FEED-A-GENE

Adapting the feed, the animal and the feeding techniques to improve the efficiency and sustainability of monogastric livestock production systems

Deliverable D6.1

Report on Delphi Analysis of expert opinion on sustainability indicators

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1. Summary

Objectives

The outputs from the activities described in this deliverable will enable sustainability assessments to be conducted on various technological innovations affecting monogastric livestock developed during the Feed-a-Gene project. Specifically D6.1's objectives are:

1. To identify appropriate sustainability indicators for the production systems proposed in the Feed-a-Gene project.

2. To identify weighting values for the sustainability indicators.

These indicators and weights will be applied in later WP6 tasks in which sustainability assessments will be conducted.

Rationale:

The novel techniques developed during the Feed-a-Gene project are expected to produce a range of positive and negative impacts affecting the natural and social systems within which livestock production is carried out. To compare the sustainability of these novel techniques (and to each other and to a baseline) a common framework should be applied. In studies of sustainability, such a framework consists of a series of indicators selected to encapsulate salient parts of the systems that will potentially be affected by the driver of interest (production technology in this case). Though salient, indicators may not all be equally important in determining sustainability, and may be ascribed different weights. There are no 'correct' weighting factors, nor is there a single 'correct' set of indicators, as individuals have different views on the relative importance of potential indicators. Consequently an objective method is required to elicit the opinions of knowledgeable informants about appropriate indicators and indicator weights.

The Delphi method is an appropriate method where there is a lack of authoritative objective information, and instead the opinions of experts are sought. This flexible and commonly-used method has been described as a "systematic solicitation and collation of informed judgments on a particular topic" (Turoff, 1970:149), which encourages the sharing and investigation of various points of view. Consequently, a two-round Delphi study of individuals professionally involved in some aspect of monogastric livestock production was performed to elicit their individual scores on the relative usefulness of a series of parameters for future deployment in sustainability assessments.

A Delphi study involves the administration of a series of questionnaires (or 'rounds') to participants. The Round 1 questionnaire for Feed-a-Gene was developed firstly by means of a literature review to identify candidate indicators for use in sustainability evaluation in livestock systems, and therefore of potential use in this study. Next, the survey instrument was tested during a stakeholder workshop in Aarhus, in April 2016, and subsequently refined. The final Delphi instrument consisted almost entirely of closed-choice questions and elicited information about the profession of respondents, knowledge of key areas, and scores relating to the perceived usefulness of a variety of economic, environmental and

social indicators for assessing sustainability. A working definition of sustainability as 'the long term viability of an activity' was provided in the questionnaire. (See Annex 1.)

The Delphi questionnaire was administered by e-mail in five member states by Feed-a-Gene partners, and the first round achieved a sample size of 137, corresponding to a 36% response rate. The Round 2 questionnaire was very similar to the 1st Round questionnaire. As expected, there was modest attrition of the sample between the first and second rounds, reducing the sample size to 102.

Respondents were asked to rate the usefulness of the three dimensions of sustainability (economic, environmental and social) for evaluating the sustainability of livestock production, and the usefulness of individual indicators related to each domain using a 5-point rating scale (anchored between 1= 'least useful' and 5 = 'most useful'). Mean scores for the usefulness of indicators and indicator groups (dimensions) were calculated. Overall, the highest-ranked dimension of sustainability was the Economic dimension (mean score of 4.51 out of 5), followed by Environmental (4.09) and then Social (3.75). Scores for individual indicators within each dimension were highest for those related to the financial viability of farming activities, reflecting the reality that farming is conducted by businesses, and the use of any technology will not continue in the future if farms cannot achieve profitability with it.

Teams involved:

AFZ, CREDA-UPC-IRTA, DLO, KU, UNEW.

Species and production systems considered:

Not applicable

2. Introduction

The Feed-a-Gene project requires the novel technologies developed during the project to be evaluated with respect to their sustainability. The systems in which animal production takes place are complex and far-reaching, including economic, environmental and social dimensions, and technological change may simultaneously cause both improvement and deterioration in different components of these systems. A set of indicators will provide a consistent framework for assessing and comparing the sustainability of the management solutions when implemented, and highlight trade-offs between dimensions.

As stated by Spangenberg *et al*. (2002), the purpose of sustainability indicators in general is to serve as simplifying communication tools helping to guide political decision making towards sustainable development. To serve for communication purposes, they should reduce complexity, be easily understandable and limited in number. To provide a sound basis for decision making they have to be:

- general, i.e. not dependent on a specific situation, culture or society;
- indicative, i.e. truly representative of the phenomenon they are intended to characterize;
- sensitive, i.e. they have to react early and sensibly to changes in what they are monitoring, in order to permit monitoring of trends or the successes of policies, and
- robust, i.e. directionally safe with no significant changes in case of minor changes in themethodology or improvements in the data base.

Task 6.1 is concerned with the implementation of a procedure to identify a coherent set of indicators from among many options. The indicator chosen should encapsulate important elements of the environmental, economic and social systems that may be subject to change as a result of the technological solutions proposed by the project. Indicators can be used individually, or combined to produce a single composite indicator (index). All indicators may be given equal weighting, or have differential weights applied to reflect their relative importance. Consequently, Task 6.1 is also concerned with identifying weights. Later in the project (Task 6.5) a composite indicator of sustainability will be constructed using indicators and weights suggested by the empirical study which is described in the following sections.

There is no single ‘correct’ set of indicators or indicator weights. Parris and Kates (2003) concluded that – due to the confusion of terminology, data, and methods of measurement – there are no indicator sets that are universally accepted, backed by compelling theory, rigorous data collection and analysis, and also influential in policy. Since indicator selection influences the conclusions (Lebacq *et al*., 2013), ‘a well-defined and transparent procedure is thus necessary to enhance credibility and reproducibility of the evaluation’ (Niemeijer and de Groot 2008). Hence reliable procedures are needed for selecting indicators that are valid (Dale and Beyeler, 2001). For questions such as this where judgement is required, expert elicitation methods may be used to identify appropriate indicators and weights. Different experts will express different opinions based on their knowledge, experience and preferences.

Consequently, an appropriate technique for identifying indicators and possible weightings is a Delphi study by which the opinions of experts can be elicited and pooled. Though practiced with many variations, it is, in essence, an iterative survey technique. Participants are initially asked to complete a questionnaire (Round 1), the results of which are collated

by the research team. Next, feedback based on the aggregated survey results is provided to participants and at the same time a second questionnaire (Round 2) is administered. Participants are invited to amend their Round 1 answers in light of the feedback received concerning the opinions of other participants. This may be followed by further 'rounds' of questionnaires (and feedback), until a group opinion emerges which is stable, though not necessarily a consensus.

The Delphi technique has several advantages. It enables the opinions of a range of experts, including those who are geographically dispersed, to be elicited without the need for a physical meeting. By provision of feedback it allows an exchange of opinions thereby emulating aspects of a physical meeting. A critical point of the Delphi technique is that feedback is anonymous. Delphi is posited to be free of the restrictions of group interactions which might influence the extent and nature of individual contributions, for example deferment to the most senior person, social loafing (non-participation) and an unwillingness to (publicly) change viewpoint (face-saving). It also removes the possible communication difficulties of non-native speakers at physical meetings.

Delays were experienced during the administration of the Delphi study, leading to the late submission of this deliverable. These were due to a slower-than-expected response by some participants and the consequent extension of deadlines for the return of questionnaires. Moreover in the UK, an initially poor response made it necessary to augment the stakeholder database after the Round 1 survey had started, which delayed its completion.

3. The Delphi Approach

The main assumption underlying the use of the Delphi technique is that group opinion is more valid than individual opinion (Snape *et al*., 2014). Originating from studies conducted by the RAND Corporation in the 1950s (Pill, 1971; Green, 2014), the Delphi approach seeks to utilise expert opinion for developing understanding and problem solving within a particular field. It is defined by Turoff (1970, p.149) as a method for the "systematic solicitation and collation of informed judgments on a particular topic". It is argued to be a particularly reliable means of data collection in situations where there is uncertainty or a lack of knowledge surrounding the area under investigation (Snape *et al*., 2014).

There are four key features of the Delphi approach: respondents are experts in a particular field, responses are anonymous, data collection proceeds as a series of rounds (iterative process), and feedback on the views of others is provided to participants (Woudenberg, 1991; Rowe and Wright, 1999). Sampling is purposeful, selecting those informed about, and specialised on, the particular field in question, rather than random.

The Delphi approach is often used as a tool to explore expert opinion, and may be employed to seek information, generate consensus or correlate judgement (Turoff, 1970). By using successive rounds of data collection, opinions may be considered in a non-adversarial manner, with anonymity giving each participant an equal chance to present ideas, unbiased by the identities of others (Linstone and Turoff, 1975; Hasson *et al.,* 2000; Keeney *et al.,* 2001). The current status of a group's collective opinion is fed back to participants after each round of data collection. This should help identify issues that some participants may

have initially missed or ignored. The iterative process gives respondents the chance to alter their opinions anonymously, and therefore they may be less likely to exhibit 'face saving' behaviour (Hassan *et al.,* 2000; Rohrbaugh, 1979). Okoli and Pawlowski (2004) conclude that for questions requiring expert judgment the quality of data generated by individual responses is consistently inferior to that generated by group decision processes, with Delphi studies producing richer data due to their multiple iterations and their ability to use feedback to revise responses.

While the usefulness of the Delphi approach is recognised widely, Turoff (1970) outlines some potential dangers. First, content validity depends on the quality of participants; in other words the approach will only be as good as the sample. Second, Delphi based studies may suffer from response bias in that the commitment of participants can be related to their involvement with the policy question (Keeney *et al.,* 2001). Moreover, although responses are anonymous some participants may feel obliged to represent particular interests. Third, as for all primary data collection, the wording of questions is critical. If the issue appears to be presented in a manner favouring a particular viewpoint, the study may be accused of merely seeking to justify a predetermined decision.

4. The Delphi study

4.1 Research design

While a variety of methods have been used in Delphi studies, there is broad agreement over the nature of the research process (Powell, 2003; Green, 2014). Like others, this study commenced with a detailed literature review, summarising the current state of knowledge and practice in the use of indicators to evaluate the sustainability of agricultural activities. Part of this exercise also identified the types of expert who could participate in the Delphi study. Drawing on the literature review, a variety of policy objectives, instruments and measures were identified along with a variety of indicator types that could be used to evaluate changes due to livestock production methods.

The Delphi study was conducted by project partners in five different countries, namely France (by AFZ), Hungary (KU), The Netherlands (DLO), Spain (CREDA-UPC-IRTA) and the UK (UNEW). The study adopted a purposeful sampling approach to the selection of experts (Patton, 1990; Green, 2014), ensuring that participants had a deep understanding of the issues being explored. Novakowski and Wellar (2008) recommend that participants meet at least one of the following criteria: extensive work experience related to the policy issue, an advanced degree in associated disciplines; a record of publications demonstrating professional or academic interest; or membership of a relevant professional body. The primary means of recruitment was the existing network of contacts of the partners and a stakeholder database developed for Feed-a-Gene. Where necessary, additional contacts were generated, for example by snowballing and internet searches. To ensure a wide range of expertise and viewpoints were reflected in the study, partners were asked to identify 30 potential respondents who have a high level of knowledge, and are actively engaged in work relevant to livestock production in the areas of pigs, poultry or rabbits, in the following six categories:

- 5 working in livestock breeding, including genetics
- 5 other livestock farmers/representatives of farmer groups/ farm advisers
- 5 supply chain actors (e.g. slaughterhouse/ abattoir, wholesale, retail, processing)
- 5 other industry actors (e.g. feed manufacturers including ingredients and additives) manufacturers/suppliers of precision livestock farming equipment)
- 5 relevant academics or policy makers
- 5 representatives of non-government organisations (e.g. consumer groups, animal welfare groups**)**

4.2 Questionnaire development

The Round 1 questionnaire consisted of three sections. (See Appendix 1.) To check the scope of the sample, Section A requested information about the participant's type of work and their levels of knowledge in key areas connected with livestock production. Section B presented explanatory information about the use of indicators, and presented a working definition of sustainability as 'the long term viability of an activity'. Section C focused on eliciting opinions about the proposed indicators. Respondents were asked to rate the usefulness of a series of 'candidate' indicators on a 5-point rating scale (anchored at 1= 'least useful' and 5= 'most useful'). Finally, Section D invited free comments from respondents on the questionnaire and related issues.

Initially a list of 'candidate' indicators was identified from existing literature and a draft questionnaire was developed. This was tested for clarity, content and practicality at a stakeholder workshop held at the 1st Feed-a-Gene Annual Meeting in April 2016, attended by both stakeholders drawn from industry and academics from the project. Subsequently the questionnaire was refined, and the final Round 1 questionnaire translated into each partner's native language (with the exception of DLO who used an English-language questionnaire) prior to administration.

4.3 Survey administration

Both Round 1 and Round 2 questionnaires were sent out as e-mail attachments with covering messages explaining the purpose and *modus operandi* of the study. The Round 1 questionnaire was sent out in October 2016, with a 3-week period for completion, during which a reminder was sent. In all a response rate of 36% was obtained, although there are wide variations (see Table 4.1). It is possible that this reflects the strength of ties between some partner institutions and their stakeholder networks, although other factors (e.g sending extra reminders or recipient questionnaire fatigue) might be relevant.

Following the completion of Round 1, all answers were collated, and the mean score and standard deviation were calculated for each indicator. The (shorter) Round 2 questionnaire was then prepared and consisted of the same questions concerning indicators that appeared in Round 1 but with the addition of the mean and S.D values (see Appendix 2). The questionnaires were then individualized by adding the participants' individual Round 1 answers (scores). The questionnaire invited respondents to consider the group scores, and to change their own response if they wished. It is clear that the rationale behind any aggregated group value is unknown, and some Round 2 respondents felt there were insufficient grounds for re-visiting the carefully-considered decisions they had reached in Round 1. Nevertheless, a substantial proportion of respondents *did* adjust

their answers in response to the feedback. One explanation is that with such a wide-ranging questionnaire, respondents may not have felt competent in all areas, and may have adjusted certain scores to bring them closer to the group average.

The Round 2 questionnaire was sent out in late-January and early-February 2017 to the 137 Round 1 respondents. Again, a three-week period was allowed for completion, during which time a reminder was sent out. Attrition of the sample between rounds is an expected occurrence during Delphi studies. However, the overall response rate for Round 2 of almost 75% is satisfactory (see Table 4.1)

Table 4.1 Response to the Delphi survey: questionnaires sent out and returned

	Round 1: Sent out (frequency)	Round 1 : Returned (frequency)	Round 1 : Returned (as % of questionnaires sent out)	Round 2 Returned (frequency)	Round 2 Returned (as % of R2 questionnaires sent out)
FR	48	30	62.5	24	80.0
HU	50	35	70.0	22	62.9
NL	37	16	43.2	8	50.0
SP	156	36	23.1	32	88.9
UK	85	20	23.5	16	80.0
Total	376	137	36.4	102	74.5

5. Results

5.1 Sample characteristics

The Round 1 questionnaire asked respondents about their type of work, whether they were a researcher or practitioner, and whether they worked in the public, private or third sector. Table 5.1 shows respondents categorized according to the type of work they do, self-selected from a list of 14 categories (with the option of specifying a further category if necessary). This resulted in 26 categories which were initially aggregated into 12 categories.

Clearly, there is some overlap between categories. Consequently, individuals who work in the third sector (e.g. NGOs – i.e. non-government organizations, such as charities) were classified according to the interests of the organization they work for, for example environmental/ecology, producer sectoral organization, ethics, etc. However, this classification is likely to obscure their particular specialism (e.g. a veterinarian working for an environmental NGO will be classified as working for an ‘Environmental organisation’.)

Table 5.1 shows that the sample encompasses a wide range of activities. By subtraction, 63% are practitioners (rather than researchers). The sample includes a substantive proportion of industry stakeholders with two-thirds of respondents working in activities closely related to farming operations (farming-related, breeding/genetics and feed and nutrition), predominantly in the private sector.

Table 5.1 Round 1 Respondents: type of work

Type of work	Freq	Percent	Public sector (%)	Private sector (%)	Third sector (%)	Researchers (%)
Farming-related	30	21.9	13.3	70.0	16.7	16.7
Breeding or genetics	21	15.3	19.0	71.4	9.5	42.9
Feed & nutrition	40	29.2	12.5	85.0	2.5	32.5
Vets & animal welfare	9	6.6	33.3	33.3	33.3	44.4
Food processing industry	7	5.1	0.0	100.0	0.0	0.0
Food retail	3	2.2	0.0	100.0	0.0	0.0
Consumer organisation	3	2.2	33.3	0.0	66.7	50.0
Policy and regulation	8	5.8	62.5	12.5	25.0	57.1
Ethics adviser	1	0.7	0.0	0.0	100.0	100.0
Researchers (univ & others)	9	6.6	88.9	0.0	11.1	88.9
Environmental organisation	4	2.9	0.0	50.0	50.0	100.0
Sectoral interests org'n,	2	1.5	0.0	50.0	50.0	50.0
Total	137	100.0	21.9	63.5	14.6	37.0

As explained in Section 4.3, there was some attrition between Rounds 1 and 2, but the sample composition in terms of job type, remains broadly similar. The attrition rate was slightly greater for practitioners compared to researchers, giving a small relative increase in researchers in Round 2. A smaller response from third sector employees causes a small relative increase in the percentages of respondents working in the public and private sectors.

Some cells are not well populated. This may reflect the relatively small number of organisations from which participants can be drawn (e.g. environmental NGOs), and possibly the difficulty in accessing senior individuals in the retail sector. Consequently, the sample was re-classified into seven categories to avoid very low cell counts, and for clarity. (See Table 5.2.)

Table 5.3 shows that the sample includes a reasonable distribution of job types across countries. As anticipated by Table 4.1, Hungary and Spain comprise a larger percentage for some cells on account of the larger sample size from these countries.

Table 5.2 Type of work: 7-fold classification

Class	Includes	Sample (n)	Public sector (%)	Private sector (%)	Third sector (%)	Researchers (%)
Breeding & genetics		21	19.0	71.4	9.5	42.9
Farming related	Livestock farming Farming organisations Farm advisors	29	13.8	72.4	13.8	17.2
Food supply chain	Food processing Food retail	10	0.0	100.0	0.0	0.0
Feed & nutrition	Animal nutrition Feed /additive production Feed technology	40	12.5	85.0	2.5	35.0
Research, policy, regulation		15	80.0	6.7	13.3	78.6
Sectoral organis-ations & NGOs	Consumer orgs Environmental orgs Producers' sectoral orgs Think tank etc	17	17.6	17.6	64.7	62.5
Vets		5	40.0	60.0	0.0	20.0
Total		137	21.9	63.5	14.6	37.0

Table 5.3 Round 1 participants: job type and country

Sector	FR	HU	NL	SP	UK	Total
Breeding_and genetics	3 14.3%	5 23.8%	4 19.0%	6 28.6%	3 14.3%	21 100.0%
Farming related	6 20.7%	8 27.6%	2 6.9%	7 24.1%	6 20.7%	29 100.0%
Food supply chain	1 10.0%	4 40.0%	0 0.0%	4 40.0%	1 10.0%	10 100.0%
Feed & nutrition	15 37.5%	6 15.0%	4 10.0%	10 25.0%	5 12.5%	40 100.0%
Research, policy, regulation	2 13.3%	8 53.3%	3 20.0%	1 6.7%	1 6.7%	15 100.0%
Sectoral organisations and NGOs	2 11.8%	3 17.6%	2 11.8%	7 41.2%	3 17.6%	17 100.0%
Vets	1 20.0%	1 20.0%	1 20.0%	1 20.0%	1 20.0%	5 100.0%
Total	30 21.9%	35 25.5%	16 11.7%	36 26.3%	20 14.6%	137 100.0%

5.2 Respondent's knowledge

The questionnaire asked respondents to rate their level of knowledge of different types of livestock and of various aspects of livestock production using a 5-point rating scale (anchored at 1= 'none at all' and 5 = 'very high'). A 'low knowledge' category was created by amalgamating scores of 1 and 2, and a 'high knowledge' category by amalgamating scores of 4 and 5.

For livestock, Table 5.4 shows the sample had high levels of knowledge about pigs compared to other livestock types. Knowledge was most lacking for rabbit and other poultry. With respect to themes, the highest knowledge was associated with the topic of 'livestock husbandry', whereas knowledge was lowest for 'farmers and their households' and 'animal feed production'.

Table 5.4 Round 1 respondents and subjective knowledge levels

Animal type	**Low knowledge (Score = 1 or 2) (%)**	**High knowledge (Score = 4 or 5) (%)**
Pigs	10.4	59.9
Broilers	40.9	32.8
Layers	41.6	28.5
Other poultry	59.6	20.4
Rabbit	73.7	15.3
Theme		
Nutrition	19.0	40.1
Animal health/welfare	19.7	46.7
Animal feed production	35.0	31.4
Livestock husbandry	19.0	62.0
Economics of livestock production	19.7	43.8
Supply chain for livestock products	19.7	40.9
Env'l impacts of livestock production	15.3	48.2
Regulations for livestock production	24.1	41.6
Consumer attitudes	24.8	38.7
Farmers and their households	36.5	30.7

5.3 Indicator scores

Respondents were asked to consider the three domains of sustainability (economic, environmental and social) and rate their usefulness for evaluating the sustainability of livestock production. Then they were asked to rate the usefulness of individual indicators presented in three sets, corresponding to each domain. As explained earlier, a 5-point rating scale (anchored between 1= 'least useful' and 5 = 'most useful') was used for all indicator questions. The questions concerning indicators were identical in Round 1 and Round 2 although, as explained in Section 4.3, in Round 2 they were augmented with the group mean and S.D, and the individual participant's own Round 1 scores.

The final dataset consists of the personal information from Round 1, the Round 2 indicator scores given by Round 2 responders, and the Round 1 indicator scores for the individuals who did not respond to the Round 2 questionnaire. Table 5.5 shows the mean scores given

by respondents for general categories of indicator, and Tables 5.6 to 5.8 provide the mean scores for candidate indicators within the economic, environmental and social domains.

Not surprisingly, given that farming is a business and is only viable if profitable, the general economic indicator group was rated most highly. Consistent with this, the top economic indicators were those related to the ability to sustain a business in the short term (profitability, animal performance and costs). The second-ranked general indicator group was environmental indicators, although for individual indicators there is a narrower range of mean scores between the top and bottom-ranked indicators compared to economic indicators. The general social indicator was third and, of the individual indicators, Public Health was rated most highly. In second place was 'Farm Livelihoods', again reflecting the need for activities to be commercially viable for them to continue. The ability to ultimately sell the output (reflected by 'Product quality') also ranks highly.

Table 5.5 Perceived usefulness of general indicator groups, by mean scores, after Round 2.

Indicator group	Mean score
Economic	4.51
Environmental	4.09
Social	3.75

Table 5.6 Perceived usefulness of economic indicators, by mean score after Round 2.

Indicator	Mean
Profit	4.42
Animal performance	4.35
Costs	4.32
Investment	3.84
Distribution of profits	3.81
Labour required	3.51
Robustness	3.51
Land required	3.46
Supply chain	3.23
Subsidy	2.76

Table 5.5 Perceived usefulness of environmental indicators, by mean score, after Round 2.

Indicator	Mean
Energy	3.95
Water	3.91
Climate_change	3.74
Pesticide_use	3.72
Nitrogen	3.71
Phosphorus	3.64
Farm_waste	3.61
Acidification	3.33
Biodiversity	3.33
Land_related	3.28

Table 5.6 Perceived usefulness of social indicators, by mean score, after Round 2.

Indicator	Mean
Public_health	4.43
Farm_livelihoods	4.32
Product_quality	4.08
Farm_household_welfare	3.82
Technol_adoption	3.81
Society_preferences	3.74
Community_viability	3.68
Availability to_consumers	3.64
Neighbours_impacts	3.38

Tables 5.7 and 5.8 suggest that there may be some differences in mean scores according to type of job and country. For example, compared to other job types, *Sectoral organisations and NGOs* rate the social and environmental domains more highly and, together with *Research, policy and regulation*, rate the economic domain lower. With regard to country, the most marked difference in mean score is in the social domain where a difference of 0.63 separates the top and bottom-scoring groups. While this is not definitive, it does reveal the non-uniform preferences of Delphi participants.

Table 5.7 Perceived usefulness of general indicator groups by occupational group, by mean scores, after Round 2.

Class	Economic	Environmental	Social
All	***4.51***	***4.09***	***3.75***
Breeding_and genetics	4.71	4.05	3.67
Farming related	4.50	3.91	3.71
Food supply chain	4.40	3.80	3.70
Feed & nutrition	4.71	4.08	3.80
Research, policy, regulation	4.19	4.31	3.73
Sectoral organisations and NGOs	4.24	4.53	4.06
Vets	4.40	3.80	3.00

Table 5.8 Perceived usefulness of general indicator groups by country, by mean scores, after Round 2.

Class	Economic	Environmental	Social
All	4.51	4.09	3.75
France	4.83	4.12	4.07
Hungary	4.48	4.05	3.49
Netherlands	4.25	4.00	3.44
Spain	4.51	4.20	4.03
United Kingdom	4.33	4.00	3.48

5.4. Respondents' free comment

The final section of the questionnaire permitted respondents to provide comments if they wished. Over the two rounds, 47 substantive comments were received. They cover a wide range of issues including both technical matters related to the use of indicators in sustainability appraisal, and what respondents do in practice at farm level. The technical comments have been organised into two thematic groups (Concern about framing of the research problem; Technical comments on the use of indicators), and they raise interesting questions which should be considered when applying the indicators. Please see Annex 3 for a summary of the technical comments received.

As shown in Annex 3, the boundaries specified for the Feed-a-Gene project were problematic for a few respondents as they limit the objectives of the current study to particular aspects of the food production system, and consequently it is beyond its scope to evaluate the entire agri-food system in a general analysis. Nonetheless, all the points made are interesting and valid, and remind us of the need to understand the systems that we are

studying, and to pay attention to the narrative underlying the selection and weighting of indicators. The outcomes of the final sustainability appraisal (Task 6.5) will depend which underlying assumptions are made (e.g. the value of weights). Insights from Delphi respondents can support the development of alternative sets of assumptions which may be tested. These comments may also be of use to others in designing similar surveys.

6. Conclusions

A two-round Delphi study produced mean scores for a range of economic, environmental and social indicators according to their perceived usefulness for assessing sustainability.

The sample consisted of 137 people from five EU countries with a wide range of professional interests in livestock production, and including those working in public, private and third sectors. It included a substantive group of stakeholders from various parts of the agri-food industry as well as a smaller group from 3rd sector organisations.

Individuals have different priorities, knowledge and experience and will score the indicators differently. Descriptive statistics show that the mean indicator scores obtained were non-uniform across professional groups and countries, illustrating the value of an approach which does not limit the selection of weights to one small constituency such as farmers, policymakers, or academics.

Overall, when considering general indicator groups, Economic indicators were perceived as most useful for assessing sustainability (mean score = 4.51 out of 5), followed by environmental indicators (4.09) and social indicators (3.75). The pre-eminence of the need to make a profit to be able to sustain a business was illustrated by the high scores given to indicators relating to farm livelihoods (social domain), energy and water use (and, by implication, costs – environmental domain), and profitability (economic domain).

Individual indicators will be populated with data gathered during the project. A life-cycle analysis (LCA) will use natural science data related to animal performance from the project and model the impacts of adopting innovative strategies in pigs and poultry farms (Task 6.2). Task 6.3 will apply cost-benefit analysis at the farm level. Task 6.4 will conduct consumer research including a choice experiment to elicit consumer's awareness of technological issues related to feed and feeding, their preferences for different production methods (including effects on animal welfare), and the trade-off with product price. In addition, a farmer survey will gather information about attitudes towards adopting innovations.

7. References

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7 Annexes

Annex 1 Round 1 Delphi questionnaire

Feed-a-Gene

The Project

Feed-a-Gene is a project funded under the European Union's Horizon2020 programme (Grant Agreement 633531). Over 20 academic and industry partners from eight European countries and China are taking part in this major initiative led by the French National Institute for Agricultural Research.

The Feed-a-Gene project responds to some of the big challenges faced by EU livestock production, namely how to improve livestock productivity and profitability while reducing environmental impacts and dependence on imported feeds such as soya.

Feed-a-Gene will develop a range of technological solutions to improve feed utilisation in monogastric livestock (poultry, pigs and rabbits). These include improvements in animal performance by breeding and genetics, development of feed additives to improve digestive efficiency, precision feeding technology, better management through decision support tools and improved monitoring of animal feeding behaviour, and development of alternative and locally sourced protein feeds.

The Delphi Study

As part of the project we will need to compare the positive and negative changes which these different innovations bring – both with each other and with current agricultural practices. This is complicated as each solution may have many different impacts (e.g. impacts on farm profits, the environment, and consumers), with a mixture of positive and negative effects. In particular we wish to compare the sustainability of different solutions to help establish whether or not their use is viable in the long term.

Consequently we will develop a set of indicators that will provide a common basis for comparing the sustainability of the solutions. It is important that these indicators reflect the most important impacts.

We would be very grateful if you could help us with this task by participating in a Delphi study. A Delphi study is a means of gathering the opinions of experts using a sequence of simple questionnaire surveys. **Responses are anonymous** and are summarised to provide feedback to all participants after each round of the survey.

What we need you to do

We would like you to complete the attached questionnaire, and another questionnaire later in 2016. The questionnaires are being sent to experts from a number of different countries and disciplinary backgrounds.

In the questionnaire we have provided a list of many 'candidate' indicators and would like to learn your opinion about how relevant they are, and their relative importance. We kindly request you to fill in this questionnaire and return it (as an e-mail attachment) to ***marian.raley@ncl.ac.uk*** by ***November 8th, 2016***. The questionnaire will take approximately *25 to 30 minutes* to complete.

What we will do

All information received will be treated in confidence and used only for research purposes. If you have any questions about the Delphi study or the Feed-a-Gene project, please do not hesitate to contact us.

We would like to thank you in advance for your time and cooperation.

Yours sincerely

Marian Raley (Research Associate), Guy Garrod (Reader) and Dr Carmen Hubbard (Lecturer),

Centre for Rural Economy,
School of Agriculture, Food and Rural Development,
Newcastle University,
Agriculture Building,
Newcastle upon Tyne,
NE1 7RU.

Tel 0191 208 6460 / 0191 208 6623

For more information on Feed-a-Gene see http://www.feed-a-gene.eu/

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SECTION 1: YOUR EXPERTISE

These introductory questions tell us more about you.

1.1 Which **ONE** of the following best describes the type of work you do in livestock production**?** *(select appropriate box and type 'X')*	
a. Livestock farming	❒
b. Livestock breeding or genetics	❒
c. Animal feed technology or feeding equipment	❒
d. Production of animal feeds, ingredients or additives	❒
e. Animal nutrition	❒
f. Veterinary services.	❒
g. Animal welfare	❒
h. Farming organisation (e.g. cooperative; farmers union)	❒
i. Food processing industry	❒
j. Food retailing	❒
k. Consumer organisation	❒
l. Farm advisory service, technical consultant	❒
m. Policy	❒
n. Regulation	❒
Other (please specify) ……	❒

1.2 Is your **MAIN** role as a practitioner or researcher? *(Select appropriate box and type 'X')*	
Practitioner ❒	Researcher ❒

1.3 Which **ONE** of the following best describes the organisation that employs you to work in livestock production? *(select appropriate box and type 'x')*	
a. Public sector	❒
b. Private sector	❒
c. Third sector (not-for-profit; charity)	❒

1.4 Please rate on a scale from 1 to 5 – **where 1 is 'none at all' and 5 is 'high'** – **YOUR LEVELS OF KNOWLEDGE** about each of the following types of livestock production *(select appropriate box and type 'X')*					
a. Pigs	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
b. Broiler chickens	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
c. Laying hens	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
d. Other poultry	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
e. Rabbits	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒

1.5 Please rate on a scale from 1 to 5 – **where 1 is 'none at all' and 5 is 'very high'** – **YOUR LEVEL OF KNOWLEDGE** about each of the following areas relating to livestock production *(select appropriate box and type 'X')*					
a. Animal nutrition	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
b Animal health, disease and welfare	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
c. Animal feed production	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
d. Livestock husbandry and managemen	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
e. The economics of livestock production	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
f. The supply chain for livestock products	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
g. The environmental impacts of livestock production	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
h. Regulations related to livestock production	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
i. Consumer attitudes to livestock production	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
j. Livestock farmers and their households	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒

SUSTAINABILITY – OUR WORKING DEFINITION

We want to compare the sustainability of the various technological solutions that will be developed in the Feed-a-Gene project but recognise that there are many competing definitions of sustainability.

For the purposes of this exercise we use the following simple definition:

'Sustainability is the long term viability of an activity'

We will measure the impacts of the new technologies on sustainability using a series of **indicators**. These will show whether the impact is good or bad for sustainability, or neutral. But which are the best indicators to use in our project? We want your opinion.

Indicators are commonly divided into 3 categories:

Environmental sustainability
Economic sustainability
Social sustainability

Below is a simple example showing a few possible impacts on sustainability of new innovations in livestock feed technology.

Technology that is <u>More</u> sustainable (i.e. more viable in the long term)		**Technology that is <u>Less</u> sustainable** (i.e. less viable in the long term)
←	**Environmental sustainability**	→
Decreases pollution		**Increases pollution**
←	**Economic sustainability**	→
Increases farm profit		**Decreases farm profit**
←	**Social sustainability**	→
Decreases food prices		**Increases food prices**

SECTION 2: CATEGORIES OF INDICATOR

The following questions will ask you to give **your opinion** on the general usefulness of the different categories of sustainability indicators before asking about a selection of specific candidate indicators in each category. The candidate sustainability indicators were chosen (from many alternatives) following a stakeholder workshop earlier in the project and represent elements of the environmental/economic/social systems that may change as a result of the technological solutions proposed by this project.

Before looking at specific indicators we ask you to rate how useful different categories of indicator would be in evaluating the sustainability of livestock production

2.1 Please consider the following **GENERAL CATEGORIES OF INDICATOR** for **evaluating the sustainability of livestock production**. Thinking about general indicators only, please rate on a scale from 1 to 5 – **where 1 is 'least useful' and 5 is 'most useful'** – the usefulness of each of the following categories of **general indicator** for **evaluating the sustainability of livestock production in Europe**. *(select appropriate box and type 'X')*					
a. Economic indicators	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
b. Environmental indicators	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
c. Social indicators	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒

SECTION 3: ECONOMIC INDICATORS OF SUSTAINABLE LIVESTOCK PRODUCTION

We now ask you to consider which **ECONOMIC** indicators would be most useful for evaluating the impact on sustainability of changes in livestock production.

3.1 Please consider the following list of **ECONOMIC INDICATORS** for **evaluating the sustainability of livestock production.** Thinking about **ECONOMIC INDICATORS ONLY**, how useful is each of the following for **evaluating the sustainability of livestock production in Europe**? Please rate on a scale from 1 to 5, **where 1 is 'least useful' and 5 is 'most useful'** *(select appropriate box and type 'X')*					
a. Indicators related to the costs of production (e.g. energy or feed costs)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
b. Indicators related to investment in livestock production (e.g. level of investment required / payback period)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
c. Indicators related to profitability (e.g. profit per kg meat or per egg)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
d. Indicators related to labour requirement (e.g. labour costs per kg meat or per egg)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
e. Indicators related to land requirement (e.g. kg meat produced per hectare of land)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
f. Indicators related to animal performance (e.g. feed efficiency)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
g. Indicators related to the distribution of profits along the supply chain (e.g. across farmers, processors, retailers)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
h. Indicators related to the supply chain (e.g. level of dependence on main supplier)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
i. Indicators related to levels of subsidy received (e.g. % of farm income derived from subsidies)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
j. Indicators related to the robustness of production (e.g. low output variability despite changes in external conditions)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒

SECTION 4: ENVIRONMENTAL INDICATORS OF SUSTAINABLE LIVESTOCK PRODUCTION

We now ask you to consider which **ENVIRONMENTAL** indicators would be most useful for evaluating the impact on sustainability of changes in livestock production.

4.1 Please consider the following list of **ENVIRONMENTAL INDICATORS** for **evaluating the sustainability of livestock production.** Thinking about **ENVIRONMENTAL INDICATORS ONLY**, how useful is each of the following for **evaluating the sustainability of livestock production in Europe**? Please rate on a scale from 1 to 5, **where 1 is 'least useful' and 5 is 'most useful'** *(select appropriate box and type 'X')*					
a. Indicators related to energy consumption (e.g. on-farm, transport and feed processing)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
b. Indicators related to climate change (e.g. CO_2 emissions)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
c. Indicators related to phosphorus (e.g. emissions to the environment)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
d. Indicators related to nitrogen (e.g. emissions to the environment)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
e. Indicators related to acidification (e.g. pH of river water)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
f. Indicators related to land (e.g. hectares under intensive management)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
g. Indicators related to water use (e.g. water used per unit of production)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
h. Indicators related to the production of farm waste (e.g. waste produced per unit of production)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
i. Indicators related to biodiversity (e.g. changes in species numbers, habitat area)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
j. Indicators related to pesticide use (e.g. pesticide used per tonne of animal feed)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒

SECTION 5: SOCIAL INDICATORS OF SUSTAINABLE LIVESTOCK PRODUCTION

Finally, we ask you to consider which **SOCIAL** indicators would be most useful for evaluating the impact on sustainability of changes in livestock production.

5.1 Please consider the following list of **SOCIAL INDICATORS** for **evaluating the sustainability of livestock production** Thinking about **SOCIAL INDICATORS ONLY**, how useful is each of the following for **evaluating the sustainability of livestock production in Europe**? Please rate on a scale from 1 to 5, **where 1 is 'least useful' and 5 is 'most useful'** – *(select appropriate box and type 'X')*					
a. Indicators related to farm livelihoods (e.g. the security of income from farming; impacts on other farmers)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
b. Indicators related to the welfare of the farm household (e.g. mental health; isolation; access to social networks)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
c. Indicators related to farmers' adoption of new production methods (e.g. preferences for new methods; compatibility with existing systems)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
d. Indicators related to the viability of rural communities (e.g. rural employment, on and off-farm)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
e. Indicators related to the availability of animal products to consumers (e.g. price; stability of supply)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
f. Indicators related to society's preferences for production methods (e.g. consumer preferences)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
g. Indicators related to product quality attributes (e.g. taste, health, cost)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
h. Indicators related to public health impacts of livestock production (e.g. food safety, antibiotic use)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒
i. Indicators related to impacts on neighbours (e.g. noise, smell, visual impacts)	1. ❒	2. ❒	3. ❒	4. ❒	5. ❒

SECTION 6: COMMENTS

Please make any further comments here.

Please provide your name and e-mail address.
(For administrative purposes. Your answers are confidential.)

NAME …….
e-mail address ……..

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE. PLEASE SEND IT AS AN E-MAIL ATTACHMENT TO marian.raley@ncl.ac.uk

THE SECOND ROUND OF THIS QUESTIONNAIRE WILL BE SENT LATER IN THE YEAR AFTER THE FIRST ROUND DATA HAS BEEN COLLATED

More information about the Feed-a-Gene project can be found at: http://www.feed-a-gene.eu/

Annex 2 Round 2 Delphi questionnaire

Feed a Gene Delphi Study: Round 2 questionnaire

Introduction

Thank you very much for filling in the Round 1 questionnaire that we sent you in autumn 2016. This Round 2 questionnaire is almost the same, but in addition we provide feedback on the answers given by other respondents in Round 1. This latest questionnaire gives you the opportunity to consider other people's responses, to reconsider the answers you gave in Round 1 (which we provide), and to change them if you wish.

Rationale: At actual physical meetings, people may change their opinions in the light of what other people have said. The Delphi survey process simulates this interaction by allowing you to confirm or change your previous answers in response to the feedback from other people. This gives us greater confidence in the results.

We kindly request you to fill in this questionnaire and return it (as an e-mail attachment) to ***marian.raley@ncl.ac.uk*** by ***February 13th, 2017***. The questionnaire will take approximately 20 minutes to complete.

Thank you very much for helping us once more.

Yours sincerely

Marian Raley and Guy Garrod
School of Agriculture, Food and Rural Development,
Newcastle University,
Agriculture Building,
Newcastle upon Tyne,
NE1 7RU.

Round 1 – reminder

The EU Feed a Gene project is developing various technological solutions including genetic improvement, better feed/ additives, novel protein sources, and improved monitoring and feeding technology. These innovations are for use in non-ruminant livestock production (pigs, poultry and rabbits). They aim to improve feed conversion efficiency.

We wish to compare the sustainability of these technical solutions. For the purposes of this exercise we use the following simple definition:

'Sustainability is the long term viability of an activity'.

We need to balance the relative importance of various environmental, social and economic impacts arising from the use of these technological innovations. Everybody's opinion about the 'correct' balance between environmental, social and economic is different, hence we have tried to obtain a wide range of viewpoints (industry, academia, farmers organisation, consumer organisations etc) in this study.

The Round 1 questionnaire was completed by 133 experts located in France, Hungary, The Netherlands, Spain and the UK. A wide range of people completed the questionnaire and many thoughtful and useful comments were made. We are very grateful to everyone who participated.

The Round 2 questionnaire

The previous questionnaire contained lists of potential indicators for assessing sustainability of livestock production. We asked you to indicate their usefulness for assessing sustainability on a scale of 1 to 5. For example if someone thinks 'animal performance' is an important criterion for measuring and comparing the sustainability of, say, different livestock production methods then they will give it a high score.

The scores of the experts as a group indicated that the economic, followed by the environmental indicators are more useful than the social indicators for assessing sustainability of livestock production. This latest questionnaire gives you the opportunity to consider other experts' responses, to reconsider the answers you gave in Round 1 (which we provide in this personalised questionnaire), and to change them if you wish. The responses of other respondents appear as the group's average score and standard deviation.

Please read the questions again, consider the group average (mean), and enter the final value you wish to give (either the same as before, or different).

All questions use the same scale, where 1 is 'least useful' and 5 is 'most useful'.

SECTION 1: CATEGORIES OF INDICATOR

Q1 Please consider the following **GENERAL CATEGORIES OF INDICATOR** for **evaluating the sustainability of livestock production**.
Thinking about general indicators only, please rate on a scale from 1 to 5 – **where 1 is 'least useful' and 5 is 'most useful'** – the usefulness of each of the following categories of **general indicator** for **evaluating the sustainability of livestock production in Europe**.
Please compare your original score to the group average, and enter either 'Same' or a new score in the right hand column.

	Round 1 responses			
	Your Round 1 score	Mean score (all respondents)	S.D.	Your revised score *'Same'* or a *new value*
a. Economic indicators		4.50	0.76	
b. Environmental indicators		4.10	0.81	
c. Social indicators		3.74	0.97	

Explanation:
A low value of standard deviation (S.D.) occurs when there is little variation in the answers, which are concentrated around the mean value. The higher the standard deviation, the lower is the level of agreement between respondents. We want to be more certain about whether there is (or is not) consensus.

SECTION 2: ECONOMIC INDICATORS OF SUSTAINABLE LIVESTOCK PRODUCTION

Q2 Please consider the following list of **ECONOMIC INDICATORS** for **evaluating the sustainability of livestock production.**

Thinking about **ECONOMIC INDICATORS ONLY**, how useful is each of the following for **evaluating the sustainability of livestock production in Europe**? Please rate on a scale from 1 to 5, **where 1 is 'least useful' and 5 is 'most useful'**.

Again, please compare your original score to the group mean, and enter either 'Same' or a new score in the right hand column

	Round 1 responses			
	Your Round 1 score	Mean score (all respondents)	S.D.	Your revised score 'Same' or a new value
a. Indicators related to the costs of production (e.g. energy or feed costs)		4.30	0.84	
b. Indicators related to investment in livestock production (e.g. level of investment required / payback period)		3.83	0.84	
c. Indicators related to profitability (e.g. profit per kg meat or per egg)		4.34	0.89	
d. Indicators related to labour requirement (e.g. labour costs per kg meat or per egg)		3.46	0.95	
e. Indicators related to land requirement (e.g. kg meat produced per hectare of land)		3.42	1.15	
f. Indicators related to animal performance (e.g. feed efficiency)		4.31	0.78	
g. Indicators related to the distribution of profits along the supply chain (e.g. across farmers, processors, retailers)		3.80	0.99	
h. Indicators related to the supply chain (e.g. level of dependence on main supplier)		3.22	1.11	
i. Indicators related to levels of subsidy received (e.g. % of farm income derived from subsidies)		2.84	1.14	
j. Indicators related to the robustness of production (e.g. low output variability despite changes in external conditions)		3.50	1.06	

SECTION 3: ENVIRONMENTAL INDICATORS OF SUSTAINABLE LIVESTOCK PRODUCTION

Q3 Please consider the following list of **ENVIRONMENTAL INDICATORS** for **evaluating the sustainability of livestock production.**

Thinking about **ENVIRONMENTAL INDICATORS ONLY**, how useful is each of the following for **evaluating the sustainability of livestock production in Europe**? Please rate on a scale from 1 to 5, **where 1 is 'least useful' and 5 is 'most useful'**.
Again, please compare your original score to the group mean, and enter either 'Same' or a new score in the right hand column

	Round 1 responses			
	Your score	Mean score (all respondents)	S.D.	'Same' or a new value
a. Indicators related to energy consumption (e.g. on-farm, transport and feed processing)		3.98	0.97	
b. Indicators related to climate change (e.g. CO_2 emissions)		3.72	1.03	
c. Indicators related to phosphorus (e.g. emissions to the environment)		3.62	0.93	
d. Indicators related to nitrogen (e.g. emissions to the environment)		3.72	0.89	
e. Indicators related to acidification (e.g. pH of river water)		3.36	0.99	
f. Indicators related to land (e.g. hectares under intensive management)		3.28	1.12	
g. Indicators related to water use (e.g. water used per unit of production)		3.91	0.96	
h. Indicators related to the production of farm waste (e.g. waste produced per unit of production)		3.64	1.04	
i. Indicators related to biodiversity (e.g. changes in species numbers, habitat area)		3.30	1.10	
j. Indicators related to pesticide use (e.g. pesticide used per tonne of animal feed)		3.68	1.07	

SECTION 4: SOCIAL INDICATORS OF SUSTAINABLE LIVESTOCK PRODUCTION

Q4 Please consider the following list of **SOCIAL INDICATORS** for **evaluating the sustainability of livestock production**

Thinking about **SOCIAL INDICATORS ONLY**, how useful is each of the following for **evaluating the sustainability of livestock production in Europe**? Please rate on a scale from 1 to 5, **where 1 is 'least useful' and 5 is 'most useful'**.

Again, please compare your original score to the group mean, and enter either 'Same' or a new score in the right hand column

	Round 1 responses			
	Your score	Mean score (all respondents)	S.D.	'Same' or a new value
a. Indicators related to farm livelihoods (e.g. the security of income from farming; impacts on other farmers)		4.27	0.81	
b. Indicators related to the welfare of the farm household (e.g. mental health; isolation; access to social networks)		3.73	0.93	
c. Indicators related to farmers' adoption of new production methods (e.g. preferences for new methods; compatibility with existing systems)		3.81	0.91	
d. Indicators related to the viability of rural communities (e.g. rural employment, on and off-farm)		3.63	0.91	
e. Indicators related to the availability of animal products to consumers (e.g. price; stability of supply)		3.69	1.00	
f. Indicators related to society's preferences for production methods (e.g. consumer preferences)		3.70	0.95	
g. Indicators related to product quality attributes (e.g. taste, health, cost)		4.08	0.90	
h. Indicators related to public health impacts of livestock production (e.g. food safety, antibiotic use)		4.36	0.83	
i. Indicators related to impacts on neighbours (e.g. noise, smell, visual impacts)		3.34	0.96	

SECTION 5: COMMENTS

Please make any further comments here.

Please provide your e-mail address. (For administrative purposes. Your answers are confidential.)
e-mail address ……..

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE. PLEASE SEND IT AS AN E-MAIL ATTACHMENT TO <local contact e-mail address>

More information about the Feed-a-Gene project can be found at: http://www.feed-a-gene.eu/

Annex 3 Summary of respondents' free comment

Theme 1: Concern about the framing of the research problem

• Two respondents commented that the sustainability appraisal will be a partial analysis, restricted largely to innovation in intensive production systems, and not considering the whole agri-food system. One commented that our inclusion of cheap food as a social indicator was indicative of support for a food system that relies on intensive production methods to provide meat, whereas a more sustainable solution would be to alter human western diets to include less meat.

'*I have considerable doubts about the appropriateness of considering the sustainability of livestock production as a stand-alone topic. Rather, it ought to be considered within the broader issue of the sustainability of agriculture, or food systems. There are critical questions to be asked about the proportion of food from animals and plants in people's diets, about the amount of nutrients (such as protein) – rather than necessarily meat or other animal products – that can be produced from a hectare of land or using certain resources or producing certain emissions, and so on*.' (UK 7)

It should be noted that the project (rightly or wrongly) is motivated by the EU's wish to reduce reliance on imported protein feeds (partly to reduce unsustainable practices and the use of genetically-modified soybeans from South America) and is therefore concerned with alternative protein sources and improving feed conversion efficiency. Hence it is very specific in its scope and considers only parts of the agri-food system.

• Two responses suggested that the scores obtained would depend on the sample composition and time horizon that is being considered:

'It could be interesting to ask experts about their age as people's sensitivity to sustainability may be related to age. Would it be valuable to do this survey with university students?' (FR 15)

'*I would like to point out that responses could change depending on the amount of time that respondents are thinking about (5, 10, 50 years…). I was thinking in a very long term, in a scenario in which labour will be not relevant, because of a higher automatization*.'(SP 24)

• Conceptualising sustainability as three domains was mostly seen as appropriate :

'Sustainability assessment must embrace all aspects: economic, environmental and social. Many times some aspects have been forgotten, which has led to deficient assessments (of the sustainability). (SP 6)

• Interpretation of the term 'sustainability' by consumers might be problematic, for example in consumer studies:

'*Sustainability in agriculture needs to be explained to the public. For example slow growing chickens need more feed, more heat and is less good for the climate change of the world. But in the mind of people, the consumers think when they buy this meat that it*

is coming from sustainable farming. The reality and the emotion have to be separated and explained'. (NL 4)

• One respondent was curious about whether effects resulting from changes beyond those to farm production technology would be considered in the sustainability assessment.

'*Which modifications of external conditions are suggested (fiscality, measures to support agriculture, climatic hazards?) Which are the leverage tools for monogastric production?*' (FR 18)

Theme 2: Technical comments on the use of indicators

• '*Indicators, as much as possible, should be outcome-focused, rather than input-focused'*. (UK 5)

• Geographical scale and location

The questionnaire related to agriculture in the EU, but a few comments pointed to possible differences in responses if different geographical contexts (local, member state, global) were considered.

'*From a global perspective, …. common indicators (such as carbon footprint, biodiversity) may be basically relevant to all activities worldwide. However, the relevance of specific indicators may differ significantly between regions and therefore be more or less relevant to a specific activity*.' (NL 5)

This issue was raised with respect to social indicators :

'I believe in the UK, the social indicators of sustainability have less influence than the economic or environmental. Particularly the impacts on the farmers/producers themselves, with most interest being on the consumer.' (UK 19)

• Interaction between indicators

Three respondents highlighted that there would be interactions between some indicators, making it difficult to score individual indicators.

'*Arguably, farm income could be an economic and a social indicator. As such, cheap food for the consumer could potentially negatively affect farm income*.' (UK 9)

'*To me, with laying hens, improving welfare directly translates into better economics* (*improved mortality, stress and production), and better sustainability*.' (UK 16)

The practical implications in farmer decision-making were highlighted by one respondent :

'A serious problem is that sustainability assessments are not aligned with a greater economic return from the productions. This compromises investment and farmers' engagement to invest in sustainability, in spite of their certainty that it is the right way of producing animals in the present and in the future.' (SP 6)

• Specific indicators (inclusion and interpretation)

There was concern that the questionnaire omitted particular indicators, particularly animal welfare (3 comments), but also renewable energy.

'*Personally I prefer an additional factor: People, Planet, Profit and Animal, where the Animal factor reflects Animal health and welfare. This gives the animal its own place and value alongside people, planet and profit.'* (NL 10)

'*In environmental indicators I think that one category is missing which would be about renewable energies (from methanisation for example) and about waste recycling (food byproducts, animal proteins, biomass etc...)*' (FR 3)

However, these concepts are subsumed within the indicators *'Society's preferences for production methods' (*Round 1 questionnaire, Q5.1f) and *'Indicators relating to climate change' (*Round 1 Q4.1b). These indicators could include measurements for variables related to these specific issues.

'Q5.1b: '*The examples of well-being for farmers (like mental health, isolation) seem to be far from the project and it would be better to evaluate health and security at work, ergonomy, leisure time and social life.*' (FR 18)

• Three respondents were unclear about the definition of farm waste (Round 1, 4.1h) and whether it includes manure, which is widely regarded as a resource.

• Two respondents emphasized the need to consider energy use along the whole supply chain:

'Energy use on primary production level is very limited; however if taking the entire production chain into account (feed production, processing of products), it is very relevant.' (NL 10)

'(Q4.1a, Indicators relating to energy consumption') *Be sure that this indicator is related to feed manufacture (at farm or in factories)*.' (FR 18)