

# SUPPLEMENTARY INFORMATION B

## Social life cycle assessment in current and future Norwegian livestock production

### Description of indicators

The indicators were developed using the UNEP methodological Sheets (UNEP, 2021) as a starting point. For some of the subcategories it was challenging to establish applicable indicators and associated data. This particularly applies to the newly introduced subcategories which have not yet been used in social LCA studies. The indicators are described below for each stakeholder group.

#### Workers

For *workers*, the subcategories ‘freedom of association and collective bargaining’, ‘fair salary’, ‘working hours in accordance with current regulations’, ‘equal opportunities’ were based on data from International Labour Organization (ILO). ‘Equal opportunities’ was additionally measured by an indicator measuring the share of female farmers based on data from Statistics Norway. For ‘child labour’, the sustainable development goals (SDG) dashboards (Sachs et al., n.d.) were used as inventory, whereas ‘forced labour’ used the Global Slavery Index. The subcategory ‘health and safety’ was composed of indicators for occupational accidents, sickness absence and mental health. Occupational accidents and sickness absence were based on domestic statistics because the data from ILO stat were inconsistent. Both indicators are important, as animal farming is associated with a high risk of accidents and exposure to dust that can lead to respiratory diseases (Logstein et al., 2023; Sigsgaard et al., 2020; Viegas et al., 2013). Mental health was built on regional data using three indicators: Depression subscale for women and men from the Hospital Anxiety and Depression Scale (HADS) in the Nord-Trøndelag Health Study, 2006–2008 (Torske et al., 2016) and results from a survey among Norwegian farmers (Logstein et al., 2023). The indicators were distributed according to the occupational accidents accounting for 50%, whereas sickness absence and mental health accounted for 25% each. This is to avoid duplicate counting for sickness absence linked to mental health.

For the subcategory ‘employment relationship’, it was not possible to find relevant data. National statistics were available for ‘sexual harassment’ (Bufdir, n.d.). The subcategory ‘conditions for smallholders including farmers’, was assessed by using the detailed level of Global Food Security Index (Economist Impact, 2022) for ‘access to agricultural input’.

#### Local community

‘Cultural heritage’ is primarily linked to food and agriculture, through craft and food traditions, buildings, and cultural landscapes. The data for domestic subsidies for safeguarding cultural objects and the cultural landscapes in agriculture was used for this subcategory, given that subsidies are a significant instrument of safeguarding landscape values not directly linked to production. ‘Safe and secure living conditions’ includes protection of public health and safety in surrounding communities, which can be difficult to quantify and link to food production. Therefore, pesticide use per hectare was specifically used as suggested by Zira et al (2020), since a

large amount of pesticide can lead to an increased risk of exposure in the immediate area, in addition to how pesticide residues can be found in locally produced foods. In addition, the disaster risk management and food safety from the Global Food Security Index (Schwab, 2017) were used as indicators for this subcategory. ‘Local employment’ was assessed by the two indicators local supplier quantity and quality, obtained from the Global Competitiveness Index. The indices assume that organisations developing relationships with locally based suppliers will further encourage local employment and development.

## Society

The data from country level indices from the Global Food Security Index (Economist Impact, 2022), Corruption perception Index (Transparency International, n.d.) and SDG dashboards (Sachs et al., n.d.) were used for ‘public commitments sustainability’, ‘corruption’, and ‘poverty alleviation’, respectively.

‘Ethical treatment of animals’ is one of the new subcategories in the guidelines (UNEP, 2020, 2021). In this study, it was rephrased to ‘animal welfare’, because it was considered a more relevant wording. There is not yet consistency for the integration of animal welfare into LCA, in fact in literature it is most often linked to environmental LCA (Lanzoni et al., 2023; Tallentire et al., 2019). There are several ways to assess ‘animal welfare’, e.g. based on legislation, market initiatives (Sandøe et al., 2022), and measuring actual welfare through observations. Legislation and regulations are important for assessing animal welfare at an overall national level, but there is still no guarantee that these are followed. Market initiatives will often have stricter requirements than the regulation and are aimed at specific productions and products. Actual observed animal welfare can include several factors such as health condition, physiological measurements, behaviour and descriptions of the animals’ environment. Existing assessment tools such as Welfare Quality (Blokhuys et al., 2018) can give a detailed assessment a herd level, but it is very demanding to collect the data and is therefore not suitable for an overall country-based welfare assessment.

In this study, EU conditions were used as a reference because it is the most relevant option for imports. Stocking density was used as indicators for all animal species and was evaluated based on regulations and requirements for each species of animal (EU Directive, 2019a, 2019b; Mattilsynet, 2022; Norwegian Food and Agricultural Ministry, 2017, 2020) and EFSA reports on welfare of pigs (2022), broiler (2023), laying hens (2023) and calves (2023). The regulations do not describe the actual conditions, but still provide a clear minimum requirement. For dairy cows, there was no provision for stocking density and therefore the share of dairy cows on pasture (van den Pol-van Dasselaar et al., 2020) and loose housing was used, based on EFSA welfare of dairy cows (2023). Inventory data for domestic livestock production was based on national reporting (Animalia, 2020; Ingris, 2021). Mortality rates for each animal species were also considered as relevant indicators, but there were no statistical data for European countries was available for preparing a reference scale. Based on this review of possible indicators with associated data, one indicator was used for pigs, broilers and laying hens respectively, whereas for ruminants, there was one indicator for calves and two indicators for dairy cows. The final indicator for animal welfare for the livestock production was calculated as an average for ruminants, which were then included in a weighted average with the other indicators, based on the distribution of the protein content in the livestock products.

‘Food security’ was assessed by two indicators i.e., the Global Food Security Index and the self-sufficiency ratio. The overall score of the Global Food Security Index measures food affordability, availability, quality and safety,

sustainability and adaptation. The self-sufficiency ratio is computed as the ratio of domestic production to domestic consumption, which considers imports and exports (FAO & Clapp, 2015). The self-sufficiency ratio is focusing on a country's capacity for food production, yet countries that are self-sufficient may still specialise their food production and both export and import food (Clapp, 2017). Puma et al. (2015) have defined a scale for the self-sufficiency ratio that ranges from 0.2-1.6, and this scale was used for defining the reference scale for this indicator.

## Value chain actors

For the stakeholder group *value chain actors*, the subcategory 'fair competition' was limited to wholesale and retail, and was assessed by using the market concentration quantified by the Herfindahl-Hirschman Index (Rhoades, 1993), with a scale from 0 to 10,000, where values lower than 1,000 indicates that the market is not concentrated, and the highest value indicates that one part has 100 % market share (Norwegian Ministry of Trade, 2020). The subcategory 'promoting social responsibility' contains many of the same elements that are included in other subcategories, e.g., labour rights, health and safety, property rights and access to natural resources, according to the 'Guidance for Responsible Agricultural Supply Chains' (OECD et al., 2016). The subcategory was evaluated by one international and one domestic indicator: 1) A hotspot analysis of oilseeds including soybeans in Brazil, based on the Social Hotspot database (Benoit Norris et al., 2019), shows that 'property rights' is one of the subcategories that has a low performance not covered by the other subcategories. Soybean production was therefore used as an example to include property rights as an indicator for 'promoting social responsibility' for the life cycle step of imported feed, and 2) The life cycle step for food industry, where their reporting on social responsibility was used as an indicator by reviewing the websites of several domestic food industries.

The result for 'supplier relationship' was based on a survey among suppliers regarding the fairness, predictability, and loyalty in the collaboration between suppliers and supermarket chains. The survey has been initiated by a supervisory authority which is established to enforce the Act on Good Trading Practices in the grocery market (Dagligvaretilsynet, 2022). 'Wealth distribution' was specified and renamed 'distribution of income between suppliers and grocery market' and was assessed by the ratio of changes in the producer price index compared to the consumer price index.

## Consumers

For *consumers*, 'health and safety' was assessed by using antimicrobial agents for food-producing livestock. The data for the subcategory 'transparency about working conditions and sustainability' was based on The Sustainable Brand Index (SB Insight, 2020), which is a combination of both environmental and social responsibility, based on the definition of sustainability according to the UN Sustainable Development Goals. 'End-of-life responsibility' was in this study specified to front-of-pack information about recycling of packaging and how to avoid food waste. This indicator was assessed by reviewing selected relevant product packaging in retail for this information.

## Children

The stakeholder group *children* had only one subcategory 'children's concerns regarding marketing practices'. Children are a vulnerable group which must be protected against marketing particularly aimed at them. In Norway, the marketing of unhealthy food and drink to children and young people is restricted through a self-

regulated, industry-led committee (Matbransjens Faglige Utvalg, n.d.). Therefore, according to good and responsible marketing practices, it is not acceptable to market unhealthy foods to children. Systematic mapping of this has been carried out (Bugge & Rosenberg, 2016) and the report was used as a basis for the assessment of this indicator.

## References

- Animalia. (2020). Kjøttets tilstand 2020 - Status i norsk kjøtt- og eggproduksjon (Status in Norwegian meat and egg production 2020). <https://www.animalia.no/contentassets/8516b3a48201409297db211f33bf6c76/kt20-komplett-origi-web.pdf>. Accessed 15 Aug 2023
- Benoit Norris, C., Bennema, M., & Norris, G. A. (2019). The Social Hotspots Database. Supporting documentation. Update 2019 (V4). <https://nexus.openlca.org/ws/files/23286>. Accessed 15 June 2023
- Blokhuis, H., Veissier, I., Miele, M., Dalmau, A., & Jones, B. (2018). Welfare Quality Network. <http://www.welfarequality.net/en-us/home/>. Accessed 15 June 2023
- Bufdir. (n.d.). Utsatthet for vold og kjønnsforskjeller. [https://www2.bufdir.no/Statistikk\\_og\\_analyse/kjonnslikestilling/Vold\\_og\\_kjonn/Utsatthet\\_for\\_vold/](https://www2.bufdir.no/Statistikk_og_analyse/kjonnslikestilling/Vold_og_kjonn/Utsatthet_for_vold/). Accessed 29 June 2023
- Bugge, A. B., & Rosenberg, T. G. (2016). Systematisk kartlegging av reklame for usunn mat og drikke rettet mot barn og unge på TV og internett (Systematic mapping of advertising for unhealthy food and drink aimed at children and young people on TV and the internet). <https://hdl.handle.net/20.500.12199/929>. Accessed 15 May 2023
- Clapp, J. (2017). Food self-sufficiency: Making sense of it, and when it makes sense. *Food Policy*. <https://doi.org/10.1016/j.foodpol.2016.12.001>
- Dagligvaretilsynet. (2022). Undersøkelsen om samarbeidsklima 2022. <https://www.dagligvaretilsynet.no/aktuelt>. Accessed 15 May 2023
- Economist Impact. (2022). Global Food Security Index 2022. 11th edition. <https://impact.economist.com/sustainability/project/food-security-index> Accessed 5 July 2023
- EFSA AHAW Panel, Nielsen, S. S., Alvarez, J., Bicot, D. J., et al (2023). Welfare of dairy cows. *EFSA Journal*. <https://doi.org/10.2903/j.efsa.2023.7993>
- EFSA AHAW Panel, Nielsen, S. S., Alvarez, J., Bicot, D. J., Calistri, P., Canali, E. et al (2023). Welfare of laying hens on farm. *EFSA Journal*. <https://doi.org/10.2903/j.efsa.2023.7789>
- EFSA AHAW Panel, Nielsen, S. S., Alvarez, J., Bicot, D. J., Calistri, P., Canali, E. et al (2023). Welfare of broilers on farm. *EFSA Journal*. <https://doi.org/10.2903/j.efsa.2023.7788>
- EFSA AHAW Panel, Nielsen, S. S., Alvarez, J., Bicot, D. J., Calistri, P., Canali, E. et al (2022). Welfare of pigs on farm. *EFSA Journal*. <https://doi.org/10.2903/j.efsa.2022.7421>
- EFSA AHAW Panel, Welfare, A., Nielsen, S. S., Alvarez, J., Bicot, D. J., Calistri, P. et al (2023). Welfare of calves. *EFSA Journal*. <https://doi.org/10.2903/j.efsa.2023.7896>
- EU Directive (2019a). Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production, Document 02007L0043-20191214 C.F.R.. <http://data.europa.eu/eli/dir/2007/43/2019-12-14>. Accessed 20 June 2023
- EU Directive. (2019b). Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs. <https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32008L0120>. Accessed 20 June 2023
- FAO, & Clapp, J. (2015). The State of Agricultural Commodity Markets 2015-16. Food self-sufficiency and international trade: a false dichotomy? <https://www.fao.org/3/i5222e/i5222e.pdf>. Accessed 12 July 2023
- Ingris. (2021). *Ingris Årsstatistikk 2020 (Annual pig production statistic 2020)*. <https://www.animalia.no/contentassets/aad3a2af83fb4029babe7a5707009b75/arsstatistikk-2020-007---endelig.pdf>. Accessed 10 May 2023
- Lanzoni, L., Whatford, L., Atzori, A. S., Chincarini, M., Giammarco, M., Fusaro, I., & Vignola, G. (2023). Review: The challenge to integrate animal welfare indicators into the Life Cycle Assessment. *Animal*. <https://doi.org/10.1016/j.animal.2023.100794>
- Logstein, B., Winsvold, A., Arnes, H., & Hvaleby, B. (2023). Helse, miljø og sikkerhet i landbruket. Resultater fra en spørreundersøkelsen blant norske bønder i 2022 (ISSN 2704-0208). [https://bygdeforskning.wpenginpowered.com/wp-content/uploads/2023/03/r-1\\_23-hms-kartleggingen-2022-b--logstein-a--winsvold-h--arnes-b--hvaleby-1.pdf](https://bygdeforskning.wpenginpowered.com/wp-content/uploads/2023/03/r-1_23-hms-kartleggingen-2022-b--logstein-a--winsvold-h--arnes-b--hvaleby-1.pdf). Accessed 28 June 2023
- Matbransjens Faglige Utvalg. (n.d.). Matbransjens Faglige Utvalg. <https://mfu.as/> Accessed 28 Aug 2023
- Mattilsynet. (2022). *Regelverksveileder. Økologisk landbruk. Utfyllende informasjon om regelverket for økologisk landbruksproduksjon (Regulations guide. Organic agriculture. Additional information on the*

- regulations for organic agricultural production*).  
[https://www.mattilsynet.no/om\\_mattilsynet/gjeldende\\_regelverk/veiledere/veileder\\_for\\_okologisk\\_landbruk.2651/binary/Veileder%20for%20%C3%B8kologisk%20landbruk](https://www.mattilsynet.no/om_mattilsynet/gjeldende_regelverk/veiledere/veileder_for_okologisk_landbruk.2651/binary/Veileder%20for%20%C3%B8kologisk%20landbruk). Accessed 28 June 2023
- Forskrift om hold av høns og kalkun (Regulations on the keeping of chickens and turkeys), FOR-2001-12-12-1494 C.F.R. (2017).
- Forskrift om hold av svin (Regulations on the keeping of pigs), FOR-2003-02-18-175 C.F.R. (2020).
- Norwegian Ministry of Trade (2020). Meld. St. 27 (2019 – 2020) Daglegvare og konkurranse – kampen om kundane (Retail and competition - the fight for customers).  
<https://www.regjeringen.no/no/dokumenter/meld.-st.-27-20192020/id2714670/?q=konkurranseituasjonen%20dagligvaresektoren>. Accessed 26 April 2023
- OECD, Food, & Nations (2016). *OECD-FAO Guidance for Responsible Agricultural Supply Chains*.  
<https://doi.org/10.1787/9789264251052-en>
- Puma, M. J., Bose, S., Chon, S. Y., & Cook, B. I. (2015). Assessing the evolving fragility of the global food system. *Environ. Res. Lett.* <https://doi.org/10.1088/1748-9326/10/2/024007>
- Rhoades, S. A. (1993). The herfindahl-hirschman index. *Fed. Res. Bull.*, 79, 188.
- Sachs, J. D., Kroll, C., Lafortune, G., Fuller, G., & Woelm, F. (n.d.). Sustainable development report.  
<https://dashboards.sdgindex.org/map>. Accessed 25 Aug 2023
- Sandøe, P., Hansen, H. O., Forkman, B., van Horne, P., Houe, H., de Jong, I. C. et al (2022). Market driven initiatives can improve broiler welfare – a comparison across five European countries based on the Benchmark method. *Poult. Sci.* <https://doi.org/10.1016/j.psj.2022.101806>
- SB Insight. (2020). Official Report 2020 Norway. <https://www.sb-index.com/norway>. Accessed 10 Aug 2023
- Sigsgaard, T., Basinas, I., Doekes, G., de Blay, F., Folletti, I., Heederik, D. et al (2020). Respiratory diseases and allergy in farmers working with livestock: a EAACI position paper. *Clin. Transl. Allergy*.  
<https://doi.org/10.1186/s13601-020-00334-x>
- Schwab, K. (2017). The Global Competitiveness report 2017-2018. <https://www.weforum.org/reports/the-global-competitiveness-report-2017-2018/>. Accessed 13 Aug 2023
- Tallentire, C. W., Edwards, S. A., Van Limbergen, T., & Kyriazakis, I. (2019). The challenge of incorporating animal welfare in a social life cycle assessment model of European chicken production. *Int J LCA*.  
<https://doi.org/10.1007/s11367-018-1565-2>
- Torske, M. O., Hilt, B., Glasscock, D., Lundqvist, P., & Krokstad, S. (2016). Anxiety and Depression Symptoms Among Farmers: The HUNT Study, Norway. *J. Agromedicine*.  
<https://doi.org/10.1080/1059924X.2015.1106375>
- Transparency International. (n.d.). Corruption Perceptions Index. <https://www.transparency.org/en/cpi/2022>. Accessed 15 Aug 2023
- UNEP. (2020). Guidelines for Social Life Cycle Assessment of Products and Organizations 2020. Retrieved from <https://www.lifecycleinitiative.org/wp-content/uploads/2021/01/Guidelines-for-Social-Life-Cycle-Assessment-of-Products-and-Organizations-2020-22.1.21sml.pdf>. Accessed 10 Mar 2023
- UNEP. (2021). Methodological Sheets for Subcategories in Social Life Cycle Assessment (S-LCA ) 2021.  
[https://www.lifecycleinitiative.org/wp-content/uploads/2021/12/Methodological-Sheets\\_2021\\_final.pdf](https://www.lifecycleinitiative.org/wp-content/uploads/2021/12/Methodological-Sheets_2021_final.pdf). Accessed 10 Mar 2023
- van den Pol-van Dasselaar, A., Hennessy, D., & Isselstein, J. (2020). Grazing of Dairy Cows in Europe—An In-Depth Analysis Based on the Perception of Grassland Experts. *Sustainability*.  
<https://doi.org/10.3390/su12031098>
- Viegas, S., Faísca, V. M., Dias, H., Clérigo, A., Carolino, E., & Viegas, C. (2013). Occupational Exposure to Poultry Dust and Effects on the Respiratory System in Workers. *J. Toxicol. Environ. Health*.  
<https://doi.org/10.1080/15287394.2013.757199>
- Zira, S., Rööös, E., Ivarsson, E., Hoffmann, R., & Rydhmer, L. (2020). Social life cycle assessment of Swedish organic and conventional pork production. *Int J LCA*. <https://doi.org/10.1007/s11367-020-01811-y>