact categories: **fertilizer usage, tillage practices, irrigation practices and land productivity.**

Limitations in terms of data availability, differences in sectoral delimitation and additional uncertainty due to extrapolations have to be taken into account. The chosen system boundaries were the nationally procured food for consumption / intermediary products where possible, or the nationally produced food where total consumption data was not available. The factors evaluated were chosen along the food value chain from primary production to the point of sale.

Factors focusing on consumption and private preparation emissions (e.g. gas stove for cooking) were not taken into consideration. The circumstances explaining the observed national differences are out of scope of this study and are not discussed in detail. The authors distance themselves from giving general reasonings for these complex issues.

The work described here encompasses the explorative research for national and regional differences in agri-food systems and the deduction and attempted quantification of possible impact factors, which could be integrated into LCA market data for the respective Alpine countries. The validation of the suggested factors and the integration into an LCA-tool might reveal more information about the applicability of the selected impact factors. However, this is out of scope for this study within the necessary process for the final integration into LCA-tools (see fig. 2).

3. Regional Differences in Environmental Footprints

The five selected countries cover a wide range of food production goods from basic staple foods, over fruits and vegetables, sea and freshwater fish and meat and dairy products to highly processed foods (Eurostat, 2024). The heterogeneity of the selected countries provided a good basis for building a methodology for comparison and a blueprint for eventually extending the scope to other European countries.

The regulatory environment is a major factor influencing food waste management and food waste initiatives and practices (see also CEFoodCycle, 2024b). In Italy, regulations are seen as essential for setting standards but can also be restrictive, limiting the flexibility needed for innovative solutions. Experts call for more adaptive regulatory frameworks that can evolve with emerging technologies and practices. Slovenian experts argue for stronger national legislation that aligns with sustainability goals, suggesting that significant progress can only be made through comprehensive governance.

The chosen quantifiable and LCA-applicable factors for the comparison of the agricultural intensity and different practices between the countries were **fertilizer usage, tillage practices, irrigation practices, and land productivity** (see table 1).

The **fertilizer usage** per hectare differs widely between the observed countries. while Slovenia has the highest usage of 219.8 kg/ha utilised agricultural area, Austria only uses on average only 129.3 kg/ha (including nitrogen (N), phosphate (P_2O_5), and potash (K_2O) fertilizers) (Ludemann et al., 2022). Factors explaining the national differences in chemical fertilizer use include the availability of N in manure, crop uptake, N released by crop residues, and soil and plant characteristics (Jiao et al., 2012; Jordan-Meille et al., 2023).

Experts from the selected regions provided key insights into the common practices, motivations and circumstantial factors for observed differences. For the reduction of fertilizer usage the high purchase price was mentioned as an already limiting factor. In all EU countries the registration of fertilizer usage is mandatory, set into law as put forward in the EU Common Agricultural Policy (CAP) and the Nitrate Directive (Council directive 1991/676/EEC), giving a good quantitative basis to work on plans to implement good practices in the employment of fertilizer. According to experts from Slovenia, national fertilizing practices rely mostly on organic fertilizers. Crop rotation is part of the common agricultural practice according to interviews conducted with experts from Italy and Slovenia. In Italy, the use of species such as alfalfa or clover as cover

Factors for Comparison	**Quantification Method**
Fertilizer usage	mean application rate of nitrogen+P_2O_5+K_2O across total crop area → Mean factor of all given crops (Ludemann et al., 2022)
Tillage practices	share of zero or conservational tillage practices of total tillable area (Eurostat, 2016a)
Irrigation practices	percentage of utilized agricultural area that is irrigated (Eurostat, 2016b)
Land productivity	harvested production per ha for the area under cultivation; product spe-

Table 1: Quantification factors for national differences.

crops on fields where potatoes or cereals are cultivated is prevalent.

Most of the selected countries already employ reduced **tillage practices** (mechanical manipulation of the soil) with reduced tillage or zero tillage practices being employed on 45.96 % to 51.99 % of the total tillable area. ractices of reduced or zero tillage practices are widespread in Austria, Germany, and France (Eurostat, 2016a). Italy uses a reduced tillage approach on 4.85 % of its total tillable area. In Italy and Slovenia, the practice is not as popular (Ibid.). For Slovenia no data was available. (Eurostat, 2016a). However, an interviewed Slovenian expert stated that a cost effective approach is used, since tillage requires tractor fuel, which leads to high costs for augmented tillage practices. Multiple experts mentioned the existing tradeoffs between tillage practices and pesticide use. An expert from Italy puts it this way: *"[...] the rule is: the less you need to spray, the more mechanical work is required."* The main reasons to employ reduced tillage practices are economic, such as higher fuel prices, but also the sizes of farms can play a role (Putte et al, 2010; Townsend, Ramsden & Wilson, 2015). Increasing uptake might require policy intervention (Townsend, Ramsden & Wilson, 2016).

Irrigation practices are very dependent on the climatic circumstances and the types of crops being cultivated. Both Italian and Slovenian experts report a recent increase in irrigation. An expert from Slovenia links this directly to climate change: "*Due to [the] recent change of climate the need for irrigation is becoming evident also in Alpine valleys."* The country specific data on irrigation practices shows that Slovenia has the lowest percentage of irrigated agricultural area per utilized agricultural area with 0.7 %, Austria (1.4 %), Germany (2.7 %) and France (4.9 %) in the mid-range and Italy with the most widespread application of irrigation practices with 20.2 % (Eurostat, 2016b). Differences in irrigation practices are connected to shortages in water supplies, increasing drought frequency, and uncertainties associated with climate change (Monaghan et al. 2013). But also the spatial distribution of irrigated areas and types of crops used play a role (Wriedt et al. 2009).

Land productivity, closely related to the **efficiency of the land used** and therefore the impact on the land use factor in environmental footprinting, differs widely over countries and crops. For the measurement of land productivity the physical outputs of agriculture divided by the agricultural area used for the specific crop were drawn on. Looking at the production of wheat in 2022, Germany gets the most out of its utilized agricultural area with 7.58 t/ha, followed by France (7 t/ha), Austria (5.8 t/ha) and Slovenia (5.47 t/ha). Italy has the lowest productivity with 3.72 t/ha. (FAO, 2023) For an estimation of national differences in land productivity, a mean value over a timespan of multiple years would have to be deducted for each crop to account for climatic differences between years. The comparison between irrigated and rain-fed agricultural areas also has to be considered to implement it into LCA-footprinting tools.

The efficiency of land use for agriculture appears to be differing to a high degree in Italy. Multiple current challenges are described. While the land used for agriculture seems to be decreasing in Italy, the amount of unmanaged land is increasing. While the economic efficiency of the land in South Tyrol for instance is very high, experts are referring to the ecological and social efficiency that is hard to quantify.

4. Conclusion & Recommendations

This text provides a short overview of the regional and national differences in environmental footprints within the agri-food sector across five European countries: Austria, France, Germany, Italy and Slovenia. By combining qualitative insights from expert interviews with quantitative data, the research highlights the significance of localized practices and conditions in determining the environmental impacts of agricultural activities.

Our findings underscore the necessity for more robust and consistent national and regional data collection on agri-food systems. The significant variations in agricultural practices and efficiency, such as fertilizer usage, tillage methods, irrigation and land productivity, point to the critical need for more and better localized data and its integration into databases and tools used for environmental footprinting. Such detailed and context-specific data are essential for accurately reflecting the environmental impacts and for formulating targeted policies and strategies.

The quantification of national differences reveals significant disparities in the input-intensity and productivity of agricultural systems. These differences have direct implications for the environmental burdens associated with agricultural production, emphasizing the need for tailored approaches to sustainable farming. The presented data not only sheds light on the national and regional disparities in factors responsible for varying environmental impacts within the agri-food sector but also provides a methodological blueprint for expanding such assessments to other European countries. By addressing these regional differences, policymakers and businesses can develop more effective strategies to reduce the environmental burdens of agriculture, foster sustainable practices, and contribute to the broader goal of sustainable food systems. Future research should focus on expanding and regionalizing existing datasets, refining conversion factors, and enhancing the applicability of LCA tools to support the continuous improvement of agri-food systems in diverse geographical contexts.

The considerations in this study result in the following recommendations for businesses in the agri-food sector and policymakers:

1) Improve data on regional level through standardized regional data collection and management strategies. This would enable businesses and regional governments to make better informed decisions and get a clearer picture of their local food systems' environmental burdens.

2) Enhance efforts in capacity building for Life Cycle Analysis and Environmental Footprinting in businesses along the agri-food value chain. In-depth knowledge of their mechanisms and applications can help businesses to evaluate their practices, adapt them to alleviate environmental burdens and fulfill upcoming legal obligations.

3) Expansion of the Farm Accountancy Data Network (FADN) to include needed data for environmental footprinting. This would facilitate a Europe-wide use of national and regional data on agricultural production and give researchers crucial information to provide needed insights for businesses and policymakers. Building on an already existing and recognized structure, such as the FADN, can limit costs and time expenditure for farmers and national agencies.

4) Further research needs to be conducted to determine in which granularity regional and local agricultural data can be used to inform LCA-tools. Since European food systems are widely interconnected and only a minor portion of produced food can really be seen as "regional", this begs the question how detailed data needs to be, in order to be useful for application in environmental footprinting studies. Future research should focus on expanding the dataset and refining the conversion factors to enhance the accuracy and applicability of LCA in diverse geographical contexts.

5. Where to get started for LCA?

- ☐ Understand LCA analysis (Kaltenbrunner et al. 2024)
- ☐ Read ISO guidelines: ISO 14044:2006, ISO 14040:2006
- ☐ Take educational courses & sign up for (online) seminars
- ☐ Study case studies, e.g. on the European Platform on LCA (2024), and guidelines, e.g. Life Cycle Assessment for the circular economy (Ellen MacArthur Foundation, 2024b)
- ☐ Look through LCA tools, e.g. Agribalyse, a database covering a wide range of data about food, agriculture and related factors based on products available in French supermarkets.
- ☐ Cooperate with experts to learn to use LCA software tools (SimaPro, Umberto, Open LCA)
- ☐ Find partners, e.g. with vcg.ai, which uses a data approach to generate meaningful value chains and to implement circular business models. It is a tool to identify specific industry solutions and possible partners.

References

Agribalyse (2024). Homepage. https://agribalyse.ademe.fr/app (accessed 11.07.2024)

CEFoodCycle (2024a). Circular Economy: Mapping Food Streams and Identifying Potentials to Close the Food Cycle. Interreg Alpine Space project. https://www.alpine-space.eu/project/cefoodcycle/(accessed 13.07.2024).

CEFoodCycle (2024b). Blueprint for an emerging sustainable circular future in the food sector. Output 1.2. Part of the Interreg Alpine Space Project CEFoodCycle. Salzburg University of Applied Sciences, Salzburg / Puch, January 2024. https://www.alpine-space.eu/wp-content/uploads/2024/07/O.1.2-Whitepaper-final.pdf

Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Communities, L 375, 1-8. http://data.europa.eu/eli/dir/1991/676/2008-12-11

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. J. N. F. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. Nature food, 2(3), 198-209.

Dietrich, J. P., Schmitz, C., Müller, C., Fader, M., Lotze-Campen, H., & Popp, A. (2012). Measuring agricultural land-use intensity–A global analysis using a model-assisted approach. Ecological Modelling, 232, 109-118.

Ellen MacArthur Foundation (2024a). What is a Circular Economy? https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview (accessed 03.07.2024).

Ellen MacArthur Foundation (2024b). Life Cycle Assessment for the circular economy. https://www.ellenmacarthurfoundation.org/life-cycle-assessment-for-the-circular-economy (accessed 11.07.2024).

European Commission (2019). Redistribution of surplus food: Examples of practices in the Member States. Saving food together. EU Platform on Food Losses and Food Waste. https://food.ec.europa.eu/system/files/2019-06/fw_eu-actions_food-donation_ms-practices-food-redis.pdf (accessed 26.06.2024).

Eurostat (2016a). Agricultural Practices. eurhttps://ec.europa.eu/eurostat/databrowser/view/ef_mp_prac/default/table?lang=enopa.eu (accessed 26.06.2024).

Eurostat (2016b). Share of irrigable and irrigated areas in utilised agricultural area (UAA) by NUTS 2 regions. https://ec.europa.eu/eurostat/databrowser/view/aei_ef_ir/default/table?lang=en (accessed 26.06.2024).

Eurostat (2024). Section: Agriculture, forestry and fisheries. https://ec.europa.eu/eurostat/databrowser/explore/all/all_themes (accessed 15.06.2024)

European Platform on LCA (2024). Homepage. https://eplca.jrc.ec.europa.eu/ (accessed 11.07.2024).

Faccioni, G., Sturaro, E., Ramanzin, M., & Bernués, A. (2019). Socio-economic valuation of abandonment and intensification of Alpine agroecosystems and associated ecosystem services. Land use policy, 81, 453-462.

Finnegan, W.; Yan, M.; Holden, N.; Goggins, J. (2018): A review of environmental life cycle assessment studies examining cheese production. In: The International Journal of Life Cycle Assessment 23 (9), 1773–1787. DOI: 10.1007/s11367-017- 1407-7.

FAO (2023).Production / Crops and livestock products - Metadata. Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat/en/#data/QCL/metadata (accessed 27.06.2024).

Gava, O., Bartolini, F., Venturi, F., Brunori, G., Zinnai, A., & Pardossi, A. (2019). A reflection of the use of the life cycle assessment tool for agri-food sustainability. Sustainability, 11(1): 71.

ISO 14044:2006 (2022). Environmental management. Life cycle assessment. Requirements and guidelines. https://www.iso.org/standard/38498.html (accessed 26.06.2024).

ISO 14040:2006 (2022). Environmental management. Life cycle assessment. Principles and framework. https://www.iso.org/standard/37456.html (accessed 26.06.2024).

Jiao, W., Chen, W., Chang, A., & Page, A. (2012). Environmental risks of trace elements associated with long-term phosphate fertilizers applications: a review.. Environmental pollution, 168, 44-53 . https://doi.org/10.1016/j.envpol.2012.03.052.

Jordan-Meille, L., Denoroy, P., Dittert, K., Cugnon, T., Quemada, M., Wall, D., Bechini, L., Marx, S., Oenema, O., Reijneveld, A., Liebisch, F., Diedhiou, K., Degan, F., & Higgins, S. (2023). Comparison of nitrogen fertilisation recommendations of West European Countries. European Journal of Soil Science, 74. https://doi.org/10.1111/ejss.13436.

Kaltenbrunner, K., Orth, D., Pladerer, C., Menedetter, V. (2024). Comparability of Life Cycle Analysis Studies on Food Waste and Food Products. A Review on the current Status of Food Waste Life Cycle Analysis and the used Methodology (Deliverable D1.1.1). Part of the Interreg Alpine Space Project CEFoodCycle. Österreichisches Ökologie-Institut, Vienna and Salzburg University of Applied Sciences, Salzburg / Puch, January 2024 https://www.alpine-space.eu/wp-content/uploads/2024/01/D1.1.1-20240125-Final-1.pdf (accessed 11.07.2024)

Lam, C.; Yu, I.; Hsu, S.; Tsang, D. (2018): Lifecycle assessment on food waste valorisation to valueadded products. In: Journal of Cleaner Production 199, 840–848. DOI: 10.1016/j.jclepro.2018.07.199.

Ludemann, C.I., Gruere, A., Heffer, P. et al. (2022). Global data on fertilizer use by crop and by country. Sci Data 9, 501. https://doi.org/10.1038/s41597-022-01592-z (accessed 27.06.2024).

Monaghan, J., Daccache, A., Vickers, L., Hess, T., Weatherhead, E., Grove, I., & Knox, J. (2013). More 'crop per drop': constraints and opportunities for precision irrigation in European agriculture. Journal of the science of food and agriculture, 93 5, 977-80. https://doi.org/10.1002/jsfa.6051.

Putte, A., Govers, G., Diels, J., Gillijns, K., & Demuzere, M. (2010). Assessing the effect of soil tillage on crop growth: A meta-regression analysis on European crop yields under conservation agriculture. European Journal of Agronomy, 33, 231-241. https://doi.org/10.1016/J.EJA.2010.05.008.

Sala, S., Amadei, A. M., Beylot, A., & Ardente, F. (2021). The evolution of life cycle assessment in European policies over three decades. The International Journal of Life Cycle Assessment, 26, 2295-2314.

Santagata, R., Ripa, M., Genovese, A., & Ulgiati, S. (2021). Food waste recovery pathways: Challenges and opportunities for an emerging bio-based Circular Economy. A systematic review and an assessment. Journal of Cleaner Production, 286, 125490.

Theurl, M. C., Haberl, H., Erb, K. H., & Lindenthal, T. (2014). Contrasted greenhouse gas emissions from local versus long-range tomato production. Agronomy for sustainable development, 34, 593-602.

Townsend, T., Ramsden, S., & Wilson, P. (2015). How do we cultivate in England? Tillage practices in crop production systems. Soil Use and Management, 32, 106 - 117. https://doi.org/10.1111/sum.12241.

Townsend, T., Ramsden, S., & Wilson, P. (2016). Analysing reduced tillage practices within a bio-economic modelling framework. Agricultural Systems, 146, 91 - 102. https://doi.org/10.1016/J.AGSY.2016.04.005.

United Nations Environment Programme (2021). Food Waste Index Report 2021. Nairobi.https://www.unep.org/resources/report/unep-food-waste-index-report-2021 (accessed 03.07.2024).

vcg.ai (2024). Homepage. https://vcg.ai/ (accessed 11.07.2024).

Voglhuber-Slavinsky, A., Zicari, A., Smetana, S., Moller, B., Dönitz, E., Vranken, L., Zdravkovic, M., Aganovic, K. & Bahrs, E. (2022). Setting life cycle assessment (LCA) in a future-oriented context: the combination of qualitative scenarios and LCA in the agri-food sector. European Journal of Futures Research, 10(1), 15.

Wilting, H. C., Schipper, A. M., Ivanova, O., Ivanova, D., & Huijbregts, M. A. (2021). Greenhouse gas and land-based biodiversity footprints in the European Union. Journal of Industrial Ecology, 25(1), 79-94.

World Resources Institute (2020). SDG Target 12.3 on food loss and waste: 2020 progress report. https://food.ec.europa.eu/system/files/2021-04/fw_lib_wri-sdg-target_2020.pdf (accessed 26.06.2024).

Wriedt, G., Velde, M., Aloe, A., & Bouraoui, F. (2009). Estimating irrigation water requirements in Europe. Journal of Hydrology, 373, 527-544. https://doi.org/10.1016/J.JHYDROL.2009.05.018.

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