TECHNICAL REPORT ON AGRICULTURAL PRACTICES AND THEIR EFFECT ON AIR EMISSIONS IN LUXEMBOURG

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1. Introduction

Air quality is the subject of the European Directive (EU) 2016/2284 (NEC Directive), which has been transposed by the Grand-Ducal Regulation of 27th June 2018 on the reduction of national emissions of certain atmospheric pollutants and aims to set the ceilings for emissions of air pollutants for each Member State by 2030 (European Parliament and Council of the European Union, 2016; Gouvernement du Grand-Duché de Luxembourg, 2018). The Grand-Ducal Regulation also ensures consistency with other national plans and programmes (e.g. the National Integrated Energy and Climate Plan) (Gouvernement du Grand-Duché de Luxembourg, 2018). National emission reduction targets were set in the NEC Directive; interim targets are to be met in 2020 and still stricter targets in 2030 for the main transboundary air pollutants: sulphur oxides (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), non-methane volatile organic compounds (NMVOCs) and fine particulate matter (PM2.5). In between these two deadlines, a linear decline in emissions is to be aimed for. Member states are obliged to establish National Air Pollution Control Programmes (NAPCPs) in order to meet the emission reduction commitments under the NEC Directive (European Parliament and Council of the European Union, 2016; Gouvernement du Grand-Duché de Luxembourg, 2018). A first draft of the Luxembourgish NAPCP is currently open for public consultation (2nd October 2020 – 1st December 2020)[1] (Administration de l'Environnement, 2020). The Grand-Ducal Regulation outlines a minimum of measures that need to be included in the NAPCP, where the actions concerning the agriculture sector mainly aim to reduce ammonia emissions. For example, a national code of good agricultural practices to reduce ammonia emissions should be outlined and include at least the following measures: a) nitrogen management, taking into account the whole nitrogen cycle; b) livestock feeding strategies; c) low emission livestock manure application techniques; d) low emission livestock manure storage systems; e) low emission animal housing systems; and f) possibilities to limit ammonia emissions from the use of mineral fertilisers (Gouvernement du Grand-Duché de Luxembourg, 2018). Further measures are proposed and described in the draft of the NAPCP (Administration de l'Environnement, 2020). In this context it is important to understand the status quo: which of these measures are already in place at Luxembourgish farms and in which manner are they put into practice?

In the framework of the project SustEATable - Integrated analysis of dietary patterns and agricultural practices for sustainable food systems in Luxembourg, which is co-financed by the Ministry of the Environment, Climate and Sustainable Development, a sustainability assessment using the SMART (Sustainability Monitoring and Assessment RouTine)-Farm Tool was performed on 87 farms in Luxembourg to assess their achievement of the SAFA (Sustainability Assessment of Food and Agriculture system) sustainability goals outlined by the FAO (Food and Agriculture Organization of the United Nations) (FAO, 2014a). The SAFA-guidelines define four sustainability dimensions (Good Governance, Environmental Integrity, Economic Resilience and Social Well-Being), 21 themes and 58 sub-themes; and Air Quality[2] is one of the sub-themes of the Environmental Integrity dimension (FAO, 2014a). During this sustainability assessment, data on 300+ indicators are collected on each farm, of which 56, depending on farm type and farm orientation, are used to evaluate a farm's impact on the sub-theme Air Quality. Against the background of the above mentioned context, the Environmental Administration ("Administration

[1] https://environnement.public.lu/fr/actualites/2020/10/pollution-sonore-atmospherique-consultations-publiques.html [Accessed November 2020]

[2] Readability notice: "Air Quality" starting with capital letters refers to the sub-theme in the Environmental Integrity Dimension of the SAFA Guidelines; "air quality" with lower case letters refers to the topic in general.

de l'Environnement") asked to receive detailed information on these Air Quality indicators. Furthermore, nine additional questions were formulated to collect data on specific topics relevant in the framework of the NAPCP and not yet covered by the Air Quality indicators of the SMART-Farm Tool. Both, the answers to the indicators and to the additional questions provide important data in order to better grasp the current status and impact of the agricultural sector on air quality in Luxembourg. The here presented technical report has for purpose to deliver this information to the Environmental Administration.

2. Materials and methods

2.1 Data collection

2.1.1 Farm-level Sustainability Assessment

The Sustainability Monitoring and Assessment RouTine (SMART)-Farm Tool, V5.0, (SMART-Farm Tool; RRID: SCR_018197), developed by Forschungsinstitut für Biologischen Landbau (FiBL) was used for the on-farm sustainability assessment (Schader et al., 2016). This sustainability assessment is based on the sustainability goals set by the Food and Agriculture Organisation (FAO) for the Food and Agriculture Systems and that are outlined in the Guidelines for the Sustainability Assessment of Food and Agriculture Systems (SAFA Guidelines) (FAO, 2014a, 2014b; Schader et al., 2016). SMART-Farm Tool operationalises the SAFA Guidelines in a science-based efficient way (FAO, 2014a; Schader et al., 2016). These guidelines provide a universal framework for such an assessment in an attempt to promote a functional and uniform sustainability assessment approach (FAO, 2014a). The guidelines define four dimensions of sustainability (Good Governance, Environmental Integrity, Economic Resilience and Social Well-Being), which are in turn divided into 21 themes and 58 sub-themes (Figure 1), with associated explicit sustainability objectives and targets. A more detailed description of the SMART-Farm Tool can be found in Schader et al. (2016).

The objective of the sub-theme Air Quality in the theme Atmosphere within the dimension Environmental Integrity is defined as “The emission of air pollutants is prevented and ozone depleting substances are eliminated” (FAO, 2014a). Air quality is assessed by the ambient concentration of air pollutants such as particulate matter, ozone, sulphur dioxide, nitrous oxides, volatile organic compounds, smoke and odours. Agriculture can be responsible for local emissions of these pollutants; however, air pollutants and their concentration in the air can be influenced by other factors such as weather conditions (e.g. direction and speed of wind). As such, a farmer may implement all the necessary measures to prevent the emission of air pollutants from its farm, and yet be affected by poor air quality due to weather conditions and location (e.g. next to a highway) (FAO, 2014a).

The assessment is based on a farm visit in combination with an interview (approx. 3h) with the farm manager during which the necessary data is collected. The farmers gave their consent to a copy of their “Flächenantrag”[3] being send by the Service d’Economie Rurale (SER) directly to IBLA. Relevant data could thus be entered before the farm visit to facilitate the interview. The data from the “Flächenantrag” as well as from the on-farm interview was then used to evaluate the 300+ indicators embedded in the SMART-Farm Tool.

[3] Area related form that farmers need to hand-in to the Ministry of Agriculture and which is mainly used to apply for the following aids: basic premium, premium for young farmers, coupled legume premium, compensatory allowance for producers situated in less-favoured areas, compensation for restrictions in water protection areas, landscape conservation premium, agri-environment-climate measures (https://agriculture.public.lu/de/betriebsfuhrung/flachenantrag.html [Accessed November 2020]).

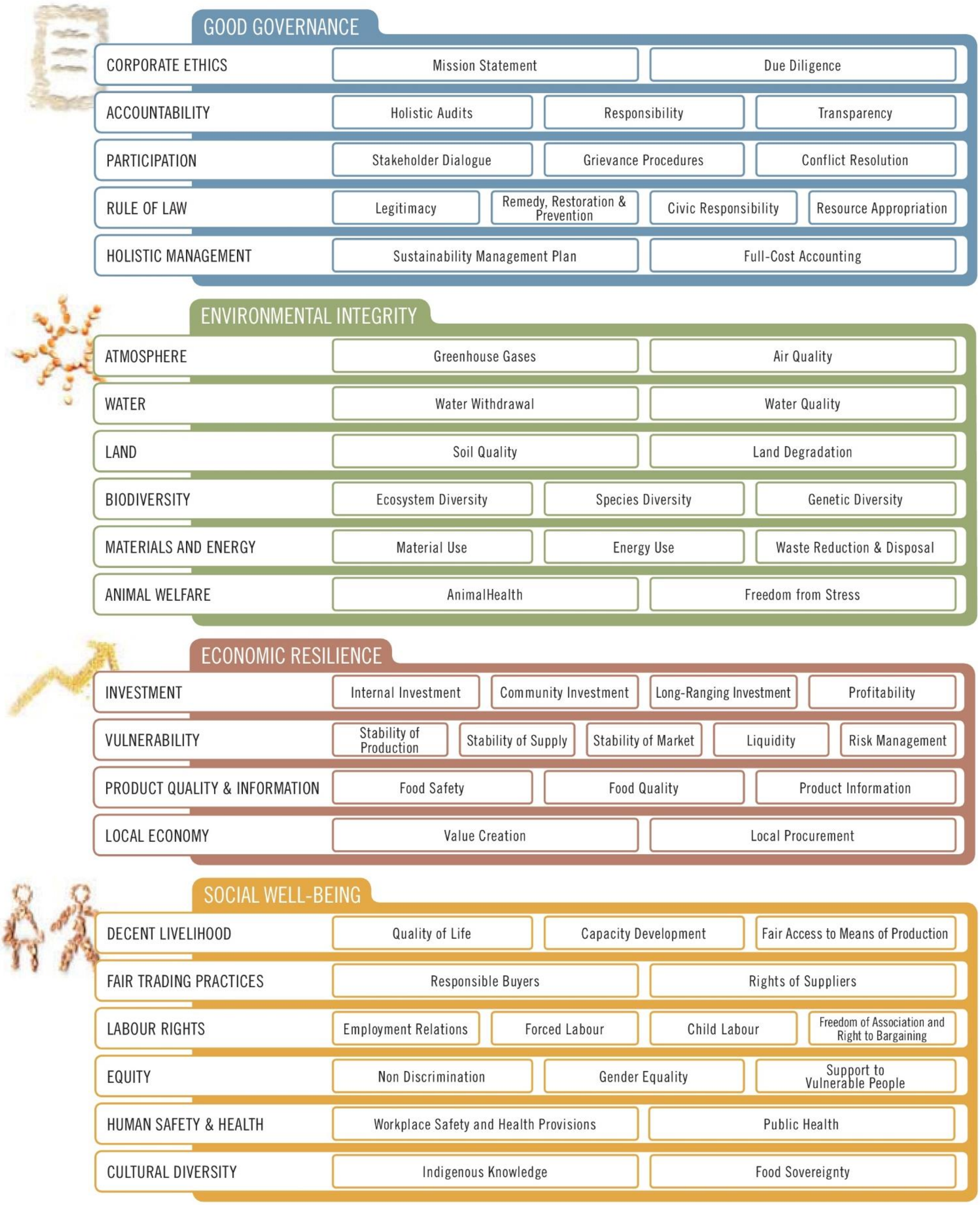

Figure 1: SAFA-Dimensions and themes. The four dimensions of sustainability Good Governance, Environmental Integrity, Economic Resilience and Social Well-Being are shown, which are in turn divided into 21 themes and 58 sub-themes (FAO, 2014a).

2.1.2 Sampling plan

Luxembourg has an area of 2586 km², of which slightly over half is land used for agricultural production (131163 ha). Of the area used for agricultural production 47 % are arable land and 51 % are permanent grassland (Ministère de l'Agriculture, de la Viticulture et du Développement rural, 2020). In 2017, there were 1943 agricultural holdings in Luxembourg, thereof, 100 were organic farms or in the process of transitioning to organic production (5.1 %) (Ministère de l'Agriculture, de la Viticulture et du Développement rural, 2020). The average size of agricultural holdings was 67.5 ha (Ministère de l'Agriculture, de la Viticulture et du Développement rural, 2020).

At the end of September 2018, a call for participation was sent to 1513 farmers out of the 1943 registered farms in the framework of the project SustEATable. Agricultural holdings that have very specialized production systems (e.g. wine production (OTE 354), mushroom production (OTE 231), tree nurseries (OTE 232), flowers and ornamental plant production (OTE 222)) were excluded. Lastly, beekeepers (OTE 843) were also not considered as they generally do not labour any agricultural land. In order to protect privacy, the call was mailed by the SER.

Furthermore, the call for participation was printed in the IBLA Newsletter N.06 in November 2018 and an advertisement was run in the "Luxemburger Bauer" in December 2018. The different Luxembourgish farmers organizations, many of which are also represented in the SustEATable Advisory Board, were contacted and asked to share the call with their members (e.g. Landwirtschaftlech Kooperatioun Uerwersauer (LAKU), CONVIS, Vereenegung fir Biolandwirtschaft Lëtzebuerg (formerly known as Bio-Lëtzebuerg) and Baueren Allianz).

We received 105 answers to our call of which 87 farms were progressively contacted and analysed for their sustainability performances. Of the remaining 18 answers, 9 farms no longer wished to participate when called back, often out of time restraints. The other 9 were excluded due to their farm type: e.g., specialised horse keeping and/or hay production for horse husbandry. The sampling run was from January 2019 until January 2020, with the main data collection having been done between January 2019 and June 2019. A detailed description of the study sample is given in Chapter 3.1.

2.2 Data analysis

2.2.1 Individual farm sustainability assessment with the SMART-Farm Tool

As mentioned above, during the on-farm interview, 300+ indicators are being assessed depending on the farm type. These indicator ratings are then used to assess the goal achievement in the 58 sustainability sub-themes. The model is semi-quantitative, meaning that mostly qualitative questions ("Does the farmer take measures to avoid soil compaction?" -Yes/No) are asked and transferred to quantitative ratings ranging from 0 to 100 %. Indicators can impact multiple sub-themes, both positively or negatively. To reflect the importance of each indicator on a specific sub-theme, the indicators are given different weightings. The respective goal achievement corresponds to the weighted average of the indicator ratings of a sustainability sub-theme (Figure 2). The goal achievement, which is given in percentages, is than assessed using a five-level scale from 0 (unacceptable: 0% - 20% of the sustainability objective are achieved) to 4 (best: 81% - 100% of the sustainability objective are achieved; Figure 3).

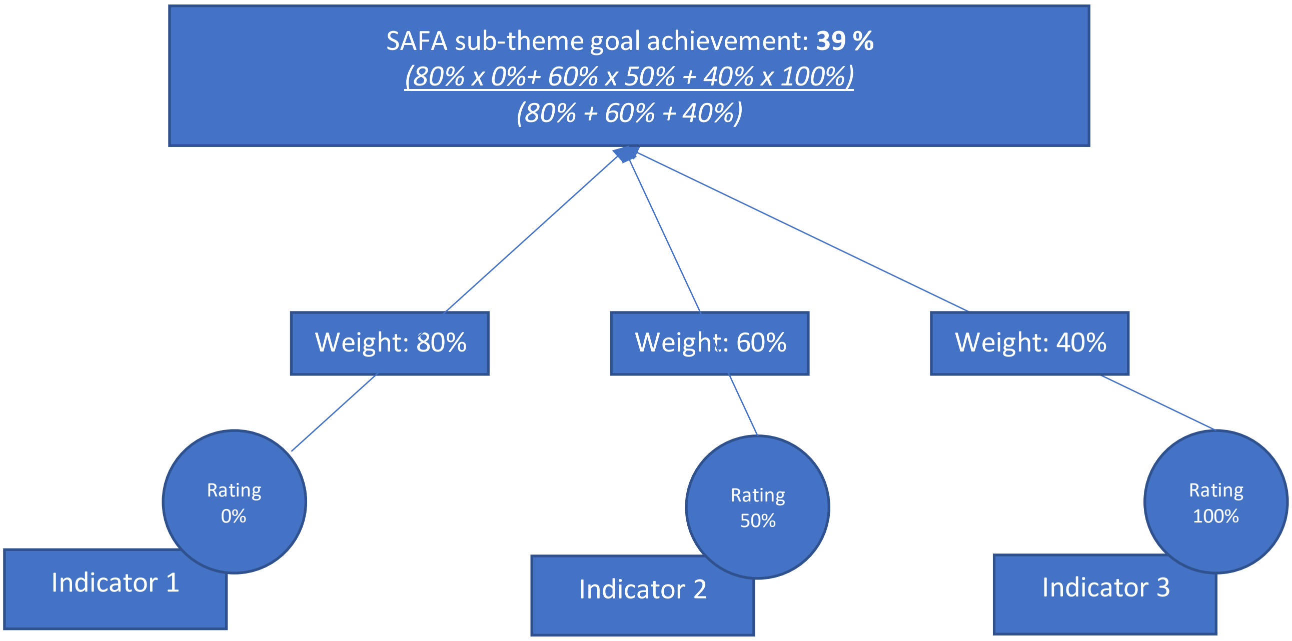

Figure 2: Example of the calculation underlying the goal achievement assessment.

Figure 3: Scheme for the assessment of the sustainability objective achievement.

2.2.2 Sub-theme Air Quality indicators

A total of 56 indicators are used in the SMART-Farm Tool, V5.0, (SMART-Farm Tool; RRID: SCR_018197) to assess the goal achievement in the sub-theme Air Quality. The complete list of the 56 Air Quality indicators with indicator name, auditor question, scale description and unit can be seen in Appendix 1. The indicators are evaluated depending on the question and the respective answer options; i.e. the indicators themselves (not their rating) are evaluated. Depending on farm type, some indicators lost their relevance and were not assessed on that farm (e.g. when no pigs were raised on a specific farm, pig husbandry related indicators were rated not relevant and not assessed for that specific farm), leading to fewer indicators being used to evaluate Air Quality goal achievement. Furthermore, Luxembourg was defined in the tool as its own region with related compliances being implemented in regards to the Luxembourgish laws and regulations (e.g. in regards to waste management and working conditions). Pre-defined compliances auto-rate some of the indicators in the SMART-Farm Tool questionnaire helping to reduce the time of the on-farm interview. Consequently, not all indicators were answered by all farm managers, which is why the sample size (n) can be <87.

There are two major types of indicators: quantitative indicators where the answer is a percentage (e.g. ID 206 – share of legumes on arable land calculated that asks what proportion of the arable land is devoted to leguminous crops) and qualitative indicators where the nominal answers are often no/partly/yes (e.g. ID 370.5 – daily outdoor access for animals that asks whether all animals have year-round daily outdoor access). For the former type of indicator an absolute frequency distribution was calculated in a grouped frequency of 10 % steps (see for example Table 5); for the latter type of indicators the nominal answers no/partly/yes were grouped and their absolute frequency are presented, too (see for example Table 6). For those indicators for which these two approaches are not expedient (i.e., the indicator was quantitative in nature but the answer is not a proportion or the indicator is qualitative in nature, but the answer is different to no/partly/yes), individual evaluations were done (e.g., ID 332 – Electricity Consumption and ID 620 – permanent grassland: mowing frequency, respectively). If the sample size or the answer variability is very small, only a descriptive evaluation of the respective indicator is given (e.g. ID 341 – setting of combustion motors) and results are not presented in a table.

For some indicators an evaluation depending on the management system was interesting. In these cases, the results for management are compared with the characteristic values of the entire sample (total) (e.g. ID 370.5 – daily outdoor access for animals).

The indicators were grouped in to the main topics

- energy,
- animal husbandry,
- feed,
- fertilisation,
- agricultural land management,
- pesticide use / plant protection and
- environmental emissions

and results are described and presented accordingly in Chapter 3.3.

2.2.3 Additional air quality data collected at farm-level

The Environmental Administration was interested in some additional information not covered in the Air Quality indicators of the SMART-Farm Tool, V5.0. In cooperation with the Environmental Administration further questions were therefore formulated to collect additional air quality data at farm-level (Table 1). These additional questions have no bearing on the SMART-Farm Tool sustainability assessment. The results to these questions were, similarly to the individual Air Quality indicators, descriptively analysed and the results are presented in Chapter 3.3.8.

Table 1: Additional air quality questions assessed at farm-level.

Additional air quality questions	Translation	Answer possibilities
Wie groß sind Ihre Güllespeicherkapazitäten?	How big are the capacities of the slurry tanks?	amount (m^3)
Separieren Sie die Gülle?	Do you separate the slurry?	yes / no
Sind die Güllespeicher nach unten abgedichtet?	Are your slurry tanks sealed at the bottom?	yes / no
Setzen Sie Mittel ein um den pH-Wert der Gülle zu reduzieren?	Do you use inputs to reduce the pH of the slurry?	yes / no
Wie oft mischen Sie die Gülle, um Bildung einer stabilen Schwimmdecke zu verhindern?	How often do you stir the slurry in order to prevent the build-up of a stable surface crust?	number
Wie schnell nach der Ausbringung von organischen Düngemitteln arbeiten Sie diese generell ein?	How quickly, after the application of organic fertilisers do you generally work them into the soil?	time (h)
Haben Sie im Stall ein Entlüftungssystem installiert, mit dem NH_3 herausgefiltert werden kann?	Have you installed a ventilation system in the stable with which ammonia (NH_3) can be filtered out?	yes / no
Bei Gülle: Wie sind die Güllespeicher abgedeckt?	How are the slurry tanks covered?	description
Bei Festmist oder Kompost: Wird dieser überdacht oder abgedeckt gelagert?	Is manure or compost stored under a roof or covered?	yes / no

2.2.4 Statistical analysis

The individual farm results from the SMART sustainability assessment were used to do an initial overarching analysis in regards to Air Quality. The impact of the treatments management systems, animal husbandry, and orientation of ruminant husbandry on the SAFA-goal achievement in the sub-theme Air Quality were statistically evaluated. The levels for the different treatments were as follows:

- Management system:
  - Organic: certified organic farms, or farms in the process of becoming certified organic farm in the reference year 2017
  - Conventional: conventionally managed farms

- Animal husbandry:
  - No animals: farms that did not raise any animals
  - Ruminants: farms with ruminant husbandry
  - Monogastrics: farms with monogastric husbandry. This refers to both pig and poultry husbandry
  - Both: farms with a combination of ruminant and monogastric husbandry (e.g. dairy cows with pig fattening, or suckler cow husbandry with laying hens)

- Orientation of ruminant husbandry (referred to in the following as “ruminants”):

- Meat: farms that raise ruminants for meat production
- Dairy: farms that raise ruminants for dairy production
- Both: farms that raise ruminants for both meat and dairy production

For the latter treatment (ruminants), the focus lies mainly on the orientation of the ruminant husbandry branch of the farms; however, farms with ruminant husbandry in combination with monogastrics are also considered.

The statistical analysis was performed in R© (Version 3.6.1) using the integrated development environment RStudio© (Version 1.2.1335) and the packages *stats* (Version 3.6.1) and *car* (Fox et al., 2020[4]; Version 3.6.3). The data was tested for normality and equal variance using the Shapiro-Wilk test and the Levene's test, respectively.

The statistical tests were chosen depending on the normality and equal variances of the data:

I. Comparison of <u>management systems</u> was done using the independent two sample t-test as normal distribution and equal variance were given
II. Comparison of <u>animal husbandry</u> was done using the one-way ANOVA and Tukey's pairwise comparison as normal distribution and equal variance were given
III. Comparison of <u>ruminants</u> was done using the Kruskal-Wallis test and pairwise comparison with Wilcoxon rank sum test as equal variance was not given

[4] https://cran.r-project.org/web/packages/car/car.pdf [Accessed November 2020]

3. Results

3.1 Sample description

A total of 87 farms was analysed using the SMART-Farm Tool. This represents 4.5 % of all agricultural holdings in 2017 (Table 2). The 87 farms laboured 8666 ha of agricultural land (6.6 % of all agricultural land in Luxembourg), which was made up of 49.9 % arable land and 49.8 % permanent grassland. These proportions are similar to the overall shares of arable land and permanent grassland of the agricultural land in Luxembourg (Table 2) (Ministère de l'Agriculture, de la Viticulture et du Développement rural, 2020). In terms of management, 29 were managed organically and 58 conventionally, where the 5 farms that were transitioning to organic farming in 2017 were classified being organic. This represents 30.9 % of all organic farms and 3.2 % of all conventional farms in Luxembourg. Organic agriculture is overrepresented in the study sample of 87 farms compared to the whole of Luxembourg (overall 5.0 % share of organic agriculture). Of the 87 farms, 10 had no animals, 57 raised ruminants, 5 raised monogastric animals (pigs, poultry) and 15 farms raised both ruminants and monogastric animals. Of the 72 farms raising ruminants (57 only ruminants plus 15 raising them along with monogastric animals), 24 focussed on meat production, 27 on dairy production and 21 produced both meat and milk as main branches of their farm enterprise. Ruminant husbandry is with 1242 farms (63.9 % of all farms) the main farm branch in Luxembourg (Ministère de l'Agriculture, de la Viticulture et du Développement rural, 2020). The importance of this sector is also mirrored in the sample with 82.8 % of farms raising ruminants.

Table 2: Characteristics of all farms in Luxembourg and farms in sample (based on data from Ministère de l'Agriculture, de la Viticulture et du Développement rural (2020)).

		All farms in Luxembourg		Farms in sample	
Number of farms		1943	(100%)	87	(100%)
Agricultural area (ha)		131163	(100%)	8666	(100%)
Arable land (ha)		62039	(47.3%)	4328	(49.9%)
Permanent grassland (ha)		67413	(51.4%)	4318	(49.8%)
Management					
	Organic	94	(5.0%)	29	(33.3%)
	Conventional	1789	(95.0%)	58	(66.7%)
Animal Husbandry					
	No animals			10	(11.5%)
	Ruminants			57	(65.5%)
	Monogastrics			5	(5.7%)
	Both			15	(17.2%)
Ruminants		1242	(63.9%)	72	(82.8%)
	Meat			*24*	(27.6%)
	Dairy			*27*	(31.0%)
	Both			*21*	(24.1%)

As can be seen in Table 3, the average size of the agricultural holdings in the sample (99.6 ha) is bigger than the average of all agricultural holdings in Luxembourg (67.5 ha) (Ministère de l'Agriculture, de la Viticulture et du Développement rural, 2020). Consequently, the average size of arable land and permanent grassland of the sampled farms is higher than the Luxembourgish average. Nevertheless, sampled farms had a similar share of arable land and permanent grassland (around 50-50 %). Organically managed farms had on average a smaller farm size than the participating conventional farms and were closer in size to the overall average farm size in Luxembourg. In terms of animal husbandry, farms with ruminant husbandry tended to have larger agricultural area than farms with no animals or only monogastric husbandry. Furthermore, the latter two tended to have a smaller share of permanent grassland compared to the national average. Farms that had both meat and dairy production had on average the largest farm size (149.5 ha), while farms only focussed on beef meat production tended to have on average the smallest farm size out of the farms with ruminant husbandry. Farms with both meat and dairy production, as well as farms with only meat production laboured on average a lower share of arable land; i.e. their agricultural land consisted of more permanent grassland.

Table 3: Characteristics of all farms in Luxembourg and farms in sample in total, for management system (organic, conventional), for animal husbandry (no animals, ruminants, monogastrics and farms with both ruminants and monogastrics), and for a deeper view on ruminants (dairy production, meat production and both dairy and meat production) (based on data from Ministère de l'Agriculture, de la Viticulture et du Développement rural (2020)).

	Number of farms	Agricultural area (ha)	Arable Land (ha)	Permanent grassland (ha)
All Farms in Luxembourg	1943	67.5	31.9	34.7
Farms in sample	87	99.6	49.7	49.6
Management				
Organic	29	69.8	36.1	33.2
Conventional	58	114.5	56.6	57.9
Animal Husbandry				
No animals	10	63.0	58.1	3.9
Ruminants	57	117.1	63.0	54.0
Monogastrics	5	50.9	42.5	8.4
Both	15	73.8	30.5	43.1
Ruminants	72			
Dairy	27	107.5	57.3	50.2
Meat	24	72.5	27.9	44.3
Both	21	149.5	62.8	86.5

3.2 Performance in the sub-theme Air Quality

Table 4 shows the minimum (min), maximum (max), median (md) and mean goal achievement in the sub-theme Air Quality and the standard deviation (sd) for all farms in sample, management (organic - conventional), animal husbandry (no animals - ruminants - monogastric - both ruminants and monogastric) and ruminants (dairy production - meat production - both). Furthermore, the p-values (p) are given for the impact of management (independent two sample t-test), animal husbandry (one-way ANOVA) and ruminants (Kruskal-Wallis test) on the goal achievement in the sub-theme Air Quality. Significant differences between treatment levels in animal husbandry and ruminants identified by the post-hoc pairwise comparison tests are indicated by different letters in Table 4, column "Mean".

On average, the sustainability performance of the 87 participating farms in this sub-theme can be classified as *good* with a mean of 62.5 % and a median of 61 % goal achievement. The sustainability performance spans two categories, from *limited* (min = 39 %) to *best* (max = 88 %) sustainability performance.

Table 4: Sample size (n), minimum (min), maximum (max), median and mean goal achievement in the sub-theme *Air Quality* and the standard deviation (StDev) for all farms in sample, for management, for animal husbandry and for ruminants are shown. Furthermore, the p-values are given for the impact of management (independent two sample t-test), animal husbandry (one-way ANOVA) and ruminants (Kruskal-Wallis test) on the goal achievement in the sub-theme Air Quality. Significant differences between treatment levels in animal husbandry and ruminants identified by the post-hoc pairwise comparison tests are indicated by different letters in column "Mean".

	n	Min	Max	Median	Mean	StDev	p-value
All farms in sample	87	39	88	61	62.8	8.3	
Management							
conventional	29	39	80	58	59.1	6.7	
organic	58	58	88	68	69.3	7.2	**<0.001**
Animal Husbandry							
no animals	10	56	88	71	71.7[a]	11.1	
ruminants	57	50	80	59	61.2[b]	7.3	
monogastrics	5	55	66	61	60.8[b]	4.8	
both	15	39	72	64	61.9[ab]	7.9	**0.002**
Ruminants							
dairy	27	50	71	59	59.5[a]	5.9	
meat	24	39	80	67.5	65.7[b]	9.4	
both	21	53	66	58	58.6[a]	3.4	**0.001**

Management ($p < 0.001$), animal husbandry ($p = 0.002$) and ruminants ($p = 0.001$) all showed a significant effect on Air Quality (Table 4). For management, the organically managed farms (md = 68 %) showed a significantly higher goal achievement than conventionally managed farms (md = 58 %). Their goal achievements fall within the *good* and *moderate* brackets, respectively.

In regards to animal husbandry, it was observed that farms with no animals (md = 71 %) had a significantly higher goal achievement than farms with ruminant husbandry (md = 59 %) and farms with both ruminant and monogastric husbandry (md = 64 %). There was no significant difference between farms with ruminant, monogastric and both ruminant and monogastric husbandry. Farms with ruminant and farms with monogastric husbandry are at the upper end of the *moderate* goal achievement bracket, while farms with both ruminants and monogastric, and farms with no animals both fall within the *good* goal achievement bracket.

Taking a deeper look at ruminant husbandry, a significantly higher goal achievement was observed for meat producing farms (md = 67.5 %) compared to farms producing dairy (md = 59 %) or farms producing both dairy and meat (md = 58 %). The latter two fall within the *moderate* goal achievement bracket, while the first falls within the *good* bracket.

3.3 Sub-theme Air Quality indicators

In the following, the results of the 56 individual Air Quality indicators from the SMART-Farm Tool are presented.

3.3.1 Energy

The indicator **ID 185 – Renewable Electricity** assesses what percentage of the total electricity consumption of the farm is sourced from renewable electricity sources. From the 87 participating farms, 86 were supplied by 100 % renewable electricity, while one farm also received electricity from non-renewable sources (results not shown). This farm's share of renewable electricity was 83 %. The high share of renewable electricity comes about as the electricity providers (mostly ENOVOS S.A.) supply private households with electricity from 100 % renewable sources and most family farms (the prevent farm structure in Luxembourg) are counted as private households.

The indicator **ID 186 – On-farm renewable energy production** assesses what proportion of the energy used on farm is generated by the farm's own installations for renewable energy production, such as from solar panels. As can be seen in Table 5, 38 from 87 farms, cover more than 90 % of their own energy needs through their own installations. These installations were solar panels installed on the roofs of the various farm buildings. Of the 87 farms, 23 farms did not have any installations for on-farm renewable energy production. During the interviews, some farmers mentioned that they would have liked to install even more solar panels on their roofs but felt hampered by the current maximum square-meters of panels allowed per private person.

Table 5: Sample size (n) and absolute frequency distribution in 10 % steps for the indicators related to the main topic „Energy ".

ID	Indicator	n	0	>0-10	>10-20	>20-30	>30-40	>40-50	>50-60	>60-70	>70-80	>80-90	>90-100
186	*On-farm renewable Energy production*	87	23	0	1	2	5	6	4	4	0	4	38
190	*Biogas Plant: Share Organic Residues*	11	0	0	0	0	0	0	2	0	1	2	6
192	*Plants for Energy Production instead of Human Consumption*	12	5	2	2	1	0	2	0	0	0	0	0
196	*Insulation of Heated Farm Buildings*	22	5	0	0	1	0	0	0	0	0	1	15
203	*On-Farm Renewable Heat Production*	87	9	1	0	1	0	1	0	0	1	1	73

The proportion of the heating-energy consumption that is provided by renewable energy is assessed by indicator **ID 187 – Renewable heating and hot water**. Out of 87 participating farms, 76 farms either did not use any heating energy (no farm buildings being heated) or 100 % of the heating energy came from renewable sources (e.g. through burning of wood chips) (results not shown). Both no heating energy needed and 100 % energy from renewable sources are rated the same in the SMART-Farm Tool and can no longer be distinguished in this indicator to identify the farms with no heating energy needed. A further 11 farms heated at least some parts of the farm buildings (this was often the milking parlour). The most common farm buildings that needed heating were poultry and pig pens, farm shops and on-farm further processing facilities.

Out of the 57 ruminant husbandry farms, 53 were rated with 100 %; however as mentioned above, it is impossible to clearly discern from this indicator what proportion did not heat at all, and what proportion used 100 % renewable energy. Nevertheless, based on the interviews, the specialized ruminant husbandry farms most commonly heated no farm buildings, except sometimes electrically the pipes in the milking parlour. The other remaining ruminant husbandry farms also heated other farm buildings, of which 3 used 0 % renewable energy sources.

Out of the 5 farms with only monogastric animal husbandry, 3 heated their farm buildings completely with renewable energy or not at all, and one with 91 % renewable energy. The remaining farm used 0 % renewable energy for heating the farm buildings. Of the 15 farms with both ruminant and monogastric husbandry, 11 farms heated their buildings with 100 % renewable energy. Of the remaining 4 farms, 3 used 0 % renewable energy and the other 84 %.

Out of the 10 farms with no animal husbandry, 8 either did not heat or used 100 % renewable energy. Out of the remaining 2 farms, one used 0 % and the other 48 % renewable energies sources to cover their heating needs.

The indicator **ID 188 – share of fuel from own production** asks what proportion of the fuel used for farm vehicles and machinery is produced on-farm. Out of the 87 farms zero farms produced their own fuel (results not shown).

The indicator **190 – Biogas plant: share organic residues** assesses what proportion of organic matter utilized in a biogas plant (own or external plant) is a surplus or leftover from food/feed production (e.g. slurry). Out of the 87 participating farms, only 11 farms delivered some type of organic material to a biogas plant (own or external) (Table 5). From these 11 farms, 6 farms mainly delivered organic residues (> 90 %) to the biogas plant. Although the remaining 5 farms delivered lower shares of organic residues to biogas plants, the lowest share was still above 50 % (57 % of material delivered). The other share of organic material was always from plants grown for energy production (e.g. energy maize). This is also more directly assessed in ID 192.

The indicator **ID 192 – Plants for energy production instead of human consumption** looks at what proportion of the substrate produced on-farm and used for energy production would also be suitable for human consumption (with focus on farms that use plant materials for energy production). The definition of plant material suitable for human consumption should be interpreted a little bit more loosely; the tool considers plants, or rather the land used for their production, that could also otherwise be used for feed or food production. The aim is to assess the competition between land used for food production and land used for energy production. Common examples of such plant materials are energy maize, energy rye and other cereals harvested as fresh matter or certain field fodder mixtures. Out of the 87 farms, the indicator was relevant for 12 farms (Table 5). As shown by the above indicator ID 190, 11 of these 12 farms deliver organic material to biogas plants (own or external plant). The remaining farm grows *Miscanthus x giganteus* for heat/energy production. Table 5 shows that 7 of the 12 farms use only a small share of plant material suitable for human consumption for energy production (0-10 %), of which 5 use no such material at all. ID 190 and ID 192 being inversely related, the results of the remaining 5 farms for ID 192 follow the opposite trend to the results of ID 190 discussed above: The lower the share of organic residues used for energy production, the more the share of plants suitable for human consumption increases. The highest share of such material used for energy production is 43 %.

The indicator **ID 195 – energy-efficient driving** (Eco-Drive) asks whether the farm manager and workers use energy-efficient driving techniques, such as driving in high gears if possible. The indicator was relevant for 86 of the 87 farms (Table 6). The remaining farm did not use any vehicles (neither tractors nor cars) in its operation. A total of 14 farms did not pay specific attention to energy efficient driving, while 27 farms did and mentioned different mechanisms to do so. For the other 45 farms, it could not be guaranteed that all drivers implemented such measures, it could not be implemented with all vehicles or implementation depended on workload (i.e. during work peaks, getting the work done had a higher priority than energy-efficient driving).

Table 6: Sample size (n) and absolute frequency distribution of the answers no/partly/yes for the indicators related to the main topic „Energy ". A forward slash "/" in the table indicates that this answer was not an option for that specific indicator.

ID	Indicator	n	no	partly	yes
195	*Energy-efficient driving (Eco-Drive)*	86	14	45	27
345	*Irrigation Low Energy Technology Pumps*	10	4	/	6

In case farm buildings are being heated, the indicator **ID 196 – insulation of heated farm buildings** looks at what proportion of the heated farm buildings are sufficiently insulated (e.g. with double or multiple glazed windows, roof / wall / floor insulation). Out of the 87 farms, 22 farms heated at least partly some of the farm buildings (Table 5). The majority of the heated building are well insulated (15 farms have more than 98 % of the heated farm buildings well insulated). Out of the 10 farms with no animal husbandry, 5 heated their farm buildings, of which 3 were well insulated (>90 -100 %), 1 was insulated between >80-90 % and 1 was not insulated at all. 7 of the 57 ruminant husbandry farms heated: 6 were well insulated (>90 -100 %) and one was >20-30 % insulated. Out of the 5 monogastric husbandry farms, 4 heated their buildings and these were also well insulated (>90 -100 %). The remaining farm did not heat its buildings. 6 out of the 15 farms with both monogastric and ruminant husbandry heated farm buildings: 2 were well insulated (>90 -100 %), and 4 were not insulated at all.

The indicator **ID 203 – on-farm renewable heat production** calculates the proportion of the heating-energy used that is generated by the farm's own installation run with renewable sources (e.g. wood chips, geothermal, solar) (Table 5). The indicator was relevant on 81 farms; however, when no heating energy is used, the indicator is rated positively. Thus, of the 67 farms with 100 % on-farm renewable heat production, 64 were automatically rated, because they do not heat at all. Consequently, only 3 farms produced the renewable resources for heat production on their own farm. Of the remaining 14 farms, 9 farms produced 0 % of their own on-farm resources for heat production. The "missing" 5 farms were farms that heated at least partially some of their buildings, but that heating was done using electricity. As such, the electricity for heating purposes was captured in the total electricity demand of the farm. However, it was impossible for the farmers to estimate the fraction of their electricity consumption used for energy or used for heating, especially as these farms were generally dairy farms, that, as mentioned above in ID 187, heated only some of their pipes a couple of degrees so they wouldn't freeze during really cold winters.

The indicator **ID 332 – electricity consumption per ha** measures how much electricity is used on the farms per hectare and year. Private use from family housing on the farm grounds was not considered. Of the 87 farms, 2 did not use any electricity (Table 7). These two were very specialised small part-time farms with no animal husbandry and no farm buildings. Most farms used >250-500 kWh/ha/year of electricity (30 farms). The farms with higher electricity consumption per hectare (>2500 kWh/ha/year) were generally either horticultural farms or specialised farms with monogastric husbandry. These types of farms are often smaller in size but more intensively use their farm buildings (e.g. greenhouse or pigsty). Consequently, smaller farms have a higher electricity consumption due its relation to farm size.

Table 7: Sample size (n) and absolute frequency distribution (not equidistant) for the indicator ID 332 -Electricity Consumption related to the main topic „Energy ".

ID	Indicator	n	0	>0-100	>100-250	>250-500	>500-1000	>1000-2500	>2500-5000	>5000-10000	>10000
332	*Electricity Consumption*	87	2	10	15	30	19	6	2	1	2

The indicator **ID 341 – setting of combustion motors** assesses how often the settings of combustion motors of farm vehicles (e.g. tractors) and other machineries are checked and adjusted. All participating farmers had regularly checked their engines and their registered tractors and stapler passed through a yearly technical control of vehicles (results not shown).

The indicator **ID 345 – irrigation: low energy technology and pumps** looks at whether the farm uses low-energy irrigation technology and pumps, drip irrigation and micro irrigation. This indicator was relevant on 10 farms (Table 6). Of the 10 farms where irrigation was implemented, 6 used low energy technologies and 4 did not.

The indicator **ID 348 – share of fuel from renewable sources** measures the proportion of the fuel consumed that is provided by renewable resources. Only 1 farm out of the 87 used fuel from renewable sources: 50 % of its fuel were bio-diesel made from rape (results not shown).

3.3.2 Animal husbandry

The indicator **ID 198 – dual-purpose breeds: ruminants** assesses the proportion of the ruminants raised on a farm are dual-purpose breeds (e.g. the European Simmental breed). On 72 farms ruminants are being raised and the indicator was rated relevant (Table 8). The majority of the farms (60 farms) do not use any dual-purpose breeds, but use breeds specific to their production aims (e.g. Holstein breed for dairy production, Limousin breed for meat production). Only 5 farms have over 75 % of dual-purpose breeds in their herd.

Table 8: Sample size (n) and absolute frequency distribution in 25% steps for the indicator ID 198 -Dual purpose breed: Ruminants related to the main topic „Animal husbandry".

ID	Indicator	n	0	>0-25%	>25-50%	>50-75%	>75-100%
198	*Dual-purpose breeds: Ruminants*	72	60	3	0	4	5

Similar to ID 198, the indicator **ID 198.1 dual-purpose breeds: poultry** looks at the proportion of poultry on a farm that are dual purpose breeds. A total of 14 farms raised poultry, either laying hens or broilers. Of these 14 farms, only two farms used dual-purpose breeds: the one farm used 100 % dual purpose breeds, the other 81 % (results not shown).

The indicator **ID 331 – waste disposal: cadaver livestock** evaluates whether all animal wastes/cadavers are disposed of properly (no risk of harm to human health or the environment). All 77 farms with animal husbandry disposed of their animal cadavers properly and according to regulations (results not shown): all livestock cadavers (even stillbirth) and associated materials are reported and collected by the society RENDAC C.E.S., which has been commissioned with this task through a state agreement by the Luxembourgish government[5].

The indicator **ID 370.5 – daily outdoor access for all animals** assesses whether all animals have year-round daily outdoor access. Of the 77 farms with animal husbandry, 70 farms did not provide year-round daily outdoor access for all animal categories, whereas 7 farms did (Table 9). 4 of these farms are organically and 3 conventionally managed. It is important to note, that if one animal category (e.g. dairy cows or laying hens) or animal group (e.g. calves, young cattle, heifers and dairy cows) was not given the daily outdoor access, the indicator was answered overall with "no".

Table 9: Sample size (n) and distribution of the answers no/yes for the indicators related to the main topic „ Animal husbandry".

ID	Indicator	n	no	yes
370.5	*Daily Outdoor Access for All Animals*	77	70	7

The indicator **ID 371 – access to pasture for ruminants** in turn looks again more specifically at the number of days per year that ruminants are out on pasture. This indicator answer, similarly to ID370.5, is based on the worst condition. This means that if one group, for example the fattening bulls, do not have access to pasture while the rest of the herd has, the indicator is still answered with 0 days. Out of the 72 farms with ruminant husbandry, 35 farms did not provide access to pasture for all groups (Table 10). Most of the farms that provided access to pasture for all ruminant groups on the farm, did so for 6-8 months out of the year (>180-240 days). Three farms provided year-round access to pasture for all ruminants.

[5] https://agriculture.public.lu/de/tierhaltung/nutztiere/tierkorperbeseitigung.html [Accessed November 2020]

Table 10: Sample size (n) and absolute frequency distribution (hourly) for the indicator ID 371 -Access to Pasture for Ruminants related to the main topic „ Animal husbandry".

ID	Indicator	n	0	>0-60	>60-120	>120-180	>180-240	>240-300	>300-360
371	*Access to Pasture for Ruminants*	72	35	0	0	6	24	4	3
	Organic farms	23	6	0	0	2	11	2	2
	Conventional farms	49	29	0	0	4	13	2	1

The indicators **ID 372 – outdoor access for pigs** and **ID 373 – outdoor access for poultry** assesses the number of hours per days that pigs and poultry, respectively, have outdoor access. Again, the score is based on worst condition, meaning if one pig or hen has no outdoor access per day, 0 hours are recorded. Of the 9 farms raising pigs, 5 farms provided 24-hour daily outdoor access to their pigs (results not shown). These were all organic farms. The other 4 farms did not provide any amount of daily access. While these were all conventionally managed farms, it also needs to be pointed out, that these farms raised pigs at a different scale: the 5 organically managed farms all raised a relatively small number of pigs (<100 animals), while the participating conventional pig farms specialised on rearing and/or fattening pigs. These 4 farmers raised easily upwards of 1000 pigs per farm. Of the 15 farms raising poultry, only 1 farm did not provide any amount of outdoor access (results not shown). All the others provide upwards of 8 hours per day, with a maximum of 12 hours.

The indicator **ID 374 – duration of transport to abattoir** looks at the average duration (in minutes) of livestock transportation to the abattoir. Here again, the SMART-Farm tool evaluates according to the worst case. Out of the 77 farms with animal husbandry the indicator was rated for 76 farms. The remaining farm was newly established and had not yet had any animals transported to an abattoir. No farm had all their animals slaughtered on-farm, even though at least one farm had the possibility for poultry (Table 11). The farms with lower transportation durations drove their animals themselves to the abattoir. As soon as an intermediary collected the animals to drive them to the abattoir, the farmer could not always be sure how many other stops were made to collect more animals from other farms and how long the drive really was. In case of uncertainty, the auditors were instructed to penalize the farmer and the transport duration was set to 180 minutes. This also explains in part the high proportion of farms in the >150-180 minutes category.

Table 11: Sample size (n) and absolute frequency distribution (30 minutes) for the indicator ID 374 -Transport Duration Abattoir related to the main topic „ Animal husbandry".

ID	Indicator	n	0	>0-30	>30-60	>60-90	>60-120	>120-150	>150-180
374	*Transport Duration Abattoir*	76	0	11	8	2	3	4	48

3.3.3 Feed

The indicator **ID 199 – bought-in concentrated feed** assesses what proportion of concentrated feed used on the farm is sourced externally. Out of the 87 farms 77 farms raised animals, and all of these 77 farms used concentrated feed in their feed rations. Concentrated feed is defined in the SMART-Farm tool as feed rich in energy and/or protein, but poor in crude fibre. According to the tool glossary, energy-rich concentrated feed usually consists of cereals, protein-rich feed often consists of legumes such as protein peas or soybean. Often industrial by-products such as rapeseed meal, soy extraction meal or dried pulp (from sugar production) are also included in concentrated feed. The majority of farms (30 farms) externally source more than 90 % of their concentrated feed needs (Table 12). At the other end of the spectrum, only 6 farms show 100 % concentrated feed autarky and do not buy any amount from outside the farm. These were all farms that raised ruminants for meat production; 4 were organically and two conventionally managed. From the interviews, it could be gathered that often at least part of the energy portion of the concentrated feed rations were grown on farm in form of e.g. cereals, whereas the protein portion, mainly soybean, was most often imported into the farm operation. In monogastric animal husbandry, generally pre-mixed ready feed rations are bought for the different phases of the production. This results in 100 % of concentrated feed used on the farm being sourced externally. Some of the farmers first sell their cereals to animal feed producers/sellers before buying back pre-mixed feed rations; however, this was not considered for this indicator. This is rated as if they would buy their feed externally, instead of using their own feed.

Table 12: Sample size (n) and absolute frequency distribution in 10 % steps for the indicators related to the main topic "Feed".

ID	Indicator	n	0	>0-10	>10-20	>20-30	>30-40	>40-50	>50-60	>60-70	>70-80	>80-90	>90-100
199	*Bought-In Concentrated Feed*	77	6	2	5	3	6	5	5	6	3	6	30
626	*Proportion Bought-In Roughage*	75	34	23	11	3	1	2	0	0	1	0	0

Furthermore, a higher relative frequency of organic farms purchased 0 % of their concentrated feed needs than conventional farms, while a higher relative frequency of conventional farmers externally sourced more than 90 % of their concentrated feed needs (Figure 4).

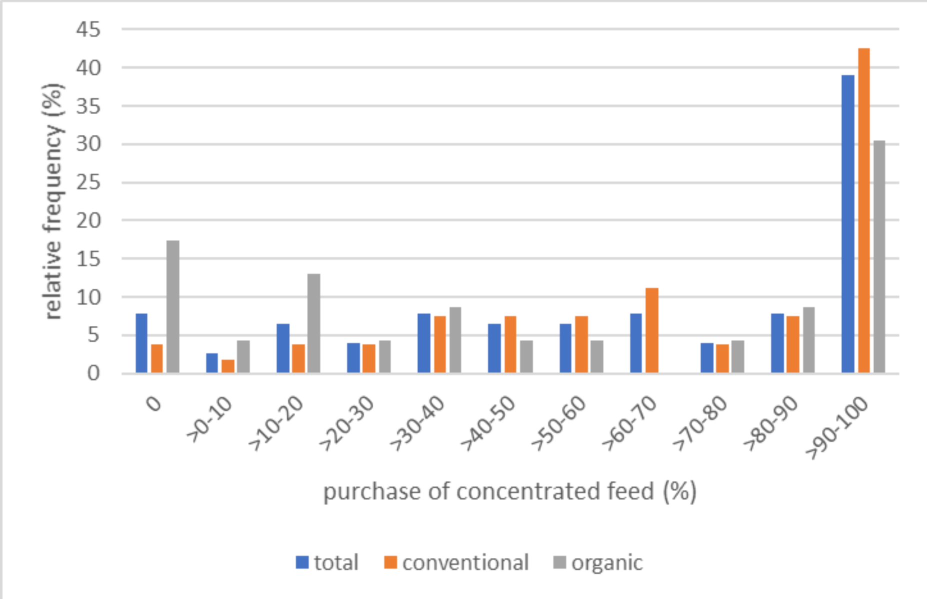

Figure 4: Sample size (n) and absolute frequency distribution in 10% steps for the indicator ID 199 – bought-in concentrated feed for the total sample and for the management systems conventional and organic.

The indicator **ID 517 – feed no food: grazing livestock** calculates the amount of the feed per livestock unit and year given to grazing livestock that would also be suitable for human consumption. Feed suitable for human consumption is defined as maize, cereals and other concentrated feedstuff such as soybean or peas. The amount of fed silage maize was converted to grain maize by dividing the amount by 4. By-products from the food industry such as draff were not considered suitable for human consumption and excluded from the calculation. Of the 72 farms with ruminant livestock, 4 farms did not feed any such feedstuff, while 15 farms fed between >0-500 kg/livestock unit/year (Table 13). The most intensive 7 farms fed >3500 kg/livestock unit/year. These were all dairy farms with corresponding high milk yield. The highest amount of feed suitable for human consumption fed to the ruminants was 4374 kg/livestock unit/year.

Table 13: Sample size (n) and absolute frequency distribution (500 kg/livestock unit/year) for the indicator ID 517 - Feed no Food: Grazing Livestock related to the main topic „Feed ".

ID	Indicator	n	0	>0-500	>500-1000	>1000-1500	>1500-2000	>2000-2500	>2500-3000	>3000-3500	>3500
517	*Feed No Food: Grazing Livestock*	72	4	15	13	9	9	5	7	3	7

The indicator **ID 518 – feed no food: non-grazing animals** in turn focusses on the proportion of the feed given to non-grazing animals (i.e. monogastrics) that would be suitable for human consumption. Of the 20 farms with monogastric animals, 18 were rated that 100 % of the feed would be suitable for human consumption (results not shown). The other two farms had a share of 5 % and 20 %, respectively, of feed in their ration that would not be suitable for human consumption (e.g., by-products from the food industry).

The indicator **ID 626 – proportion bought-in roughage** calculates the proportion of used roughage that is sourced externally. The indicator was relevant for 75 farms (farms with ruminant and pig husbandry) (Table 12). Out of these 75 farms, 34 were completely self-sufficient in terms of roughage in the year 2017 and did not source any proportion externally. A further 23 farms only bought-in between >0-10% of their roughage needs. The highest bought-in proportion was 78 %. For reference, the year 2017 was on average warmer than the average of the reference period 1981-2010 and was marked by a strong rainfall deficit in the first half of the year (January – June), while the second half was marked by an excess of rainfall (Ministère de l'Agriculture, de la Viticulture et de la Protection des consommateurs, 2018). These weather extremes resulted for many of the participating farms in bad yields for the first two cuts, which could be somewhat compensated with better yields for the third or fourth cut of the season.

3.3.4 Fertilisation

The indicator **ID 200 – covered slurry stores (or stable natural crust)** assesses whether slurry stores are covered and/or have a stable natural crust. Out of the 87 farms, 60 produced and stored slurry on their farm (results not shown). The slurry stores of all of them were either covered or had a stable crust formed on top of them. The predominant slurry store was underground storage.

The indicator **ID 201 – slurry application with drag hose system or by injection** assesses to what extent / proportion these systems are being used for slurry application. The indicator looks at the area fertilised with slurry and calculates on what proportion the area the methods are implemented. A total of 63 farms fertilised with slurry, 33 of which did not use methods for close to ground level slurry application (Table 14). The other 30 used such methods on at least part of the slurry fertilised land, with 17 using them on over 90 % of the area.

Table 14: Sample size (n) and absolute frequency distribution in 10% steps for the indicators related to the main topic „Fertilisation “.

ID	Indicator	n	0	>0-10	>10-20	>20-30	>30-40	>40-50	>50-60	>60-70	>70-80	>80-90	>90-100
201	*Slurry Application with Drag Hose System or by Injection*	63	33	0	2	0	0	1	0	1	5	4	17
712.1	*Imported Organic Fertilisers Calc*	83	54	4	3	3	0	3	2	1	1	1	11

The indicator **ID 290.1 – determining fertiliser requirements** assesses how often soil analyses are performed to determine nutrient contents (at least nitrogen (N), phosphorous (P), potassium (K)) and soil properties (e.g. pH) in view of fertiliser requirements. Of the 86 farms with agricultural land, 6 performed soil analyses every year on the majority of their fields, 46 performed soil analyses at least every 2 to 5 years on each field and 31 at least every 6 to 10 years (Table 15). On 3 farms no soil analyses were performed in the last 10 years. The majority of the farms generally assess the basic nutrient contents (P, K, Magnesium (Mg) and Calcium (Ca)), especially in the framework of the "Landschaftspflegeprämie", but often do not analyse N, neither in form of total N (Ntot) nor mineralized N (Nmin).

Table 15: Sample size (n) and absolute frequency distribution of the answers every year/2 to 5 years/6 to 10 years/ > 10 years for the indicator ID 290.1 – Determining Fertiliser Requirements related to the main topic „Fertilisation".

ID	Indicator	n	Every year	2 to 5 years	6 to 10 years	> 10 years
290.1	*Determining Fertiliser Requirements*	86	6	46	31	3

The indicator **ID 323.1 – N from fertiliser calc** calculates how much N from fertilisers (in kg) the farm applies on its agricultural area per hectare and year. Out of the 86 farms with agricultural area, 83 farms apply N either through mineral or organic fertilisers onto their fields (Table 16). The majority of the farms applied less than 200 kg N/ha/year: 29 applied >0-100 kg N/ha/year and 29 applied >100-200 kg N/ha/year. Another 20 applied >200-300 kg N/ha/year. The highest amount of N spread was 417 kg N/ha/year.

The Grand-Ducal regulation states that the application of nitrogen fertilisers is only allowed to cover the physiological needs of plants, taking care to limit nutrient losses and taking into account the availability of nitrogen in the soil (Gouvernement du Grand-Duché de Luxembourg, 2000). The amount of organic fertiliser applied per year per hectare must not exceed 170 kg of nitrogen, except for protein crops and pure legume crops for which the limit is 85 kg of nitrogen. These limitations are also used as the baseline in the national regulation in the framework of the programme of premiums for the upkeep of the countryside and the landscape (Gouvernement du Grand-Duché de Luxembourg, 2016). Furthermore, the total quantity of mineral nitrogenous fertilisers applied per year and per hectare must not exceed the maximum quantities of nitrogenous fertilisers as defined in the annex 1 of the regulation, depending on the nature and yield of the crops (e.g. the highest nitrogen fertiliser amount is allowed for field fodder crops with 300 kg N/ha/year at an expected dry matter yield of 110 dt/ha, followed by permanent grassland areas with an allowance of 260 kg N/ha/year at an expected dry matter yield of 90 dt/ha) and taking into account local specificities and the agro-climatic conditions of the year. In the case of a combination of organic and mineral fertilisers, the maximum mineral nitrogen fertiliser must be reduced according to the quantity of organic fertiliser applied, taking into account the nature of the organic fertiliser, the method of application, the type of crop and the period of application (Gouvernement du Grand-Duché de Luxembourg, 2000). It is important to note, that while given upper limits are crop specific, the compliance to the regulation is based on the total agricultural area. In the SMART-Farm tool, however, the amount of N fertiliser applied is divided by the actual area that fertilisers were applied onto, consequently resulting in a higher amount of N/ha/year. Thus, the amount of N applied may be within the acceptable range set out by the Luxembourgish regulations when calculated across the whole agricultural area of the farm, while the total N per hectare actually fertilised area exceeds 400 kg N as seen here. Furthermore, the amount of N from organic fertilisers is based on default values from databases stored in the SMART-Farm Tool, when the farmer did not know the nutrient content of their own slurry or manure. This may result in more extensively managed farms being overbudgeted in terms of N applied to their fields.

Table 16: Sample size (n) and absolute frequency distribution (increments of 100 kg N/ha/year) for the indicator ID 323.1 – N From Fertiliser Calc related to the main topic „Fertilisation“.

ID	Indicator	n	>0-100	>100-200	>200-300	>300-400	>400-500
323.1	*N From Fertiliser Calc*	83	29	29	20	4	1

The indicator **ID 712.1 – imported organic fertilisers calc** calculates the proportion of the entire organic fertilisers used that is externally sourced. The calculation is based on the N content of the fertilisers and green manure is not included. Out of the 87 farms, 83 used organic fertilisers: 54 of these did not import any share of their organic fertiliser needs, while 11 imported >90-100 % (Table 14). The farms that imported such a high share of their organic fertiliser use were either farms without animal husbandry (horticultural and crop production farms) or farms that exported the whole of the organic fertiliser produced on the farm to a biogas plant and then imported back the equivalent in biogas slurry (4 farms).

3.3.5 Agricultural land management

The indicator **ID 202 – agro-forestry system** measures on what percentage of agricultural area such systems are established. This Indicator was relevant for 86 of the 87 farms and only three of these farms implemented such systems. Two had established these systems on an area >0-10 % of the agricultural area; however, one farm implemented agro-forestry on 100 % of their agricultural area (results not shown).

The indicator **ID 204 – woodlands: deforestation** assesses what proportion of the farm's current agricultural area has been deforested over the past 20 years to convert to a non-forest use. Of the 86 farms with agricultural land, 74 did not remove any forests to gain agricultural land (results not shown). 11 farms deforested between > 0 – 10 % of their agricultural land in the past 20 years; one farm gained 18 % of their farm land through deforestation; however, it needs to be noted here, that this was on land in one of our neighbouring countries and was thus not subject Luxembourgish laws and regulations.

The indicator **ID 206 – share of legumes on arable land** calculated the proportion of the arable land devoted to leguminous crops. Out of the 87 farms, 79 farms laboured arable land: 12 of these farms did not grow any leguminous crops in 2017, 32 farms grew legumes on >0-10 % of their crop land, 12 on >10-20 %, 14 on >20-30 %, 6 on >30-40 % and the remaining 3 on >40-50 % on their crop land (Table 17). The highest share was 45 %. When we look at the influence of management on this indicator, it can be seen, that a higher relative frequency of organically managed farms grew leguminous crops on a larger proportion of their arable land, compared to conventionally managed farms (Figure 5).

Table 17: Sample size (n) and absolute frequency distribution in 10% steps for the indicators related to the main topic „Agricultural land management".

ID	Indicator	n	0	>0-10	>10-20	>20-30	>30-40	>40-50	>50-60	>60-70	>70-80	>80-90	>90-100
206	*Share of Legumes on Arable Land*	79	12	32	12	14	6	3	0	0	0	0	0
207	*Arable Land: Share of Direct Seeding*	78	67	3	4	1	0	0	0	1	0	0	2
208	*Woodlands: Share of Agricultural Area*	87	27	47	4	5	2	2	0	0	0	0	0
253	*Permanent Grasslands: Extensively Managed*	81	11	32	9	7	1	1	3	0	1	2	14

The indicator **ID 207 – arable land: share of direct seeding** measures the proportion of the arable land that is managed by method of direct seeding. This indicator was relevant for 78 farms, (Table 17). One of the farms only grew perennial field fodder and did not plough or sow any new crops in 2017. Of the 78 farms, 67 farms did not use the method of direct seeding on any share of their arable land. Overall, the method is only implemented on small shares of the arable land, with only three farms using the method on a share > 60 %.

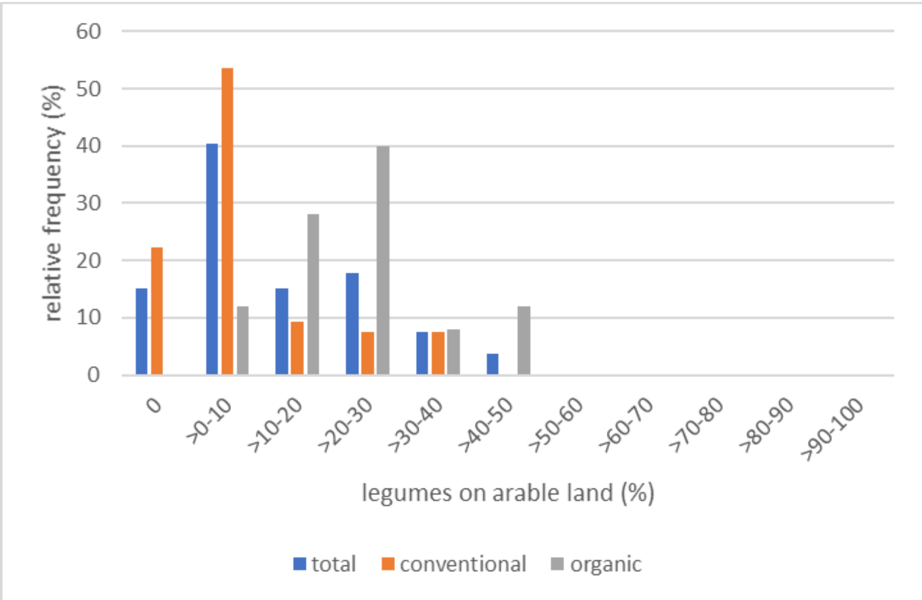

Figure 5: Sample size (n) and absolute frequency distribution in 10 % steps for the indicator ID 206 – share of legumes on arable land for the total sample and for the management systems conventional and organic.

The indicator **ID 208 – woodlands: share of agricultural area** assesses the proportion of the agricultural land that are woodlands. Of the 87 farms, 27 farms did not own any forest or woodlands, while for 47 farms, woodlands made up between > 0-10 % of their agricultural area (Table 17). The highest share of woodlands was 48 %.

The indicator **ID 253 – permanent grasslands: extensively managed** assesses the proportion of the area of permanent grasslands that is under extensive management. Extensive management is defined in the SMART-Farm Tool as double mowing/grazing or less and zero use of inputs such as fertilisers including lime, pesticides, or other soil improvement measures. A total of 81 farms had permanent grasslands as part of their agricultural area. Of these 14 managed >90-100 % extensively (Table 17). Generally, only a small proportion of the permanent grasslands were managed extensively with 11 farms managing 0 % extensively, 32 farms between >0-10 % and a further 9 farms >10-20 %. When looking at the different management systems, it can be observed that a higher relative frequency of organic farms managed a larger proportion of their grassland extensively compared to conventional farms (Figure 6).

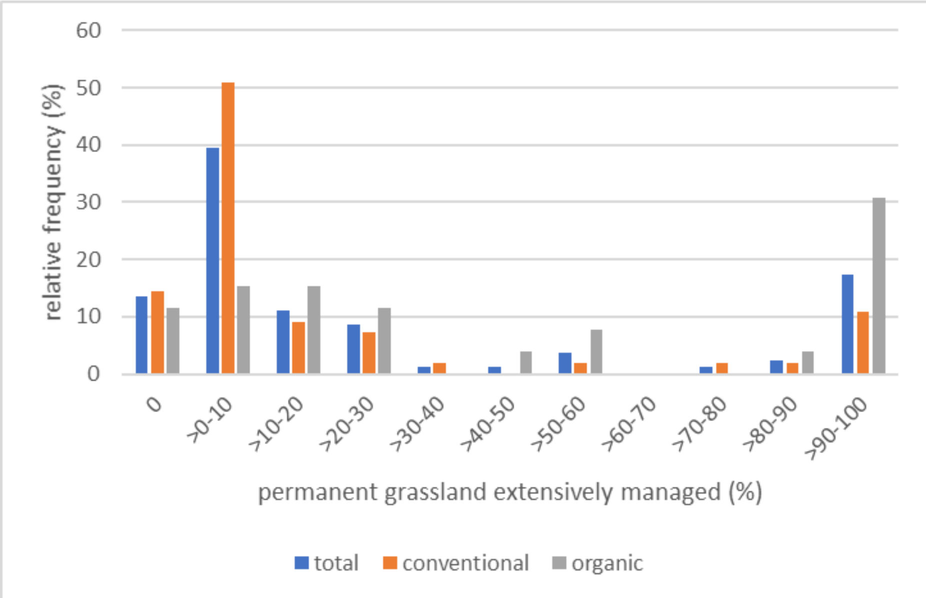

Figure 6: Sample size (n) and absolute frequency distribution in 10 % steps for the indicator ID 253 – permanent grasslands: extensively managed for the total sample and for the management systems conventional and organic.

The indicator **ID 286 – soil degradation: measures taken to counter** evaluates on what proportion of agricultural area endangered by soil degradation processes (other than erosion, e.g. compaction, contamination salination) measures are taken to combat soil degradations. It is important to note here, that if no areas were endangered by soil degradation processes or if measures to combat these processes on the whole affected area, both were rated with “yes”. Soil degradation in Luxembourg is mainly due to soil compaction and 28 farms indicated that they have compaction on their area. Accordingly, 3 of these farms did not implement measures to counteract soil degradation on 100 % of the thus affected areas: two farms did not implement measures on any affected areas (i.e. on 0 % of the area endangered by soil degradation processes) and one farm implemented measures on 41 % of the affected areas (Table 18).

Table 18: Sample size (n) and distribution of the answers no/partly/yes for the indicators related to the main topic „Agricultural land management".

ID	Indicator	n	no	partly	yes
286	*Soil Degradation: Measures taken to counter*	87	2	1	83

The indicator **ID 620 – permanent grassland: mowing frequency** focusses on how often the grassland is mowed on average. Extensive mowing frequency is defined as 1-2 cuts, medium 3-4 cuts and intensive mowing frequency as 5 or more cuts on average. A total of 80 farms had permanent grasslands that was mowed (Table 19). The majority cut their grassland only 1-2 times (42 farms), while 38 farms mowed them 3-4 times (medium). No farm mowed their permanent grassland on average 5 or more times in a season. It is important to note that this indicator only refers to mowing frequency; this does not include use for grazing.

Table 19: Sample size (n) and absolute frequency distribution of the answers extensively/medium/intensively for the indicator ID 620 – Permanent Grassland: Mowing Frequency related to the main topic „Agricultural land management".

ID	Indicator	n	extensively	medium	intensively
620	*Permanent Grassland: Mowing Frequency*	80	42	38	0

The indicator **ID 748 – humus formation: humus balance** asks whether a humus balance is calculated and, if yes, this balance is positive, balanced or negative on average. The indicator was only relevant for farms with arable land, so for 80 farms (Table 20). On 49 farms no humus balances were calculated, while humus balances were calculated for 31 farms. This was often done in the framework of the fertilisation planning by one of the extension services allowed to offer the corresponding consultancy module n° 1 "Plan de fumure" (Gouvernement du Grand-Duché de Luxembourg, 2020). In 4 cases, the soils of the farm showed a negative humus formation, while the soils on the other 27 farms showed a balanced or positive humus balance.

Table 20: Sample size (n) and distribution of the answers no/yes, negative/yes, balanced or positive for the indicator ID 748 – humus formation: humus balance related to the main topic „Agricultural land management".

ID	Indicator	n	no	yes, negative	yes, balanced of positive
748	*Humus Formation: Humus Balance*	80	49	4	27

The indicator **ID 764 – share of legumes on perennial crops area** calculates the proportion of perennial cropland area devoted to legumes. Perennial crops are for example permanent grassland, fruit trees or asparagus. However, the indicator only becomes relevant, when permanent crops like the latter two examples are cultivated. As such, only two farms grew perennial crops and here the share of legumes was 5.3 % and 13.7 %, respectively (results not shown).

The indicator **ID 800 – land clearing method** looks at which land clearing methods have been used to establish and/or to renovate plantations and fields over the past 20 years. Only one farm out of the 86 with agricultural area cleared woodland over the past 20 years to establish a field, and this on a piece of land that used to be a field before the wood was planted (results not shown).

The indicator **ID 802 – agro-forestry: number of layers** counts the number of layers the agro-forestry system consists of. The rating is based on the agro-forestry area under the worst condition. Of the 3 farms implementing agro-forestry system, one had 1 layer, one had 2 layers and the one with 100 % agroforestry systems (mentioned above for ID 202) had 3 layers established (results not shown).

3.3.6 Pesticide use / plant protection

The indicator **ID 231 – no use of synth. chem. herbicides** calculates the proportion of agricultural area that does not receive synthetic chemical herbicide applications. When looking at the results of this indicator, it is important to keep in mind that a 100 % result means that no synthetic chemical herbicides were applied on any of the agricultural area, and a 0 % result means that such herbicides were applied on the total agricultural area of the farm (Table 21). This also holds true for the other two indicators related to pesticide application ID 233 and ID 234. Out of the 86 farms with agricultural area, 37 farms did not use any synthetic chemical herbicides on > 90-100 % of the agricultural area; of these 37, 27 were organically managed and used no such herbicides at all. The other 10 farms were conventionally managed of which 9 also completely renounced the use of these herbicides in 2017. No farm used synthetic chemical herbicides on 100 % of their agricultural area; the lowest share of agricultural land where herbicides were applied was 1.8 % by a farm that did not fully renounce the use of herbicides. It needs to be pointed out that the use of chemical synthetic pesticides was assessed based on crops and did not allow to differentiate when not all fields with the same crops or not the whole field of one crop were treated differently in terms of pesticide application. For example, in terms of herbicide use in permanent grassland, many of the participating farmers treat areas where nests of problematic weeds occur with a small hand sprayer. In the SMART-Farm Tool, the whole field was nevertheless calculated as have been treated. This again also holds true for the indicators ID 233 and ID 234.

Table 21: Sample size (n) and absolute frequency distribution in 10 % steps for the indicators related to the main topic „Pesticide use / plant protection ".

ID	Indicator	n	0	>0-10	>10-20	>20-30	>30-40	>40-50	>50-60	>60-70	>70-80	>80-90	>90-100
231	*No Use of Synth. Chem. Herbicides*	86	0	3	1	3	0	2	12	13	11	4	37
233	*No Use of Synth. Chem. Fungicides*	86	0	1	0	1	0	0	1	7	7	12	57
234	*No Use of Synth. Chem. Insecticides*	86	0	0	0	1	0	0	0	1	4	1	79

The indicator **ID 233 – no use of synth. chem. fungicides** looks at the proportion of agricultural area that does not receive synthetic chemical fungicide applications. The indicator was relevant for 86 farms, of which 57 did not use any synthetic chemical fungicides on >90-100 % of their agricultural area (Table 21). Of these 57 farms, 27 were again organically managed; 23 of the 30 conventionally managed farms in this percentage range did also not use such fungicides on any of their agricultural land. As with ID 231, no farm used fungicides on 100 % of their agricultural area;

however, the lowest share of agricultural land where no such fungicides were applied was 4.1 %. Consequently, synthetic chemical fungicides were applied on 95.9 % of the agricultural area of this farm. As mentioned above for ID 231, there was no differentiation if not all fields of the same crops or not the whole field of one crop were treated the same in terms of fungicide application.

The indicator **ID 234 - no use of synth. chem. insecticides** measures the proportion of agricultural land that does not receive synthetic chemical insecticide applications. The indicator was again rated for 86 farms, of which 79 did not use any synthetic chemical insecticides on >90-100 % of their agricultural area: 27 farms were organically managed and used no such pesticides at all, while 43 conventional farms also did not apply any synthetic chemical insecticides on their agricultural land in 2017 (Table 21). The lowest share of agricultural land where no such insecticides were applied was 20.8 %. Similar to ID 231 and 233, all fields of the same crop or a whole field of one crop were treated the same in terms of insecticide application in the SMART-Farm Tool, even when a farmer differentiated between and within them, e.g. only applied insecticide on field A sown with barley but not on field B with barley.

The indicator **ID 377.75 – pesticides: acute toxicity inhalation** evaluates whether active substances are used in the applied pesticides, which are considered acute toxic when inhaled by the users according to the “Globally Harmonized System of Classification (GHS)”. The different pesticides are classified into 5 different groups according to their acute inhalation toxicity: 1 equalling extremely toxic and 5 equalling not toxic when inhaled. Of the 86 farms with agricultural area, 54 applied pesticides (including organic farms applying pesticides allowed in organic agriculture) (Table 22). Of these 54, 41 used active substances that were extremely toxic when inhaled (category 1), and three used active substances that were classified as not toxic when inhaled (category 5).

Table 22: Sample size (n) and absolute frequency distribution in the toxicity classifications 1 (extremely toxic when inhaled) - 5 (not toxic when inhaled) for the indicator ID 377 – Pesticides: Acute Toxicity Inhalation related to the main topic „Pesticide Use / plant protection“.

ID	Indicator	n	1	2	3	4	5
377.75	*Pesticides: Acute Toxicity Inhalation*	54	41	7	0	3	3

The indicator **ID 740 – growth regulation** assesses whether farms decline to use synthetic chemical growth regulators. The indicator was relevant for 83 out of the 87 farms in the sample. The other four farms did not have any arable land and or arable crop production, to which the relevance of this indicator is linked. The indicator was automatically positively rated for the 27 organic farms, as well as 2 conventional farms; the former because they per se do not use such products and the latter because they also renounce the use of any synthetic-chemical inputs on their farm. Thus, Table 23 shows the answers given by the remaining 56 conventional farms: 14 farms declined the use of growth regulators, while the other 42 use such inputs.

Table 23: Sample size (n) and distribution of the answers no/yes for the indicators related to the main topic „Pesticide Use / plant protection“.

ID	Indicator	n	no	yes
740	*Growth Regulation*	56	42	14

The indicators **ID 741 – steaming on open ground** and indictor **ID 742 – steaming in the greenhouse** assess whether soil steaming is performed on open ground and in the greenhouse, respectively. When steaming is performed, the depth of steaming is also considered: flat steaming is up to a depth of 10 cm; everything deeper is considered as deep steaming. Since this is a method generally used in horticulture, the indicators were only relevant for the 12 farms that grew vegetables, either field vegetables or in greenhouses (results not shown). Only one farm used (deep) steaming as a method for soil disinfection, both on open ground and in its greenhouses.

The indicator **ID 747 – flowering regulation** looks at the use of products to influence the flowering of plants or for desiccation. Such products are prohibited for use in Luxembourg, and consequently no farmers regulated flowering or desiccation utilising such products.

The indicator **ID 749 – soil disinfection** assesses whether chemicals are used for soil disinfection. The indicator was relevant on 14 farms (horticulture and fruit production); none of the farms used such chemicals.

3.3.7 Environmental emissions

The indicator **ID 380 – on-farm point sources of nutrients and pollutants** looks at whether it can be excluded that there are direct point source emissions of nutrients and pollutants to the atmosphere and water bodies (incl. wells and drinking water sources) on the farm and its utilized areas. Examples are emissions through discharge and degas from exercise yards, farmyards manure stores near water sources or direct entry of animals into the water bodies. Of the 87 farms, such point sources could only be excluded with certainty on 15 farms (Table 24). This is in part due to the fact, that the indicator covers a very vast area of possibilities for such point sources, and in part due to the fact, the SMART-Farm Tool assesses here the risk such a point source could happen, since we can't actually measure it. Thus, even though a risk exists on 72 farms, that nutrients and/or pollutants can enter the environment (either atmosphere or water bodies), this does not mean, that such point sources are currently emitting nutrients and/or pollutants on these 72 farms.

Table 24: Sample size (n) and distribution of the answers no/partly/yes for the indicators related to the main topic „Environmental emissions“. A forward slash "/" in the table indicates that this answer was not an option for that specific indicator.

ID	Indicator	n	no	partly	yes
380	*On-Farm Point Sources of Nutrients and Pollutants*	87	72	/	15
511	*Contamination through Emissions: exhaust emissions, factories or airports*	87	77	/	10
720	*Silage Storage*	68	0	18	50
788	*Open Burning of Farm or Household Wastes and Bushes*	86	82	/	4

Similarly, to ID 380, the indicator **ID 511 – contamination through emissions: exhaust emissions, factories or airports** assesses whether there exists a risk of contamination from motorways (or other heavy traffic roads), industry or airports. The risk that such contamination could occur was deemed possible on 10 out of the 87 farms (Table 24). These all had fields close to motorways or other heavily used roads.

The indicator **ID 720 – silage storage** evaluates whether the silage is stored appropriately to minimize losses and avoid contamination. Of the 87 farms, 68 used silage as a way to preserve fresh feed for the winter months (Table 24). On the majority of farms (50 farms), the silage was stored in ways to both reduce the risk of nutrients losses and contamination of the silage (e.g. silage was stored on fixed plates, leachate was collected and the silages were cleanly closed). On the remaining 18 farms this could only be guaranteed in part: examples were some of the silage round-bales being stored on unpaved ground, holes in the silage foil being observed and possible leachate not being collected.

The indicator **ID 738 – production materials: use of problematic elements** assesses whether the farm only uses production materials that are made of less problematic plastic types. Two examples of problematic plastics given in the SMART-Farm Tool are polystyrene and PVC (polyvinyl chloride). This is a very vast topic and given that no clear definition of a problematic plastic was given in the SMART-Farm Tool coupled to the inability of farmers being able to name what types of plastics are used on their farm (e.g. silage foil, nettings, hoses, planters, etc.), this indicator could only be rated on one farm with certainty with a "yes – no problematic plastic types are used on the farm" (results not shown).

The indicator **ID 788 – open burning of farm or household wastes and bushes** looks at whether the farm refrains from burning bushes and/or crop residues. This practice has been prohibited in Luxembourg since 1994 (Gouvernement du Grand-Duché de Luxembourg, 2012, 1994); however, during the interviews it became clear that many of the farmers believed that it only became recently outlawed. As a consequence, 4 farmers out of the 86 with agricultural area were still burning their cuttings from hedges and trees in 2017 (Table 24).

3.3.8 Additional air quality data collected at farm-level

In the following, the results to the additional air quality data collected at farm-level are presented. As previously with the indicators, the additional questions are evaluated depending on the respective answer options and not all questions were relevant for all farms. The sample size (n) for the questions can therefore be <87.

Answers to the additional question "**How big are the capacities of the slurry tanks?**" were collected on 77 farms, of which 74 could be evaluated (Table 25; "current capacity"). The other 3 responses were farms that exported their slurry to biogas plants and, thus, the on-farm slurry tank capacity is not of relevance. In order to have an inclination whether on-farm storage capacities were big enough, the needed capacity was calculated based on on-farm livestock units and standardized metrics[6] for expected slurry production per livestock unit for a rough estimation if current capacities meet the minimum requirement of 6 months slurry storage capacity (Gouvernement du Grand-Duché de Luxembourg, 2000). It can be seen from the summarized data, that current storage capacities cannot fully meet needed capacities based on livestock units (Table

[6] Needed slurry capacity (m3) = livestock unit x 6 months x 2.2 m3 slurry produced/dairy cow/month; the 2.2 m3 slurry produced/dairy cow/month is based on data from the KTBL book "Festmist- und Jaucheanfall" by Rutzmoser et al. (2014) ISBN 978-3-941583-68-9

25). However, as only a rough estimation of needed storage capacities was done, an overestimation of needed capacities is to be expected: no differentiation was done in terms of housing conditions (on most farms, at least part of the herd is kept on deep litter housing or bedded stalls, minimising slurry production) or orientation of husbandry (dairy cows were used as the basis for the slurry production calculation (see footnote 6); slurry production in suckler cows for example is generally lower). Furthermore, while no slurry was produced on 17 of the 73 farms, their theoretical capacity requirements were still calculated further distorting the results shown in Table 25. In hindsight, this additional question would have benefitted from a different formulation, maybe asking specifically whether the farm meets the minimum slurry storage requirements. The overall feedback from the auditor team is, however, that the farmers' first answer generally was, that these requirements are being met, before providing the actual storage volume in m^3.

Table 25: Sample size (n) and absolute frequency distribution (increments of 1000 m^3) for the for the additional air quality question *„How big are the capacities of the slurry tanks?"*.

Additional question	**n**	**0**	**> 0 - 1000**	**>1000 - 2000**	**>2000 - 3000**	**>3000 - 4000**	**>4000 - 5000**	**>5000 - 6000**	**>6000 - 7000**	**> 7000**
current capacity (m^3)	74	17	26	15	11	0	2	1	1	1
needed capacity based on livestock units (m^3)	74	0	20	28	11	8	4	0	2	1

Out of the 87 farms participating in the study, data on **the practice of slurry separation ("Do you separate the slurry?")** was collected on 84 farms (Table 26). Only four farms separated their slurry in 2017 before application. Of these four farmers, one uses the solid residue as a bedding material in the stalls. In the group of farmers that answered "No", two had tested this method in the past, but were not satisfied with the results. Both mentioned the high energy demand involved with the separation technology. One farmer explained, that they were thinking about separating the slurry in the future.

Table 26: Sample size (n) and distribution of the answers no/ yes/ no slurry for the additional air quality question *„Do you separate the slurry?"*.

Additional question	**n**	**no**	**yes**	**no slurry**
Do you separate the slurry?	84	54	4	26

The additional question "**Are your slurry tanks sealed at the bottom?**" was not as easily answered as originally thought. Data was collected on 58 farms with slurry tanks (results not shown). Many of the farms had slurry tanks build during different periods of farm expansion and depending on the age of the slurry tanks and the regulations in place at the time of the building, the slurry tanks were sealed specifically at the bottom or not. On 39 farms, there was no specific sealing in place for the slurry tanks, as they were generally built before 2010. Slurry tanks build after 2010 in contrast either a special foil or a rubber layer were used to provide an extra seal to the bottom: 19 farms had such newer slurry tanks build. However, most of these farms also still had older slurry tanks in use without additional sealing in place.

The additional question "**Do you use inputs to reduce the pH of the slurry?**", all farmers answered with No; no farmer used any inputs to reduce the pH of their slurry to prevent emissions.

Answers to the additional question "**How often do you stir the slurry in order to prevent the build-up of a stable surface crust?**" were collected on 80 farms, of which 27 did not produce slurry. The stirring frequency of the other 53 farms is shown in Figure 7. The answers to this additional question varied widely; from "multiple times a day" to "never". It even varied on individual farms, if multiple slurry tanks were present: tank size, tank depth, the group of animals and their feeding ration (the slurry might become more or less solid depending on the age group and their respective feeding regime), etc. all influenced the farmers' decision on stirring frequency. When discrepancies in stirring regime were very prominent, multiple answers were counted per farm (e.g. one slurry tank stirred every week, the other one only before application). This occurred on two farms; consequently, total number of answers is 55. The most common answer was "before application"; however, this could also mean, that they started the stirring process two weeks before the first application is planned, so the slurry is well mixed when needed.

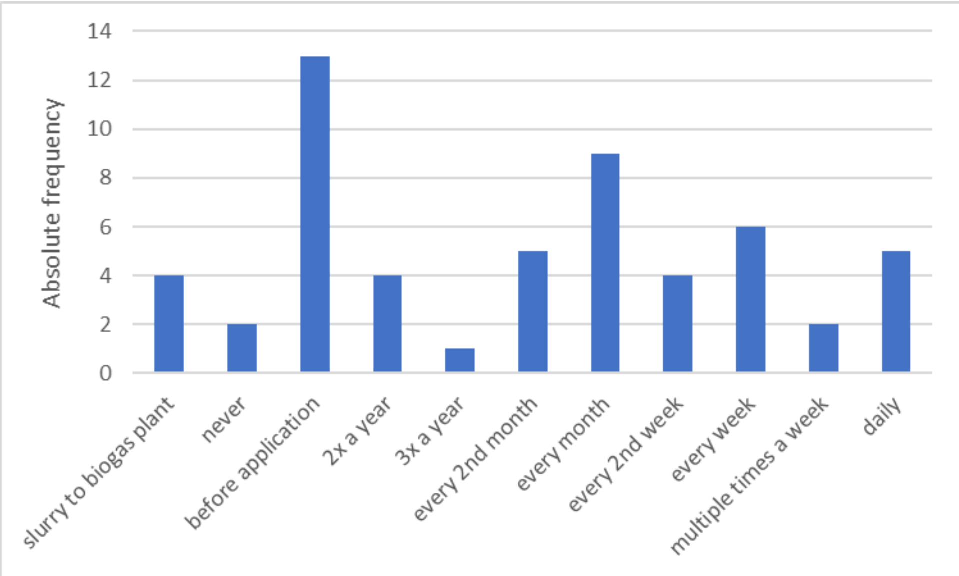

Figure 7: Absolute frequency distribution of the answers to the additional question "How often do you stir the slurry in order to prevent the build-up of a stable surface crust?". Total number of answers n = 55; multiple answers were possible.

Data was collected on 77 farms for the additional question "**How quickly, after the application of organic fertilisers do you generally work them into the soil?**" (Figure 8) and one of them answered "no organic fertilizers". Of the remaining 76 farms, 4 only have permanent grassland and 2 do not do any soil tillage (no-dig permaculture). A further 2 farms only apply organic fertilisers on their permanent grasslands or perennial field fodder areas. Of the remaining 68 farms, 33 incorporate the organic fertilisers directly during or after the application process, while 27 work the organic fertilisers into the soil within 24 hours of application. It is important to note that it was difficult for the farmers to indicate a precise number of hours; they said "directly", "the same day" or "within 24 hours" of the application. The real time window probably lies between the answers "directly" and "within 24 hours". Knowing that they need to work with the weather conditions, the most honest answers would probably have been "as soon as possible".

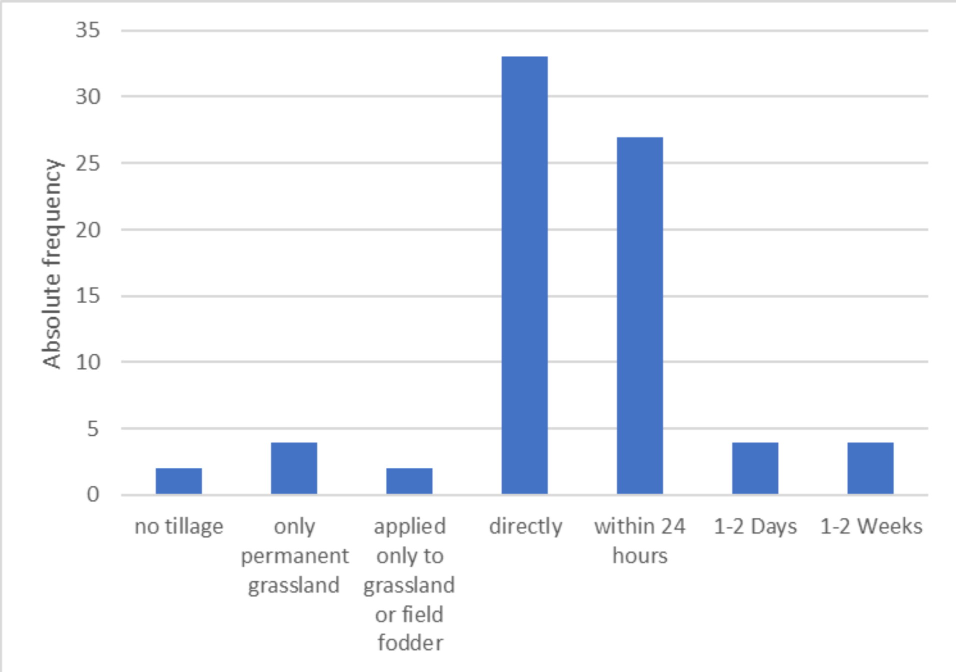

Figure 8: Absolute frequency distribution of the answers to the additional question "How quickly, after the application of organic fertilisers do you generally work them into the soil?". Total number of answers n = 76.

To the additional question "**Have you installed a ventilation system in the stable with which ammonia (NH_3) can be filtered out?**" all farmers answered with No. No such systems were installed on any of the farms. Some of the pig and poultry farms had active or passive ventilation systems to ensure good air quality in the stable for animal welfare; however, these systems did not filter out NH_3.

To the additional question "**How are the slurry tanks covered?**", data was collected on 52 farms with slurry production (results not shown). On these farms, under floor slurry tanks were the storage method in place on all farms, with no material added for the purpose of providing additional cover. The bedding of the stalls, falling through the slattered floor, acts as an additional cover on top of the slurry, helping reduce gaseous emissions. Additional to the underfloor slurry tanks, 5 farms opted to deliver their slurry regularly to biogas plants and one farm even has their own biogas plant on the farm. Here the digestate is stored in an open tank with a stable crust. Such an open tank storage system with a stable crust is also used by another farm to store its fresh slurry as an additional storage method to the underfloor slurry tanks.

The additional question "**Is manure or compost stored under a roof or covered?**" was answered 73 times (results not shown). Only on one farm was manure partially stored under a roof. The farm had a roof installed over the manure storage area next to the newly build stable for its meat production farm branch.

4. Summary

The aim of this report was to provide data on the implemented agricultural practices related to the impact of the agricultural sector on air quality. The basis for the data were results from the farm-level sustainability assessment performed in the project SustEATable. Here 87 Luxembourgish farms were analysed for their sustainability performance using the SMART-Farm tool. For the purpose of this report, a descriptive analysis was performed on the 56 indicators from the SMART-Farm tool, that impact the goal achievement in the sustainability sub-theme Air Quality. Furthermore, nine additional air quality related questions were collected during the interviews with the farm managers. The answers to these questions were also descriptively analysed and results presented here.

The 87 farms that participated in the study at hand represent 4.5 % of all agriculture holdings in Luxembourg in 2017. The agricultural land laboured by these 87 farms is on average split nearly equally between arable land and permanent grassland. These proportions are comparable to the overall share between arable land and permanent grassland of the whole agricultural land of Luxembourg. In terms of management, organic farms are overrepresented in our sample with 33.3 % compared to a share of 5 % organic agriculture in the whole of Luxembourg. The comparability of the different animal husbandry shares is difficult to gauge, however, ruminant husbandry is the most important husbandry type in Luxembourg (with 63.9 %) which is also the case in our sample with 82.8 %. The slight overrepresentation of ruminant husbandry in our sample also explains the overall larger average farms size of the sample (99.6 ha) compared to the average farms size of the whole Luxembourg agricultural sector (67.5 ha). Furthermore, it needs to be noted, that due to the nature of the project and the formulation and framework of the call for participation, it can be expected that the sample is biased towards farms that already operate more sustainably or have taken an interest in the topic of sustainability and the implementation of sustainable farming practices on their farm. As such, the presented results need to be interpreted accordingly.

On average, the sustainability performance of the 87 participating farms in the sub-theme Air Quality can be classified as *good* with a mean of 62.5 % and a median of 61 % goal achievement. The sustainability performance spans two categories, from *limited* (min = 39 %) to *best* (max = 88 %) sustainability performance. Management ($p < 0.001$), animal husbandry ($p = 0.002$) and the orientation of the ruminant husbandry ($p = 0.001$) all showed a significant effect on the goal achievement. Organically managed farms had a significantly higher goal achievement than conventionally managed farms, while farms with no animal husbandry had a significantly higher goal achievement than farms with ruminant husbandry or farms with both ruminant and monogastric husbandry. A deeper look at ruminant husbandry revealed, that meat producing farms reached a significantly higher goal achievement than dairy producing farms or farms producing both dairy and meat.

The Air Quality indicators from the SMART-Farm Tool were grouped into the topics: energy, animal husbandry, feed, fertilisation, agricultural land management, pesticide use / plant protection and environmental emissions.

A total of 13 indicators were grouped under the topic of **energy**. In terms of electricity, most farms have a consumption of below 500 kWh/ha and is almost always (except for a small proportion on one farm) sourced from renewable energy. Almost 75 % of the participating farms produced at least to some extent electricity on their own farms, with the majority covering thus 90-100 % of their own needs. The use of fuel from renewable sources was only used on one farm and none of the participating farmers produced their own fuel on-farm. Farm buildings are often not heated, and if they are, they were generally well insulated. However, only a small proportion produced their own resources on-farm for heat production. In terms of bioenergy production, slurry as a waste product was the majority of the material used in biogas plants; however, some farmers also grew a considerable amount of plants specifically for energy production (up to 43 % of material delivered to biogas plant), resulting in a competition between land for food production and land for energy production.

Out of the 56, 8 indicators covered **animal husbandry**. Many of these indicators are answered and rated based on the worst-case principle, meaning that if a condition could not be fulfilled for one animal group or category, the indicator question was answered negatively. For example, for ID 370.5, if one animal category (e.g. dairy cows or laying hens) or animal group (e.g. calves, young cattle, heifers and dairy cows) had no daily outdoor access, the indicator was answered overall with "no", even when the majority of the animals on the farm had. The results show that the majority of farms did not provide daily outdoor access to all animals. Similarly, a large proportion of farmers did not provide access to pasture for all ruminant categories on their farm; however, when access was granted across the whole herd, the majority were on the pasture for 6-8 months out of the year. Daily outdoor access for pigs was only granted on organic farms; while daily outdoor access for poultry was the norm independent of management system; only one poultry farm did not grant daily outdoor access. Dual-purpose breeds in both ruminants and poultry play so far only a very marginal role in Luxembourg and were only used on a very small number of farms. Most of the farmers did not know how long the duration of the transport to the abattoir took. All participating farms used proper disposal pathways for livestock cadavers.

Linked to animal husbandry, the topic of **feed** grouped 4 indicators. All farms with animal husbandry used concentrated feed in their feed rations and most bought in over 90 % of their concentrated feed needs. Only 6 farms were completely self-sufficient when it comes to concentrated feed needs. When looking at management system, it could be observed that a higher relative frequency of organic farms purchased 0 % of their concentrated feed needs, while a higher relative frequency of conventional farmers externally sourced more than 90 % of their concentrated feed needs. In terms of feed no food, the majority of farms fed below 1000 kg per livestock unit per year of feedstuff that is in competition with human food production, with 4 feeding no such feed. However, 7 farms still fed above 3500 kg/livestock unit per year. In the context of this indicator ID 517, maize silage is considered as food competition. In regards to basic fodder supply, the farms showed a very high autarky: most farms bought in less than 20 % of their roughage needs externally, meaning that over 80 % were produced on-farm, with 34 being 100 % self-sufficient.

The impact of **fertilisation** practices was assessed using 5 indicators. The majority of farms is self-sufficient when it comes to organic fertiliser, while 11 farms imported over 90 % of their organic fertiliser needs. These were either farms without animal husbandry or farms that exported their own slurry to biogas plants and then imported back the biogas slurry. Slurry was stored on all farms either covered and/or with a stable crust. The application of slurry close to the ground by e.g. drag hose principle is not yet used on half of the participating farms. However, when such techniques are employed, they are utilized to spread the majority of slurry of a farm. Soil analyses are commonly done every 5 years on each plot in the framework of the "Landschaftspflegeprämie", although these do generally only cover the basic nutrients. Total nitrogen or mineralized nitrogen content determination is less often included or performed. The total nitrogen in kg N/ha in the SMART-Farm tool is calculated based on the actual fertilised area, not the total agricultural area of the farm, and lies for 58 farms below 200 kg N/ha. The highest amount of N spread was 417 kg N/ha/year.

More general information on **agricultural land** and the thereupon implemented practices were collected through 12 indicators. Agroforestry is only established on 3 out of the 87 farms. The agroforestry systems on these farms encompassed 1, 2 and 3 layers, respectively. Most farms, also own at least a small portion of forest, while on 12 farms, small areas of woodlands were deforested, assessed as share of agricultural land. However, only one farm cleared forest to gain agricultural field, looking at the past 20 years. Most of the participating farms do not or manage only a very small share of their permanent grassland extensively (0-10 %), with higher shares observed among organically managed farms. Looking at the cutting frequency of permanent grasslands, half of the participants cut their grasslands on average 1-2 times, while the other half does 3-4 times; 5 or more cuts on average were not realised by any of the farms. Legumes generally make up no more than 30 % of arable land, with higher shares of legumes noted on organic farms. Calculations of humus balances are not the norm; however, on the farms, where such calculations were performed, these show largely a balanced or positive tendency. Most farms implemented measures to counter soil degradation, when degradation was observed. Only 3 farms did not or only partially implement such measures. Direct seeding only played a very small role in crop production on the 87 farms that participated in the study.

Pesticide use and plant protection measures were assessed based on 9 indicators. Chemical synthetic insecticides were used by 16 farms of which 9 only applied them on >0-10 % of their agricultural land, thus the majority of the participating farms did not use any such insecticides. Synthetic chemical fungicides were used by 36 farms, of which 7 only used them on >0-10 % of their agricultural land. The highest share of agricultural land, where such fungicides were applied was 95.1 %. Chemical synthetic herbicides were the most widely used form of pesticides. Only 36, of which 27 were organically managed, renounced the use of herbicides on any share of agricultural land. The remaining farms applied such herbicides on >0-40 % of their agricultural land. Many of the farms used pesticides that are highly toxic when inhaled and growth regulators were also utilized by a majority of the participating farms. Products for the regulation of flowering were not used on any of the farms, since such products are prohibited in Luxembourg. Chemical soil disinfection in greenhouses is not implemented on any of the farms, while only one farm uses steaming technology as a disinfection method, both in their greenhouses as well as on open ground.

The topic of **environmental emissions** was covered by 5 indicators. Most farms could not completely ensure that there are no on-farm point sources of nutrients and pollutants on the farm. Here again the worst-case principle was applied. As a risk for emissions to the environment existed, the farms were accordingly rated negatively. Only a small number of farms had fields close to heavily travelled roads or highways with an accompanying risk of contamination from exhausts. With the same principle, it could not be concluded with certainty that no problematic plastic types are being used on the farms, so that this indicator was also rated negatively. Silage is generally stored in such a way to minimize losses and contamination. Open burning of green cuttings was still performed by 4 farmers, thinking that this was still legal practice in 2017.

In regards to the **additional questions** some of them were not adequately formulated to fully encompass and cover the complexity of the issues treated in the question, even though the pre-tests showed positive results. Nevertheless, valuable information could be gained, especially when supplemented with qualitative data from the interviews. One such question was the evaluation of the capacity of slurry tanks. While the quantitative answers to the question of whether current capacities were big enough to cover needed capacities were not very conclusive, the qualitative feedback from the interviews was, that all farms met the 6 months storage capacity requirements. Only four farms separated their slurry before application in 2017; negative experiences recounted had to do with high energy expenditure linked to the separation process. Slurry tanks were sealed to prevent leakages according to techniques common at the time of their build; as most of the tanks of the participating farms were older than 20 years, there often was no extra sealing in place. None of the farms used inputs to reduce the pH of the slurry, nor did any of the farms have special ventilation installed for NH_3 filtration. There was no extra cover used on slurry; tanks were generally underground, and open-air tanks had a stable swimming layer. Stirring practices of slurry varied widely among farms, and even on farms, depending on slurry consistency and slurry tank size and depth. The majority of participating farms, however, mainly started stirring before application. The timing of incorporation of organic fertiliser into the soil after application also varied widely among farmers and the question was in general difficult for farmers to answer. Most honest answer would probably have been “as soon as possible”. Finally, in terms of manure storage, only one farm stored a part of the produced manure under a roof.

In summary, it can be said, that practices to reduce emissions to the environment, may that be to water, soil or air, are already in place and implemented, e.g. underground storage of slurry is the norm, heated farm buildings are generally well insulated and the use of predominantly renewable electricity sources is the standard. However, further improvements are possible especially in terms of slurry application close to the ground, adaptation of livestock feeding strategies (e.g. reduction in concentrate feed in ruminant rations), and better adaptation of fertilisation strategies based on crop requirements and actual fertilised area. Nevertheless, other proposed strategies in the draft of the NAPCP for reduction in air pollutant emission from agriculture will be difficult to implement into practice, based on the very nature of agriculture. For example, incorporation of organic fertilisers within 4 hours of application might not always be possible due to weather restrictions, and slurry application using techniques for close to the ground spreading might not be feasible in certain environments, due to e.g. slope or presence of landscape elements.

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Appendix

Appendix 1: List of indicators influencing *Air Quality* goal achievement.

ID	SMART-Farm Tool Indicator	Question to auditor	Scale description	Unit
185	Renewable electricity	What proportion of the electricity consumed is derived from renewable resources? [% of electricity consumption]	f(x)=0+[% of electricity consumption]*1 (Number to enter: Answer to auditor question.)	% of electricity consumption
186	On-farm renewable energy production	What proportion of the energy used is generated by the farm's own installation for renewable energy production? [% of energy consumption from own source]	f(x)=0+[x]*1 (Number to enter: Answer to auditor question.)	%
187	Renewables heating and hot water	What proportion of the heating-energy consumption is provided by renewable energy or waste heat? (Only consider consumption related to agricultural production) [% of heating energy consumption]	f(x)=0+[% of heating energy consumption]*1 (Number to enter: Answer to auditor question.)	% of heating energy consumption
188	Share of fuel from own production	Which proportion of the fuel used for farm vehicles and machinery is produced on-farm? [% of total fuel consumption]	f(x)=0+[% of total fuel consumption]*1 (Number to enter: Answer to auditor question.)	% of total fuel consumption
190	Biogas plant: share organic residues	What proportion of organic matter utilized in a biogas plant (own or external plant) is a surplus or leftover from food/feed production? [% of organic wastes]	f(x)=0+[% of organic wastes]*1 (Number to enter: Answer to auditor question.)	% of organic wastes
192	Plants for energy production instead of human consumption	(If a farm uses plant materials for energy production:) What part of the substrate used for energy production would also be suitable for human consumption? [% of total substrate]	f(x)=1+[% of total substrate]*-1 (Number to enter: Answer to auditor question.)	% of total substrate
195	Energy-efficient driving (Eco-Drive)	Do the farm manager and the workers use energy-efficient driving techniques (e.g. Eco-Drive advice: low speed of engine (revolutions per minute) and driving with high gears if possible etc.)?	0% = No 50% = Partly 100% = Yes (Number to enter: %- Rating)	
196	Insulation of heated farm buildings	(If there are heated farm buildings:) What proportion of the heated farm buildings are sufficiently insulated (e.g. with double or multiple glazed windows, roof / wall / floor insulation)? [% of heated farm buildings] (Do not score heated greenhouses, covered in ID 745)	f(x)=0+[% of heated farm buildings]*1 (Number to enter: Answer to auditor question.)	% of heated farm buildings

198	Dual-purpose breeds: Ruminants	What proportion of the ruminants are dual-purpose breeds? (Any dual-purpose breed that is only kept for one purpose (e.g. meat only/dairy only) does not count as a dual-purpose breed.) [% of ruminants]	f(x)=0+[% of ruminants]*1 (Number to enter: Answer to auditor question.)	% of ruminants
198.1	Dual-purpose breeds: poultry	What proportion of the poultry are dual-purpose breeds? (Any dual-purpose breed that is only kept for one purpose (e.g. meat only/eggs only) does not count as a dual-purpose breed.) [% of poultry]	f(x)=0+[% of poultry]*1 (Number to enter: Answer to auditor question.)	% of poultry
199	Bought-in concentrated feed	What proportion of the concentrate feed used on the farm is sourced externally? (In case no concentrate feed is given to the livestock, rate positively (= 0%).) [% of total feed concentrate]	f(x)=1+[% of total feed concentrate]*-1 (Number to enter: Answer to auditor question.)	% of total feed concentrate
200	Covered slurry stores (or stable natural crust)	Are slurry stores covered or does a stable natural crust cover the surface?	0% = No 50% = Partly 100% = Yes, 100% = No slurry is generated / stored (Number to enter: %- Rating)	
201	Slurry application with drag hose system or by injection	On what proportion of the area fertilised with slurry does the farm use drag hose or injection systems (to apply slurry)? [% of area fertilised with slurry]	f(x)=0+[% of area fertilised with slurry]*1 (Number to enter: Answer to auditor question.)	% of area fertilised with slurry
202	Agro-forestry systems	On what percentage of the agricultural area are agro-forestry systems established? [% of agricultural area]	f(x)=0+[x]*1 (Number to enter: Answer to auditor question.)	%
203	On-farm renewable heat production	What proportion of the heating-energy used is generated by the farm's own installations that are run with renewable sources (wood chips, geothermal, solar)? [% of heat energy consumption from own source]	f(x)=0+[% of heat energy consumption from own source]*1 (Number to enter: Answer to auditor question.)	% of heat energy consumption from own source
204	Woodlands: Deforestation	Which portion of the farm's current agricultural area has been deforested over the past 20 years? (Remark: deforestation = removal of a forest or stand of trees where the land is thereafter converted to a non-forest use.) [% of agricultural area]	0% = [% of agricultural area] > 0.06 25% = 0.06 ≥ [% of agricultural area] > 0.04 50% = 0.04 ≥ [% of agricultural area] > 0.02 75% = 0.02 ≥ [% of agricultural area] > 0 100% = [% of agricultural area] = 0 (Number to enter: Answer to auditor question.)	% of agricultural area

206	Share of legumes on arable land	What proportion of the arable land is devoted to leguminous crops? [% of arable land]	0% = [% of arable land] < 0.05 25% = 0.05 ≤ [% of arable land] < 0.1 50% = 0.1 ≤ [% of arable land] < 0.2 75% = 0.2 ≤ [% of arable land] < 0.3 100% = [% of arable land] ≥ 0.3 (Number to enter: Answer to auditor question.)	% of arable land
207	Arable land: Share of direct seeding	What proportion of the arable land is managed by the method of direct seeding? [% of arable land]	f(x)=0+[% of arable land]*1 (Number to enter: Answer to auditor question.)	% of arable land
208	Woodlands: Share of agricultural area	What share of agricultural area are woodlands? [% of agricultural area]	0% = [x] < 0.01 25% = 0.01 ≤ [x] < 0.05 50% = 0.05 ≤ [x] < 0.1 75% = 0.1 ≤ [x] < 0.15 100% = [x] ≥ 0.15 (Number to enter: Answer to auditor question.)	%
231	No use of synth. chem. herbicides	What proportion of the agricultural area does not receive synthetic chemical herbicide applications? [% of agricultural area]	f(x)=0+[% of agricultural area]*1 (Number to enter: Answer to auditor question.)	% of agricultural area
233	No use of synth. chem. fungicides	What proportion of the agricultural area does not receive synthetic chemical fungicide applications? [% of agricultural area]	f(x)=0+[% of agricultural area]*1 (Number to enter: Answer to auditor question.)	% of agricultural area
234	No use of synth. chem. insecticides	What proportion of the agricultural area does not receive synthetic chemical insecticide applications? Spinosad, Neem and other broad-range organic insecticides count. [% of agricultural area]	f(x)=0+[% of agricultural area]*1 (Number to enter: Answer to auditor question.)	% of agricultural area
253	Permanent grasslands: Extensively managed	What proportion of the area of permanent grassland is under extensive management? (Extensive means: double mowing/grazing or less, zero use of inputs, e.g. fertilisers, pesticides, soil improvement measures) [% of permanent grassland]	f(x)=0+[% of permanent grassland]*1 (Number to enter: Answer to auditor question.)	% of permanent grassland
286	Soil degradation: Measures taken to counter	On what proportion of the agricultural area endangered by soil degradation processes (other than erosion (e.g. compaction, contamination, salination)) are measures taken to combat soil degradation? Rate positively (=100%) if no degradation processes are evident. [% of endangered agricultural area]	f(x)=0+[% of endangered agricultural area]*1 (Number to enter: Answer to auditor question.)	% of endangered agricultural area

290.1	Determining fertiliser requirements	When determining nutrient contents and soil properties, how often are soil analysis performed? -> note down in comment how often for N, P, K and pH	0% = Longer than 10 years 25% = Between 6 to 10 years 50% = Between 2 to 5 years 100% = Every year (Number to enter: %- Rating)	
323.1	N from fertilisers calc	How much N from fertilisers (in kg) does the farm apply on its agricultural area per hectare per year? [kg N / ha / year]	Case 1: [x] > 170 --> 0% Case 2: 170 ≤ [x] ≤ 25 --> Linear interpolation between 0% and 100% Case 3: [x] < 25 --> 100% (Number to enter: Answer to auditor question.)	%
331	Waste disposal: cadaver livestock	Are all animal wastes/cadavers disposed of properly (no risk of harm to human health or the environment)? (Score positive if no such wastes arise.)	0% = No 100% = Yes (properly diposed) (Number to enter: %- Rating)	
332	Electricity consumption per ha	How much electricity is used on the farm per hectare per year? [kWh / ha / year] (Make sure private use is not included. If only one electric meter, calculate deduction based on number of people. For private use 1.000 kWh/adult/year and 500 kWh/child/year can be deducted)	0% = [x] > 750 25% = 750 ≥ [x] > 500 50% = 500 ≥ [x] > 250 75% = 250 ≥ [x] > 0 100% = [x] = 0 (Number to enter: Answer to auditor question.)	
341	Settings of combustion motors	How often are the settings of combustion motors of vehicles (e.g. tractor, stapler) and other machineries checked and adjusted (engine, air filter etc.)? e.g.: based on exhaust emissions test results (If no tractor is used give highest score.)	0% = > 5 years 50% = at least every 5 years 100% = at least every 3 years (Number to enter: %- Rating)	
345	Irrigation: Low energy technology and pumps	(Only ask if irrigation is used:) Does the farm use low-energy irrigation technology and pumps, drip irrigation and micro irrigation? Score positively in case of no irrigation and if irrigation is done manually.	0% = No 100% = Yes (Number to enter: %- Rating)	
348	Share of fuel from renewable sources	What proportion of the fuel consumed is provided by renewable resources? [% of fuel consumption]	f(x)=0+[% of fuel consumption]*1 (Number to enter: Answer to auditor question.)	% of fuel consumption

370.5	Daily outdoor access for animals	Do all animals have daily outdoor access (year-round)? (Score based on worst animal category. Rate positvely (= Yes) if outdoor access is provided at least 26 days per month and minimum 4 hours per day. For poultry: possibility for outdoor access is sufficient (even if not used daily e.g. due to bad weather conditions).)	0% = No 100% = Yes (daily access) (Number to enter: %- Rating)	
371	Access to pasture for ruminants	How many days per year are the ruminants out on pasture? (In case of several livestock housing/animal species: score based on the worst condition.)	0% = [x] < 62 25% = 62 ≤ [x] < 120 50% = 120 ≤ [x] < 180 75% = 180 ≤ [x] < 225 100% = [x] ≥ 225 (Number to enter: Answer to auditor question.)	
372	Outdoor access for pigs	On average, how many hours per day do the pigs have outdoor access?	0% = [x] < 6 25% = 6 ≤ [x] < 12 50% = 12 ≤ [x] < 18 75% = 18 ≤ [x] < 24 100% = [x] ≥ 24 (Number to enter: Answer to auditor question.)	
373	Outdoor access for poultry	On average, how many hours per day do the poultry have outdoor access? (In case of several livestock housing/animal species: score based on the worst condition.)	0% = [x] < 3 25% = 3 ≤ [x] < 6 50% = 6 ≤ [x] < 9 75% = 9 ≤ [x] < 12 100% = [x] ≥ 12 (Number to enter: Answer to auditor question.)	
374	Duration of transport to abattoir	What is the average duration of livestock transportation to the abattoir (in minutes)? (Score based on worst animal category. If animals are slaughtered at the farm score positive.)	0% = [x] > 240 25% = 240 ≥ [x] > 120 50% = 120 ≥ [x] > 60 75% = 60 ≥ [x] > 30 100% = [x] ≤ 30 (Number to enter: Answer to auditor question.)	

377.75	Pesticides: Acute toxicity inhalation	Pesticides: Are active substances used, which are considered acute toxic when inhaled by the users according to the "Globally Harmonized System of Classification (GHS)"?	0% = [x] < 2 25% = 2 ≤ [x] < 3 50% = 3 ≤ [x] < 4 75% = 4 ≤ [x] < 5 100% = [x] ≥ 5 (Number to enter: Answer to auditor question.)	
380	On-farm point sources of nutrients and pollutants	Can it be excluded that there are direct point source emissions of nutrients and pollutants to the atmosphere and water bodies (incl. wells and drinking water sources) on the farm and its utilized areas? E.g. exports (= emissions through discharge and degass) from exercise yards, farmyard manure stores, livestock water facilities or shelter of animals near to water on pastures, direct entry of animals into the water and cleaning areas.	0% = No 100% = Yes (Number to enter: %- Rating)	
511	Contamination through emissions: exhaust emissions, factories or airports	Is there a risk of contamination from motorways/heavy traffic roads, industry or airports?	0% = Yes 100% = No (Number to enter: %- Rating)	
517	Feed No Food: grazing livestock	What amount of the feed given to grazing livestock would be suitable for human consumption (For maize silage take standard yields for grain maize)? [kg/livestock unit/year]	0% = [kg/livestock unit/year] > 300 25% = 300 ≥ [kg/livestock unit/year] > 200 50% = 200 ≥ [kg/livestock unit/year] > 100 75% = 100 ≥ [kg/livestock unit/year] > 0 100% = [kg/livestock unit/year] = 0 (Number to enter: Answer to auditor question.)	kilogram
518	Feed No Food: non-grazing animals	What proportion of the feed given to non-grazing animals would be suitable for human consumption? (Contrary to e.g. waste products; Score based on worst animal category [% of feed])	f(x)=1+[% of feed]*-1 (Number to enter: Answer to auditor question.)	% of feed
620	Permanent grasslands: Mowing frequency	How often is the grassland mowed on average?	0% = extensively (1-2 cuts) 50% = medium (3-4 cuts) 100% = intensively (5 and more cuts) (Number to enter: %- Rating)	

626	Proportion bought-in roughage	Which proportion of the used roughage is sourced externally? [% of roughage]	f(x)=1+[% of roughage]*-1 (Number to enter: Answer to auditor question.)	% of roughage
712.1	Imported organic fertilisers Calc	What proportion of the entire organic fertilisers used is externally sourced? - Green manure not counted in calculation - If applicable use indications in tonnes or m3 to calculate value based on N content - [% of organic fertilisers in kg N]	f(x)=1+[% of organic fertilisers in kg N]*-1 (Number to enter: Answer to auditor question.)	% of organic fertilisers in kg N
720	Silage storage	Is the silage stored appropriately to minimize losses and avoid contamination?	0% = No 50% = moderate 100% = Yes (Number to enter: %- Rating)	
738	Production materials: Use of problematic elements	Does the farm only use production materials made of less problematic plastic types? (Check problematic materials (e.g. PVC, polystyrene))	0% = No 100% = Yes (Number to enter: %- Rating)	
740	Growth regulation	Does the farm decline to use synthetic chemical growth regulators?	0% = No 100% = Yes (Number to enter: %- Rating)	
741	Steaming on open ground	1) Is soil steaming performed on open ground? If yes: 2) Is deep or flat steaming performed?	0% = Deep steaming 50% = Flat steaming 100% = None (Number to enter: %- Rating)	
742	Steaming in the greenhouse	1) Is soil steaming performed in the greenhouse? If yes: 2) Is deep or flat steaming performed?	0% = Deep steaming 75% = Flat steaming 100% = None (Number to enter: %- Rating)	
747	Flowering regulation	Does the farm use products to influence the flowering of plants or for desiccation? (Rate positively (=No) in case nature identical ethylene gas is used.)	0% = Yes 100% = No (Number to enter: %- Rating)	
748	Humus Formation: Humus balance	Is a humus balance calculated and is the humus balance positive, balanced or negative on average? (In case of small holder farms, check whether the farmer focuses on practices that improve humus balance)	0% = No 50% = Yes, negative 100% = Yes, balanced or positive (Number to enter: %- Rating)	

749	Soil disinfection	Does the farm refrain from the use of chemicals for soil disinfection? (If such substances are applied:) Is documentation and justification for the use of soil disinfection products available?	0% = No, no documentation 50% = No, with documentation and justification 100% = Yes (Number to enter: %- Rating)	
764	Share of legumes on perennial crops area	What proportion of the perennial cropland area is devoted to legumes? [% of perennial crop area]	0% = [% of perennial crop area] < 0.05 25% = 0.05 ≤ [% of perennial crop area] < 0.1 50% = 0.1 ≤ [% of perennial crop area] < 0.2 75% = 0.2 ≤ [% of perennial crop area] < 0.3 100% = [% of perennial crop area] ≥ 0.3 (Number to enter: Answer to auditor question.)	% of perennial crop area
788	Open burning of farm or household wastes and bushes	Does the farm refrain from burning of bushes, crop residues?	0% = No 50% = Partly 100% = Yes (Number to enter: %- Rating)	
800	Land clearing method	Which land clearing methods have been used to establish and/or to renovate plantations/fields over the past 20 years?	0% = On an area with native forests, established by slash and burn or removal of vegetation 25% = On an area with native forest, established by slash and mulch 75% = On a former plantation/fallow land, established by slash and burn 100% = On a former plantation/fallow land, established by slash and mulch (Number to enter: %- Rating)	
802	Agroforestry: Number of layers	How many layers does the agro-forestry system consist of? Rate according to the agroforestry area under the worst condition covering at least 10 % of the total agroforestry area.	0% = [x] < 2 50% = 2 ≤ [x] < 3 100% = [x] ≥ 3 (Number to enter: Answer to auditor question.)	

Imprint

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