Environmental Impacts of Livestock production

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Post-workshop summary of impacts

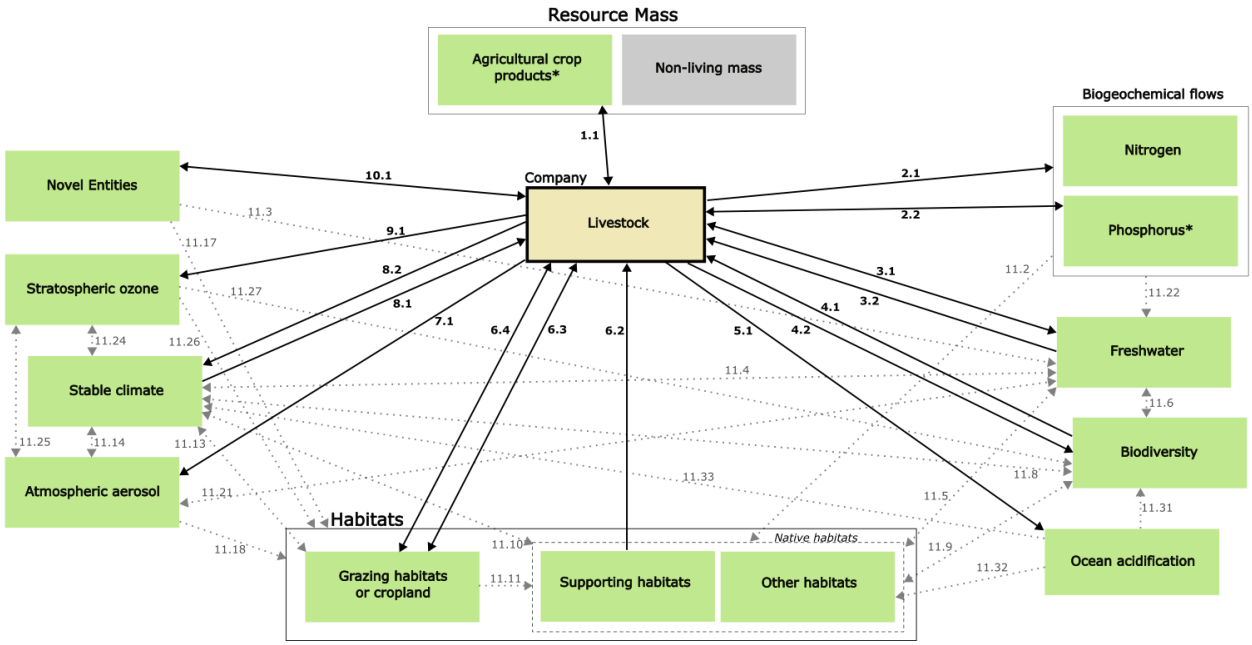

Figure 1. Conceptual systems diagram showing potential interactions between a company (yellow box) and various environmental dimensions. Dimensions are based on processes captured by the planetary boundaries framework, with the addition of natural resources. Solid lines represent direct impacts and/or dependencies of the company on various environmental dimensions. Dashed lines represent interactions between environmental dimensions. Viewed together, solid, and dashed lines represent the indirect impacts and dependencies of the company. Numbers refer to Tables 2 and 3 in this document. Boxes are shaded depending on if mechanistic links (i.e. arrows) are present (green) or not (grey).

Table 1. Direct environmental impacts and dependencies of livestock sector, shown as solid lines in figure 2. Links between a company operating in this industry, and the different environmental dimensions, are visually represented in Figure 1. References are numbered, 'W' indicates data from the expert elicitation workshop.

No.	Category	Sub-category	Impact, Dependency or Both	Description of Mechanisms	References
1.1	Resource mass	Living biomass	Both	Use of living biomass, e.g. agricultural crop products as feed	1
2.1	Biogeochemical flows	-	Impact	Effluent discharge can disrupt biogeochemical cycles and cause nutrient pollution, e.g. run-off from pig, poultry, beef and dairy farms (including from manure) causes nutrient pollution in water bodies	1, W
2.2	Biogeochemical flows	Phosphorus	Both	Dependency on finite mined phosphorus resource in phosphate feed for pigs and poultry. The impacts are both due to pollution from farms via manure and the effect of mining P on the environment. However, there is a trade-off because if phosphates are not added to diet, production could get worse and nutrient excretions could increase.	W
3.1	Freshwater	-	Both	Dependency on freshwater use – pig, poultry, beef and dairy production has a significant water footprint, mainly due to production of feed. However, some types of animal feed (e.g. pasture) mainly use rainwater. (Water used to grow corn or soy for feed is captured in 'Agricultural crop products.')	1, W
3.2	Freshwater	-	Dependency	Dependency on good water quality.	1
4.1	Biodiversity	-	Dependency	Dependencies based on biodiversity, e.g. disease control, genetic material in the production animals	1
4.2	Biodiversity	-	Impact	Direct impacts on biodiversity, e.g. intensive mono-breed farming reduces genetic diversity. However, certain types of production could benefit biodiversity, e.g. cattle which graze levels of grass in particular patterns.	2
5.1	Ocean acidification	-	Impact	Emissions of CO_2 increase the acidity of surface seawater	3
6.2	Habitats	Supporting habitats	Dependency	Dependencies on supporting habitats, e.g. filtration, buffering and erosion control, bioremediation and flood and storm protection	1
6.3	Habitats	Appropriated habitats	Both	Dependencies on appropriated habitats where grazing and crop production habitats provide feed for livestock and require good soil quality. Impacts on appropriated habitats depends on practices, e.g. overgrazing leads to soil compaction and degradation and monocultures with annual crops leads to poorer biodiversity and soil quality	1, 4, W
6.4	Habitats	Appropriated habitats	Dependency	Use of space of appropriated habitats. This often leads to land use change, which negatively impacts native habitats.	1

7.1	Atmospheric aerosol	-	Impact	Release of atmospheric aerosols, e.g. emissions of ammonia (NH_3) and nitrogen oxides contribute to formation of secondary particulate matter ($PM_{2.5}$) and tropospheric ozone, with impacts on air quality.	5
8.1	Stable climate	-	Dependency	Climate regulation provides favorable conditions for production. Both feed production, whether imported or self-produced, and animal productivity are negatively affected under climate change, e.g. extreme weather (dry periods) cause effects on harvests, and make livestock systems less efficient with poorer feed or nutrient utilization. In extreme heat cattle may not get pregnant or eat enough, emissions increase relative to production.	1, W
8.2	Stable climate	-	Impact	GHG emissions, e.g. CO_2, CH_4, N_2O. CH_4 is a byproduct of digestion via enteric fermentation, N_2O is produced from nitrification/denitrification of manure and urine, CO_2 emissions result from energy use, production of feed and fertilizers, and indirect emissions from land, specifically deforestation and desertification from livestock grazing.	1, 6, W
9.1	Stratospheric ozone	-	Impact	Nitrification/denitrification of manure and urine releases N_2O, which is the dominant ozone-depleting substance emitted in the 21st century. It decomposes in the stratosphere to form nitrogen oxides (NO_x), which catalyze ozone destruction.	6, 7
10.1	Novel entities	-	Both	Inputs of novel entities, e.g. synthetic hormones, veterinary antimicrobials. Many pollutants are associated with large-scale animal production, including due to animal feed practices, many of which are excreted with animal waste e.g. bacteria, antibiotic-resistant bacteria, prions, arsenicals, dioxins, hormones, ammonia, heavy metals.	8, 9

Table 2. Interactions between environmental processes relevant to livestock sector, shown as dashed lines in figure 1. Links are visually represented in Figure 1. References are numbered, 'W' indicates data from the expert elicitation workshop.

No.	Categories	Description of Mechanisms	References
11.2	Biogeochemical flows, Habitats (Native)	Nutrient runoff causes eutrophication, hypoxia and/or soil pollution in native habitats	10
11.3	Freshwater, Novel entities	Release of novel entities causes freshwater pollution e.g. herbicides, pesticides, nutrients, heavy metals	8, 11
11.4	Freshwater, Stable climate	Interactions between climate and hydrological cycle. Climate change has driven detectable changes in the global water cycle, including intensification of both heavy precipitation events and droughts, when those occur.	10
11.5	Freshwater, Habitats (Native)	Interactions between native habitats and water cycle and quality, e.g. nutrient pollution from livestock production to surface waters degrades aquatic ecosystems, causing eutrophication in rivers, lakes, estuaries and coastal oceans.	10
11.6	Freshwater, Biodiversity	Interactions between hydrologic services and biodiversity, e.g. degradation of water quality can cause fish kills and loss of biodiversity	10
11.8	Biodiversity, Stable climate	Climate change and biodiversity loss are mutually reinforcing; resolving either issue requires consideration of the other, e.g. climate change increasingly alters ecosystems and organisms, and is a key driver of biodiversity loss.	13
11.9	Biodiversity, Habitats (Native)	Interactions between native habitats and biodiversity, e.g. Habitat destruction is a leading cause of species extinction. Livestock production is a large contributor to biodiversity loss as it drives conversion of natural habitats to intensely managed systems.	14, 15
11.10	Habitats (Native), Stable climate	Interactions between native habitats and climate regulation, e.g. tropical rainforests are large carbon sinks, so deforestation for livestock production is detrimental for climate stability. Forests also benefit from climate regulation.	13
11.11	Habitats (Appropriated), Habitats (Native)	Habitat conversion to create space for livestock leads to degradation, loss, fragmentation and clearing of native habitats, e.g. deforestation	14
11.13	Habitats (Appropriated), Stable climate	Interactions between appropriated habitats and climate regulation, e.g. climate regulation benefits rangelands and silvopastoral systems, which can also sequester carbon. However, deforestation for grazing land and overgrazing contribute to climate change.	16, 17
11.14	Atmospheric aerosol, Stable climate	Aerosols have complex interactions with the climate system. Aerosols produced by NO_x-driven photochemistry generally have a cooling effect. Uncertainty arises from complexity of aerosol absorption and impacts of aerosols on cloud microphysics.	18, 19
11.17	Habitats, Novel entities	A range of pollutants are excreted with animal waste, including pathogens, natural and synthetic hormones, antimicrobials and heavy metals, which can enter farmland soils, and surface and groundwater.	9
11.18	Atmospheric aerosol, Habitats	Aerosols have harmful impacts on native and appropriated habitats, e.g. exposure to ozone can damage crops and natural ecosystems. Acid precipitation causes acidification of water, soil and forest environments.	20

11.21	Atmospheric aerosol, Freshwater	Aerosols influence the hydrological cycle by altering mechanisms that form precipitation in clouds. Aerosols may substantially influence the Asian monsoon circulation.	21, 22
11.22	Biogeochemical flows, Freshwater	Flows of biogeochemical effluents pollute freshwater resources, degrading water quality, e.g. improper disposal of animal waste or handing of carcasses can lead to leaching of harmful nitrogen and sulfur compounds into ground water	23
11.24	Stable climate, Stratospheric ozone	Complex interactions between GHGs and ozone-depleting substances. Nitrous oxide (N_2O) is both a powerful GHG and the dominant ozone-depleting substance emitted in the 21st century, because it decomposes in the stratosphere to form nitrogen oxides (NO_x), which catalyze ozone destruction. However, other GHGs reduce the effectiveness of N_2O in destroying ozone (CO_2, CH_4).	24, 7
11.25	Atmospheric aerosol, Stratospheric ozone	High stratospheric aerosol loading reduces the ozone depletion potential (ODP) of N_2O, because NO_x is converted to HNO_3 on aerosol surfaces. In addition, aerosols affect ozone loss through Cl_y chemistry.	24
11.26	Stratospheric ozone, Habitats	Stratospheric ozone depletion leads to increased solar UVB radiation, causing DNA damage in plants	25
11.27	Stratospheric ozone, Biodiversity	Stratospheric ozone depletion leads to increased solar UVB radiation, causing DNA damage in fauna, such as marine Antarctic organisms.	26
11.31	Ocean acidification, Biodiversity	Many marine organisms are highly sensitive to changes to ocean CO_2 chemistry, especially those using carbonate ions to form calcium carbonate shells or structures. Ocean acidification could be deleterious to such organisms, which would constitute a major disturbance to marine ecosystems with highly uncertain impacts. Marine plankton are also vulnerable.	3
11.32	Ocean acidification, Habitats	Ocean acidification may have serious impacts on various marine and coastal habitats.	3
11.33	Ocean acidification, Climate	Oceans remove a large proportion of anthropogenic CO_2, but acidification threatens the ability of oceans to continue to function as a carbon sink.	3

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ELICITATION RECORD – Part 1

The Workshop Context

Elicitation title	Essential Environmental Impact Variables
Workshop	Livestock
Date	14 November 2022
Part 1 start time	13:00

Attendance and roles	Facilitator, Note taker, Experts 1, 2 and 3
Purpose of elicitation	1. Assessment of background review: assess the background review of impacts and ensure that all significant and salient impacts from an industry on the environment are captured in the conceptual systems diagram and the associated tables. 2. Assessment of greatest impact: assess which of these impacts have the greatest impact on the environment. By 'greatest' we mean that impacts have either 1) a large globally cumulative impact; or 2) impacts that are locally incurred but are identified as generally having the largest local effect.
This record	Participants are aware that this elicitation will be conducted using an adapted Sheffield Elicitation Framework, and that this document, including attachments, will form a record of the session.
Orientation and training	Participants received a pre-workshop participant brief.
Participants' expertise	<u>Expert 1</u> *Expertise:* Researcher in pig nutrition and management covering nutrient and management issues. Health and welfare aspects in relation to nutrition. Work on organic production systems for pig slaughter, and health and welfare of pigs. Lay crops as feed ingredient resource for pigs. Lay crops – crop rotation and other aspects of system. Protein, alternative feeder sources. <u>Expert 2</u> *Expertise:* Same topic as Expert 1 of ruminant nutrition, including dairy cows, and impact of cattle production. Farm animals and sustainability issues, focusing on livestock production. Research

	includes algae as means of mitigation for methane emissions. Longevity in dairy cows and how to keep longer in production systems. <u>Expert 3</u> *Expertise:* Poultry: egg-producing birds and broiler chickens. Research on management, nutrition and sometimes combination of the two. Both conventional and organic. Some (limited) experience on ammonia emissions from litter of hens, a problem for both animals and environment. Note: All experts knew each other before the workshop.
Declarations of interests	No competing interests
Strengths and weaknesses	<u>Expert 1</u> *Strengths:* Pig nutrition and management, Swedish context *Weaknesses:* International contexts (other than Sweden) <u>Expert 2</u> *Strengths:* Ruminant nutrition, emissions, longevity of dairy cows, Swedish context *Weaknesses:* International contexts (other than Sweden) <u>Expert 3</u> *Strengths:* Poultry – egg-producing birds and broiler chickens – management and nutrition. Swedish context. *Weaknesses:* Complex systems, international contexts (other than Sweden)
Evidence	*Clarifying question asked:* (Expert 2) Regarding level, impression is that the tool is for EU level, but things in table are global scale. Because difficult to try and do something at one level and reference another level. *Answer:* (Facilitator) Part is what we do in workshop – impacts of a sector. Usually based on size of company involved. We are aiming towards company disclosure. Production size controlled by company. Probably be applied to Western, large scale production style. I know you may be more familiar with Swedish, or European production systems, but we are also looking for any insights on how systems vary across the world. Want disclosure to be applicable to any company, but the processes we try to feed into are EU level.

	Production big enough that a company runs it. Small scale also useful. *Question:* (Expert 2) Primary producers mainly? *Answer:* (Facilitator) Yes *Question:* (Expert 2) Some are also enskild firmar, smaller companies. *Answer:* (Facilitator) This would be useful to understand. In some sectors it is many smaller producers. *Expert 1:* Focus should be on primary producers but of course, often in livestock, it interacts with industry in various ways. Producers of fertilizers, feeds (covered by tables). Tricky if focus is on farm level. *Facilitator:* Especially in fed systems, feed is a big part. We are thinking of feed as part of the system and sourcing of feed. Didn't want a diagram to be continuously expansive, including agriculture sector. Let us know if for the producers you are familiar with, it is integrated – if they produce feed themselves, or source feed elsewhere. Indicate how blurred the line is. But we are not necessarily looking at the production of fertiliser. *Expert 1:* Can go into more detail later. But at some points, I would add something relevant, e.g. if there is a dependency on fertilizer, that matters. *Facilitator:* I see what you mean that fertilisers are a part of farm impact. But not looking at e.g. the climate impacts of producing fertilisers.
Structuring	The variables were not elaborated or rephrased at this stage.
Definitions	1. Assessment of background review of impacts, ensuring all significant and salient impacts from an industry sector on the environment are captured. 2. Assessment of which are the *greatest* impacts on nature, meaning that impacts have either 1) a large globally cumulative impact, or 2) impacts are more locally incurred but are the largest for individual firms.

Part 1 end time	13:24
Attachments	

ELICITATION RECORD – Part 2: Outcome 1

Eliciting Expert Knowledge on Qualitative Outcomes

Elicitation title	Essential Environmental Impact Variables
Workshop	Livestock
Date	14 November 2022
Outcome	1. Assessment of background review: assess the background review of impacts and ensure that all significant and salient impacts from an industry on the environment are captured in the conceptual systems diagram and the associated tables. Specify if any impacts are missed, should be rewritten/rephrased or removed.
Anonymity	Experts are identified as Experts 1, 2 and 3 (aligned across all elicitation records).
Start time	13:25

Definition	Assessment of background review of impacts, ensuring all significant and salient impacts from an industry sector on the environment are captured.
Evidence	A participant brief was provided in advance, containing a background review and evidence.
Individual elicitation	**Missed –** <u>Expert 1:</u> 2.2 Biogeochemical flows - Dependency Dependency of a finite resource of phosphorous e.g. in phosphate feeds for pigs and poultry, which otherwise will increase pollution from pig and poultry farms (via manure). 7.3 Stable climate – Impact Use of feed phosphates (e.g. in pig and poultry farms) from mined sources causes large ecological footprint from mining, geopolitical instability in the source countries and long transports. <u>Expert 2:</u> None <u>Expert 3:</u> None

	Rewritten/rephrased – <u>Expert 1:</u> 2.1 Biogeochemical flows - Impact Effluent discharge can disrupt biogeochemical cycles and cause nutrient pollution, e.g. run-off from pig, poultry, beef and dairy farms (including from manure) causes nutrient pollution in water bodies. 7.2 Stable climate - Impact GHG emissions, e.g. CO2, CH4, N2O. CH4 is a byproduct of digestion via enteric fermentation, N2O is produced from nitrification/denitrification of manure and urine, CO2 emissions result from energy use, production of feed and fertilizers and indirect emissions from land, specifically deforestation, desertification from livestock grazing. 5.3 Habitats - Appropriated habitats - Both Dependencies on appropriated habitats where grazing crop production habitats provide feed for livestock and require good soil quality. Impacts on appropriated habitats depends on practices, e.g. overgrazing leads to soil compaction and degradation and monocultures with annual crops leads to poorer biodiversity and soil quality Stable climate, Habitats (supportive) Interactions between climate effects and supportive habitats, e.g. extreme weather (dry periods) causing effects on harvests, and indirectly less efficient livestock systems (e.g. poorer production, feed utilisation) and higher climate footprints of livestock. <u>Expert 2:</u> Freshwater use Add nuance – beef and dairy production has a significant impact. But animal feed (e.g. pasture) mainly uses rainwater [see below discussion]. Biodiversity Clarify what is meant by genetic material

	Note that grazing can be good for biodiversity, especially cattle which have a special pattern of grazing certain levels of grass. Other species graze too much. Novel entities Very broad spectrum within Novel Entities. Depends very much on location of production and legislation [see below discussion]. Expert 3: None **Removed –** Expert 1: None Expert 2: None Expert 3: None
Matches/ Mismatches	There was mainly agreement amongst the experts. As they all have expertise in the Swedish context with different types of animal production, they often agreed on the main idea of a point and contributed with knowledge about their systems. Hence, a key message was to add to many points in the materials 'pig and poultry', as it currently focuses on cattle. None wanted to remove any points.
Group discussion	**Crop production for feed** Expert 1 raised the point that crop monocultures for feed lead to poorer biodiversity and soil quality. Expert 2 agreed and added that even if farmers buy feed, they need to put the manure somewhere, economically makes sense to grow grains. Not all are for animal feed, some are for humans. Nonetheless, they are monocultures. Scientists advocate for lay crops in cultivation. Expert 1 raised that an issue is if there is a surplus of cereals, then it contributes to better use of resources to include in livestock feed. There is a big discussion in research about how to use by-products that do not compete with human food.

	Expert 3 mentioned it is easier for pigs than poultry as pigs eat wet food, which is an easier form for waste foods. Poultry eat only dry food, more sensitive to quality. By-products can have uneven quality. Expert 1 raised that good quality cereal feeds are better for supporting high production level at the good quality demanded by consumers and slaughterhouses, so it's difficult. Expert 2 supported that point and said farmers cannot do their own thing as the consumers, restaurants, ready-to-eat food industry all expect a certain type of products. Expert 2 added that at the global level, it is very important issue to use resources not competitive for human food. Facilitator asked how much of cereals are food quality. Expert 2 said that everyone wants to know. A Master's study indicated a large proportion, but lower quality – there is potential. **Freshwater use** Expert 2 said that that is a complicated issue. Beef and dairy production have a significant impact. Expert 1 said to add pigs and poultry. Expert 2 raised the point of grassfed beef – we don't irrigate pastures a lot in Sweden, a lot is rainwater producing feed. Expert 1 asked about other countries. Expert 2 said they don't know how much is irrigated for food production or how much is for feed. However, in general it is expensive to have irrigation and feeds need to be cheap. Expert 3 asked if we add water for cereal production. Expert 2 said that farmers irrigate if they have a lake or pond nearby but not really tap water. Difficult to write it like that. Expert 1 said they think that in Sweden it is not very common but maybe other countries, does not know. Water is used to grow corn or soy. Expert 2 said that farmers usually adjust to the area, grow what you can grow without adding extra costs. Facilitator asked if that is especially the case for feed because not for high end consumer? Requirement for high volume of cheap feed. Expert 2 agreed. Use freshwater for tomatoes, but animal feed mainly rainwater.

	Biodiversity (genetic material) Expert 2 said they were not sure if we meant genetic material in animals, feeds. Facilitator clarified mainly the animals themselves due to selective breeding, lose genetic diversity and decrease the genetic pool. Expert 2 and Expert 1 confirmed this is true. Expert 1 said we use the same breeds all over. Expert 2 added maybe pig and poultry more than cattle. Dairy, black and white cows dominate. Expert 3 clarified it's different in poultry as no breeding farm level. There is a breeding pyramid, and breeding companies. End products are a cross of several lines. You must always buy in new animals. Expert 1 clarified for pigs it's a bit different, genetic development run by international companies but there is breeding on farms. **Novel entities** Expert 2 said that there is a super broad spectrum within Novel Entities. Depends very much on location of production and legislation, e.g. antimicrobial resistant bacteria severe in Denmark but not in Sweden. Sweden also free of salmonella, strict laws on antibiotic use in production. Expert 3 added that it is banned to use antibiotics preventatively, but you can use them when animals get sick. Expert 1 highlighted that the ban was in 1988 so practices were changed proactively to prevent disease. Expert 2 said it was similar with hormone use in different countries and jurisdictions. **Feed dependencies** Facilitator asked how industry is thinking about their P dependency and extreme weather events. Expert 2 said there was a growing awareness of the need for a backup system. Cattle highly dependent on forage, as demonstrated with the heatwave of summer 2018. Expert 1 supported that it was also a big problem for pig farmers to find feed ingredients with the

	low yields. Expert 3 mentioned that it is now a problem with the war. There was agreement that feed is the biggest dependency. Expert 1 said that the P dependency is an acknowledged problem internationally. Resource likely to end in near future. Interest in closing the loop and recycling P. Facilitator asked if it was a stressor if no solutions in sight. Expert 1 said it was more so for the feed industry. **Biogeochemical flows** Expert 2 said that all farms need to put manure somewhere, farmers put it on their own fields, often also work with neighbours. Expert 3 said most have their own field, but it doesn't mean they produce for feed. Also farms with no land but not so many. More common with smaller egg producers to have contract with someone else. Too much manure is common. That is common amongst all production. Expert 1 agreed and raised the limitation how much N and P can spread per ha, hence many need a contract with some other farm. Facilitator confirmed that for pig and chicken production, have own land and grow some kind of crop, they then sell on. Expert 3 said farmers sometimes use their own N mix concentrate. Expert 1 said they don't know how common to use vs. sell crop. Expert 3 said that chickens today do not want to eat the cereals. People buy the full feed. Expert 1 said it depends on pig category. Sows and piglets, amount of full feed is higher. Most common to have cereals and buy concentrate with protein and premix, mix at farm. Facilitator checked that it is fairly circular for bulk of feed, plus extra added parts. Group indicated agreement. Expert 1 added that it is often imported Facilitator checked that although producers produce crop products, entities different from those only producing crops. Expert 1 confirmed that in general agriculture is specialised, you tend to be one or the other. However, those with animals have some crop production. There is exchange and sharing.

Group elicitation	Take from notes of discussions – nobody disagreed with anything anyone else had said.
Chosen outcome	See above.
Discussion	The experts had fairly narrow expertise in Swedish livestock production systems. Would need to be complemented by other inputs to be relevant to other systems, or globally. Experts were less comfortable with the systems lens and did not want to comment on things outside their area of expertise. Highlights need to be aware of what the expertise does and does not cover.

End time	15:49
Attachments	

ELICITATION RECORD – Part 2: Outcome 2

Eliciting Expert Knowledge on Qualitative Outcomes

Elicitation title	Essential Environmental Impact Variables
Workshop	Livestock
Date	14 November 2022
Outcome	2. Assessment of greatest impact: assess which of these impacts have the greatest impact on the environment. By 'greatest' we mean that impacts have either 1) a large globally cumulative impact; or 2) impacts that are locally incurred but are identified as generally having the largest local effect.
Anonymity	Experts are identified as Experts 1, 2 and 3 (aligned across all elicitation records).
Start time	13:25

Definition	Assessment of which are the *greatest* impacts on nature, meaning that impacts have either 1) a large globally cumulative impact, or 2) impacts are more locally incurred but are the largest for individual firms.
Evidence	A participant brief was provided in advance, containing a background review and evidence.
Individual elicitation	<u>Expert 1:</u> **Impact:** Pollution and nutrient leakage from biogeochemical flows into air, surface and water. **Reason:** On a global (and national) level one of the greatest impacts from livestock sector. Direct impacts by feed resources, management strategies, efficiency in nutrient utilisation and resource use. **Impact:** Biodiversity (or loss of it). Needs for actions at different levels within livestock sector to maintain (if not possible to increase) the biodiversity **Reason:** On a global level maybe one of the largest threats for life. Direct impacts on biodiversity, e.g. intensive monoculture feed production, devastating rainforests, mono-breed farming etc. reduces diversity

	Impact: Use of antimicrobials **Reason:** On a global level, antibiotic resistant bacteria is a large threat for human health. The excessive use must be controlled. There is a need for better control, and lower use in the livestock sector. **Impact:** Feed-food competition. Not only from a social-ethical perspective, also an environmental perspective, for sustainable production systems. **Reason**: On a global and national level, need to find alternative feed resources (with low environmental impact) that can be used efficiently. Strategies for the livestock sector to be able to use those resources (availability, techniques/processes for improved nutrient quality etc.) as well as acceptance on productivity of the livestock is needed. Expert 2 and Expert 3 did not clearly state in their individual elicitations what they believed to be the greatest impacts.
Matches/ Mismatches	N/A
Group discussion	**Climate change** Expert 2 raised climate change, because of the severity of the situation and that cattle has a large impact. However, difficult for farmer to do anything about [if continuing with cattle farming] – it is due to biological processes. Also mentioned there is discussion on a tax on Methane from dairy. **Biodiversity** Expert 1 raised biodiversity, which is a real threat. There is a need for other strategies in feed production. Genetic material can also have a great impact, e.g. establishing lay crops in cereal annual production. Can increase biodiversity at the farm. Zones for pollinators. Some of this is already done. Expert 2 said that on land conversion, we mentioned rainforest and clear cutting. But there is also conversion of forest land to grazing land – lost a lot in Sweden, ecologists say would need to increase amount of grazing land to improve or maintain biodiversity in Sweden. We would benefit from having more animals grazing. **Ecosystem services**

	Expert 2 said it is not an environmental issue but people talk more about ecosystem services. Not only biodiversity and water quality but the aesthetic things people want. E.g. people want farms and grazing animals in landscape, walking. Expert 3 said it is about clear goal conflicts. High production, low input has low environmental impact. Not appreciated by some. **Nutrient leakage into freshwater** Expert 2 said that dairy cows in New Zealand had high problems N leakage into freshwater resources. Now trying to work on it but has already gone so far. Expert 1 agreed and said that nutrient leakage a major issue, depending on where you are. **Antibiotics** Expert 1 said that use of antibiotics a huge global health problem we face. We will back in the times of deadly diseases, big threat globally. **Efficiency and consumption** Expert 2 said it was difficult for farmers to reduce impacts. Expert 1 agreed. Expert 1 said there are two approaches to reduce impacts: lower production in total or make production more efficient. Expert 3 suggested that maybe the only way to decrease impact is to eat less eggs and meat.
Group elicitation	**Impact:** Climate change **Reason:** Biggest impact from sector, but one that is very difficult to do anything about if you are still going to have animals/produce meat. **Impact:** Biodiversity **Reason:** Mainly through feed (through monoculture production), but also some due to breeding and the effects on genetic diversity.
Chosen outcome	• Climate change • Biodiversity
Discussion	More 'sustainability' people in the other workshops Swedish focus – need to fill in with knowledge about other systems Interesting points about legislation relating to Novel Entities – in Sweden, not allowed antibiotics so changed practices to prevent disease

	Only one person sent us their individual elicitation. One person (Expert 3) did not contribute as much as the other two.

End time	15:49
Attachments	