Assessment of the plausibility of regular stratified surveys on farm and manure management in Switzerland

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Abstract.
Data on farm and manure management was assessed based on stratified surveys in Switzerland for 2002, 2007 and 2010. It provided the basis for the calculation of the national ammonia emission inventory. For the 2010 survey yielding 2957 datasets a further evaluation of the plausibility of the results was performed. The proportion of missing and non-objective entries that underwent tests for plausibility and procedures for correction ranged between some 10% and 20% relative to all entries to be completed per questionnaire. A comparison between an investigation including questions on farm and manure management conducted by the Swiss Federal Statistical Office (FSO) in 2010 and the 2010 survey showed moderate discrepancies for about 50% of the topics. For some data, the differences were surprisingly high. However, scenarios showed that the differences between the two datasets used for emission calculations remained low with respect to the amount of ammonia emitted.

Introduction

Knowledge on farm and manure management is difficult to assess since the variability between farms is considerable and the methods used for data collection and evaluation might bias the results. However, such data are crucial for various issues such as inventories of ammonia emissions. Therefore, representative stratified surveys on farm and manure management were conducted in Switzerland for 2002, 2007 and 2010, respectively. This allows for the first time to evaluate the plausibility of the data resulting from such regular surveys.

Material and Methods

The data collection was performed by means of mail surveys. The questionnaire included 40 questions on housing systems, feeding and grazing, manure storage and application. A stratified random sample of 3877, 6565 and 6351 farms was used in the surveys of 2002, 2007 and 2010, respectively. This number represented 5.8%, 10.6% and 10.8% of the Swiss farms in 2002, 2007 and 2010, respectively. Farm classes were defined for the stratification accounting for five farm types (arable farms, cattle farms, pig or poultry farms, mixed farms, other farms), three geographical regions and three altitude zones. The participation in the survey was optional for the respondents. In order to enhance the return rate, a prize lottery for the participating farmers was carried out. A response of about 50% returned questionnaires was obtained yielding 1950, 3133 and 2957 datasets for 2002, 2007 and 2010, respectively. The questionnaires were designed in a way that allows a straightforward completion by the respondents and facilitates fully automated data processing. Thus, data were mostly collected using check boxes. Inputs requiring figures were avoided as far as possible. If numbers were requested check boxes were provided that covered a certain range (e.g. grazing hours per day: less than 5 hours, 5 to 12 hours etc.). Tests for plausibility and procedures for correction were established for non bijective and missing entries in the questionnaire. Briefly, non bijective and missing entries were replaced or completed, respectively, by values that deemed most likely under common practical conditions based on expert judgement. Assumptions that would induce an underestimation of the emissions were avoided.

For the 2010 survey, the occurrence of non bijective and missing entries in the questionnaire and hence the potential impact on the outcome of the survey was assessed. Additionally, a survey including questions on farm structures and techniques conducted by the Swiss Federal Statistical Office (FSO) in 2010 [1] yielding datasets for 13,510 farms was evaluated in parallel. In contrast to our survey of 2010, this investigation was mandatory. Missing or erroneous entries were clarified by

further inquiries over the phone by collaborators of the FSO. 68 questions addressed the same topics in both surveys. The resulting data were compared according to the following formula:

$$\Delta = (P_{FSO} - P_{S2010}) \, / \, P_{FSO} \qquad (1)$$

where Δ is the difference between the results from the investigation carried out by the FSO and our survey 2010 in %, P_{FSO} the proportion of the occurrence of an entry according to the investigation carried out by the FSO in % and P_{S2010} the corresponding proportion according to our survey 2010 in %. The outcomes of this comparison were used to crosscheck the plausibility of our 2010 survey and to assess the impact on emission calculations.

Results
Occurrence of missing and non bijective entries in the questionnaire
Proportions of missing and non bijective entries in the questionnaire related to housing, exercise yard and grazing for dairy cows are presented in Table 1. The percentage of missing entries relative to the sum of entries over all questionnaires ranged from 8.7% to 28%. For other livestock categories, values of up to 40% were reached for the corresponding items. Non bijective entries were in the range between 0.2% and 13%. Interestingly, the proportion of missing entries was lower if related to the livestock number included in the survey. Apparently, operators of larger farms completed the questionnaire more reliably. This is supported by the herd sizes for those with missing entries which were lower than the average herd sizes. It can be hypothesized that this is due to a higher level of education of farmers operating larger farms. In contrast to these findings, farms with larger livestock numbers were more susceptible for non bijective entries. High livestock numbers are more likely to be related to several systems (e.g. for housings) requiring multiple entries.

Table 1. Occurrence of non bijective and missing entries in the questionnaire for the questions on housing, exercise yard and grazing for dairy cows in the 2010 survey

| | Housing | | Exercise yard | | | | | | Grazing | | | |
| | | | Type of exercise yard | | Duration of access | | Surface properties | | Hours per day | | Days per year | |
	Missing	Non bijective	Missing	Non bijective	Missing	Non bijective	Missing	Non bijective	Missing	Non bijective	Missing	Non bijective
Mean proportion per questionnaire	8.7%	17%	28%	0.6%	24%	0.7%	16%	13%	13%	1.1%	15%	0.2%
Mean proportion relative to the total livestock number	2.3%	24%	22%	3.5%	6.9%	0.8%	7.3%	13%	6.2%	1.3%	7.7%	0.2%
Mean herd size*	21	21	21	21	21	21	21	21	21	21	21	21
Mean herd size missing data**	6	30	17	125	6	24	10	21	10	26	11	29

* Mean herd size of all farms participating in the survey
** Mean herd size of the farms participating in the survey exhibiting missing or non bijective entries

Missing values tended to occur more frequently for items that are difficult to delimit towards related issues. For example, an exercise yard can consist of a specifically constructed area or of a pasture/paddock. If the latter occurs on a farm it could be allocated to grazing or exercise yard and therefore, a respondent might record it under the category grazing instead of exercise yard. On the other hand non bijective entries were rarely found for topics where multiple entries are not required (e.g. for grazing days per year).
Overall, the proportion of missing and non bijective entries that underwent tests for plausibility and procedures for correction ranged between some 10% and 20% relative to all entries to be completed per questionnaire.

Comparison of the results derived from our 2010 survey and from the investigation conducted by the Swiss Federal Statistical Office in 2010

Figure 1 presents an overview of the differences between the results from our survey 2010 and from the investigation carried out by the FSO in %. The numbers are combined to the classes giving differences ranging from 0 to 30%, 31 to 60%, 61 to 90% and 91 to >100%. It turns out that the class including a 0 to 30% difference (i.e. representing a relatively good agreement of the data from the two surveys) applied for about 50% of all data. The concurrence was somewhat better for the Valley zone but weaker for the region West/South and the Mountain zone. Results with a difference between 30% and 90% which can be considered as a medium to weak agreement between the two surveys were at 26% for entire Switzerland and ranged between 19% and 26% for the regions and the altitude zones, respectively. Differences of more than 91% (i.e. an insufficient concurrence) amounted to 22% for Switzerland and exhibited a proportion of 35% for the Mountain zone.
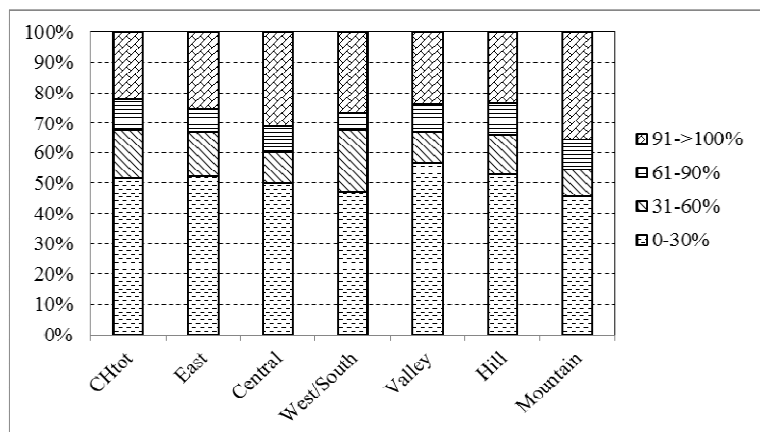

Figure 1. Comparison of the results according to the investigation carried out by the FSO in 2010 and our 2010 survey for entire Switzerland (CHtot), and related to the regions East, Central and West/South and the altitude zones Valley, Hill and Mountain given as the difference according to formula (1) in %. The class yielding a difference ranging from 0 to 30% indicates a relatively good agreement and the class yielding a difference of more than 91% points at an insufficient concurrence between the two surveys, respectively.

Figure 2 shows the results of housing systems for dairy cows as an example for the outcomes of the two surveys. The most important housing systems were tied housings producing both slurry and farm yard manure (FYM) and loose housing systems with production of slurry which both occurred for about one third of the Swiss dairy cows. Tied housings producing slurry and loose housings producing both slurry and FYM exhibited proportions of about 20% and 10%, respectively. Loose housings with deep litter were of minor importance. The occurrence of housing systems differed little between the regions. The repartition of housing systems in the central part of Switzerland mostly coincided with the mean for whole Switzerland. The region East showed a slightly higher number of housings producing slurry for both tied and loose housings. The region West/South exhibited more straw based systems due to larger surfaces of arable land with grain production and thus a high availability of straw. These findings are equally reflected by both surveys. Differences at the level for entire Switzerland were 10% or less except for loose housings with deep litter where a discrepancy by a factor of 3 was found. This is likely due to a difference between the two surveys on how this category was assessed. Loose housings with deep litter were used for less than 1% of dairy cows and thus, this discrepancy is of minor importance for emission calculations.

Other topics which showed a high discrepancy were more important however, e.g. housing systems for nursing sows. Here, a proportion of 10% and 32% resulted for the system multi-area pen with an outside yard according to the investigation of the FSO and our 2010 survey. Neither of the two surveys explicitly quoted the term "multi-area pen with an outside yard" in the questionnaire but the assignment to this system based on the existence of an outside yard. This was assessed in the FSO questionnaire by a check box entitled "outside yard available" and in our 2010 survey by a check box

entitled "outside yard not available". If the existence of an outside yard was assessed in our 2010 survey by entries in check boxes asking for the type of the floor of outside yards the results of both surveys were comparable. It seems likely that farmers hesitated to admit not to have an outside yard even if it was the case for their farm.
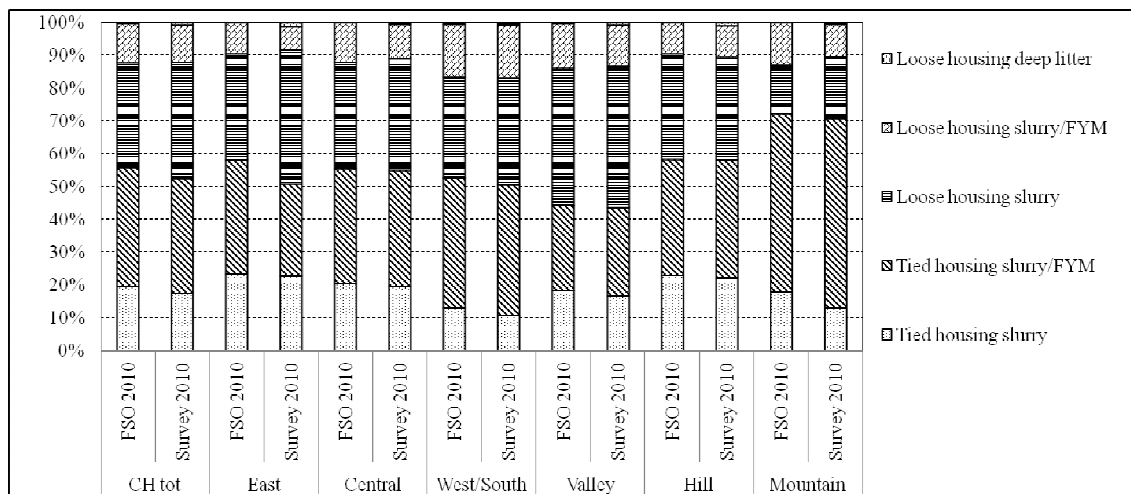

Figure 2. Proportions of housing systems for dairy cows according to the investigation carried out by the FSO in 2010 and or 2010 survey for entire Switzerland (CH tot), and related to the east, the central and the western/southern part of Switzerland (East, Central, West) and the altitude zones Valley, Hill and Mountain.

A further topic which yielded a large discrepancy was related to slurry application technique. For shallow injection, a proportion of 6% and 1% resulted according to the investigation of the FSO and our 2010 survey, respectively. There is high evidence that the investigation of the FSO significantly overestimated the amount of slurry application using this technique. Inquiries among marketing centres for farm machines and contractors carried out ex post revealed that tankers equipped with shallow injectors were not available to an extent that would allow for application of slurry according to the numbers yielding from the FSO investigation. This obviously incorrect information provided by the respondents is difficult to explain.

In order to assess the impact of differing inputs from the two surveys on ammonia emissions model calculations were performed with the regional mode of the Agrammon model (http://www.agrammon.ch/regional-model/). It turned out that total ammonia emissions differed by about 1% when using the data sets of the two surveys.

Conclusion and perspectives

Overall, the proportion of missing and non bijective entries that underwent tests for plausibility and procedures for correction in the 2010 survey ranged between some 10% and 20% relative to all entries to be completed per questionnaire. The differences between the results from the investigation carried out by the FSO and our survey 2010 were low for about 50% of the topics. For some data, the differences were surprisingly high. This was due to differences of the wording in the questionnaires or to incorrect information provided by the respondents. It is thus important to crosscheck the data resulting from such surveys by redundant data sources. However, even if some important discrepancies between the two surveys were discovered, the impact of the differing datasets on the results of emission calculations remained low.

References

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