TOWARDS IMPROVEMENT OF **RUMI**NANT BREEDING
THROUGH **GEN**OMIC AND EPIGENOMIC APPROACHES

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Deliverable 2.1

Room of Acceptance Ex-Ante

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Contents

1 Summary

Genetic adaptation of production animals is likely to be a societally controversial intervention. To support responsible research and innovation on potentially controversial issues a “Room of Acceptance” is proposed that can support aligning societal views and prioritise ruminant breeding. The ex-ante room of acceptance was developed through 2 workshops and a review of 2 streams of literature. For the ex-ante room 14 main dimensions consisting of 27 subdimensions are proposed, with a description of an acceptable, an unacceptable and a boundary situation each. In addition, differences in trust levels, worldviews and ethics are considered to constitute contextual dimensions that can explain differences in societal views. Suggestions for further development, use and validation of the room of acceptance approach for the Rumigen project and in general are provided.

2 Objectives

Rumigen’s deliverable 2.1 provides the ex-ante Room of Acceptance for task 2.2 of Rumigen. The scope of this report consists of the first part of task 2.2.

Task 2.2 initially explored the workings and configuration of the "Room of Acceptance" by desk study research on acceptance studies on biotechnology, Eurobarometer and national surveys and research projects with the purpose of relating these findings to livestock breeding technologies. The remaining parts of task 2.2 will be reported in Deliverable 2.4 (D2.4).

After finalising the ex-ante room of acceptance its further development and validation will be supported by an online survey, translated to at least 8 EU languages, exploring potentially new opinions on breeding that are not covered by the draft "room of acceptance". This survey will be explorative, not representative, because the aim is to add perspectives, not to study the relative strength of opinions. The data will serve to improve the acceptance hypothesis and provide a theoretical frame. In addition, scenarios in task 2.3 which serve as point of comparison in the participatory citizen consultation of task 2.4 contribute to the development of the ex-post "room of acceptance". After the activities in task 2.4, task 2.2 continues to develop the final ex-post room of acceptance, which will be an element of the model for acceptance studies developed in task 2.5.

3 Introduction

Success or failure of the adoption of gene-based adaptations to ruminants depends on societal acceptance. Previous gene-based agriculture applications have met with substantial societal protests, particularly in Europe. The discussion on the acceptability of, particularly first generation, genetic modification, has resulted in a debate where fierce supporters and opponents dominated the discussion. The subsequent debate resulted in a polarised and entrenched situation, where both supporters and opponents of gene-technologies locked in on decisive justification of their position. This has resulted in many propositions why gene-technology must be accepted (brought forward by supporters) or what barriers for acceptance make it intrinsically unacceptable (brought forward by opponents). In addition, the entrenchment and polarisation has resulted in the limited willingness to compromise and focus on creating societally acceptable gene-technology applications.

A huge body of research has considered reasons why the public might accept or reject gene-technologies. While most of this literature has focused on plant applications, there is also some considerable literature on animals (see e.g. Frewer et al., 2013). Most of the extant research focuses on one or a few determinants of acceptance or rejection without considering the combinations of such determinants. In addition, there is relatively little research what the specific boundaries are where acceptability becomes unacceptable.

Within Rumigen, the aim is to create and finetune a set of boundary conditions that describe the combination of attributes or dimensions of gene-technology applications applied to ruminants where the application of gene-technology becomes or ceases to be acceptable to society at large. This multidimensional space might give a more nuanced view on acceptability of applications.

This approach is being newly developed within Rumigen. We have labelled this idea a (multidimensional) “Room of Acceptance.” We postulate that if development of a specific gene-technology remains within that room, it should be acceptable to society.

Within Rumigen we aim to develop such a multidimensional nuances space, which we label a “Room of Acceptance.” Different acceptance dimensions determine the shape of the room. The “walls” of the room of acceptance are formed by an estimation of the level at which attributes of the technologies and their application become unacceptable to society. It should be kept in mind that the “wall” may not be a solid (brick like) wall, but may also constitute blurred regions, where the shift from acceptable to unacceptable may vary somewhat over time depending on context.

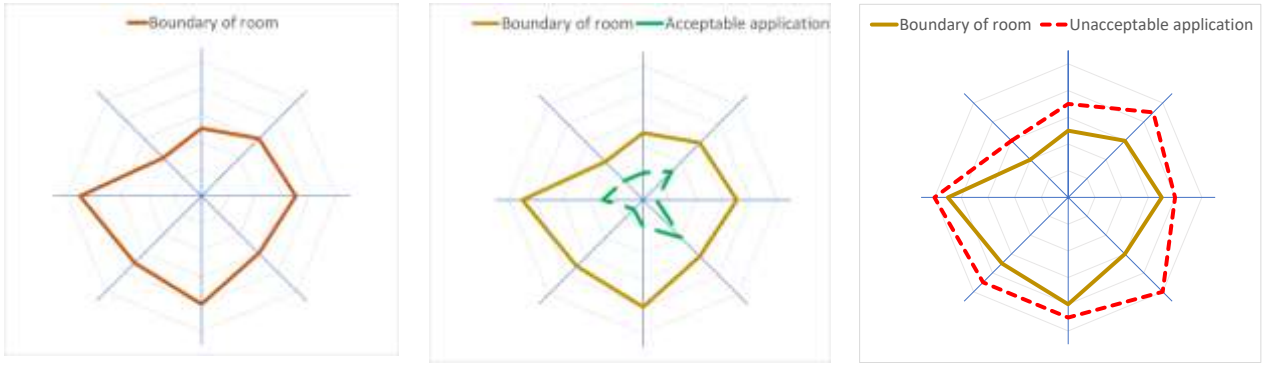
In practical terms, on the one hand, the room of acceptance should inform developers of gene technologies to prioritise their development of these techniques to meet a manageable set of societally and environmentally relevant criteria, on the other hand it requires societal organisations to consider under what conditions, what kinds of gene-technology could be acceptable.

The development of the room of acceptance will be a sequential process over the duration of the Rumigen project. Starting from initial insights by the authors of this deliverable (i.e., the partners involved in the task), additional information from existing sources will be combined into an *ex-ante* room of acceptance. Through subsequent workshops, scenario studies, and discussions, the relevance and usefulness of the room of acceptance as a general concept, and the specific room of acceptance for ruminant breeding, specific to Rumigen will be explored. In D2.4 a revised version of the room of acceptance, the *ex-post* room of acceptance, based on experience throughout Rumigen will be detailed.

4 The concept of the Room of Acceptance

The concept of the room of acceptance assumes a multidimensional space that describes the boundaries where a gene technology is acceptable. The boundary where acceptance turns to rejection constitutes the shape of the room. Any application remaining within such boundary is likely to be acceptable, those outside the room are likely to be unacceptable.

The number of dimensions and the boundary for each dimension needs to be determined. A fictitious example would be a simple room of acceptance with 8 dimensions that are not related to each other (figure 4.1a). If the proposed application score within the boundaries on all dimensions, this application is likely to be acceptable (figure 4.1b), if it falls outside, it is likely to unacceptable (figure 4.1c)



a) b) c)

Figure 4.1. Panel a) fictitious 8-D room of acceptance. Panel b) a likely acceptable (fictitious) application within the room. Panel c) a likely unacceptable (fictitious) application falling outside the room.

Such relatively simple rooms of acceptance may support discussions on acceptability of gene-based applications. However, already in initial discussion (both within the team and with stakeholders) it was suggested that reality is probably more complex. To deal with this, we can consider several (hypothetical) extensions to the simple approach to the room of acceptance. For the development of the ex-ante room of acceptance these will not be further integrated, but in the remainder of the work we will consider to what extent it is possible and relevant to integrate these hypothetical extensions. In this we will adopt a pragmatic approach, where we aim to provide a room of acceptance approach that is as simple as possible to allow actual use, while it is also sufficiently precise to be content wise relevant. To establish such a balance, we will consider the following questions and required extension of the simple room of acceptance:

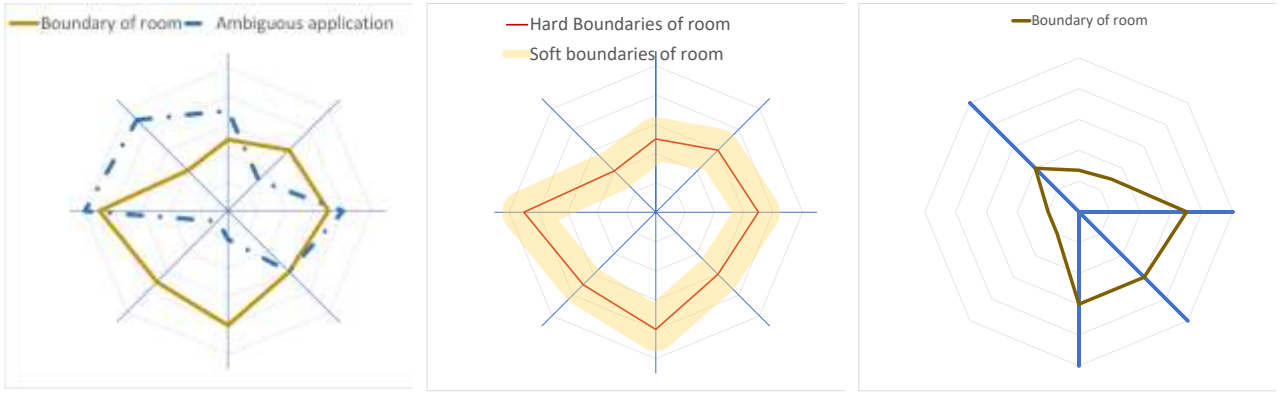
(1) Is it possible to compensate an application that does not meet all acceptability criterions (example in figure 4.2a)? If this is possible, is this equally possible for all dimensions or are there some that cannot be compensated for? We expect that for such compensation other dimensions need to score very good, beyond mere acceptance and thus make up for the less than desirable score on another dimension, we also expect some dimension will have a hard boundary (red line) that cannot be compensated for. This will be evaluated further in the subsequent work.

(2) What is the range where acceptance becomes rejected, within which attributes can be compensated for (example in figure 4.2b)? For some attributes there might be a relatively large grey

area where citizens start to feel uneasy about the specific dimension but may not yet definitively reject the application. There will also be an upper boundary of unacceptance beyond which the application can never be accepted. This range might be wide or narrow and will determine to what extent ambiguous applications as depicted in 4.2a can become acceptable given performance on the remaining dimensions. In the specification of boundaries, we will further explore to what extent such “soft” or “hard” boundaries exist and matter. It is likely that non-compensatory dimensions may show harder boundaries.

(3) Can dimensions be considered independent? It is likely that some dimensions are not independent, thus creating a non-symmetrical room of acceptance (panel 4.2c). This can create opportunities, but also complicates and possibility limits the application and development of the room of acceptance that are unlikely to be defined ex ante. In subsequent work we will consider whether it is necessary to specify the room of acceptance with such interrelated dimensions, where a pragmatic approach to maximise parsimony will be adopted to avoid as much complexity as possible.

Although we will not explore these issues for the ex-ante room in depth, we nevertheless mention those issues upfront to keep good track of these issues while working with the proposed draft room and will reflect on these issues when defining the ex-post room of acceptance.



a) b) c)

Figure 4.2 Panel a) Ambiguous application with attributes that are acceptable and not acceptable Panel b) Hard boundary (small margin of crossing the line) and soft boundary. Panel c) 4-dimensional room with related subdimensions (right lower set of 3)

5 Developing the draft room of acceptance based on prior knowledge

5.1 The field of public acceptance of gene technologies

Prior knowledge on gene-technologies, including the application to animals has resulted in a massive body of publications.

5.1.1 Surveys and other quantitative empirical approaches

The literature on societal acceptance of gene-technologies includes a group of reports relying on closed questionnaires on acceptance and rejection factors to genetic modification as technology. Several specific instances of the Eurobarometer on biotechnology were conducted in this way (most

recently in 2010 Gaskell et al., 2004; Simon, 2010), but also many surveys using attitude, risk-benefit (see: Frewer et al., 2013 for a meta analysis) or willingness to pay measures (see: Lusk et al., 2005 for a meta analysis). As well as closed question questionnaires looking at specific application domains (Frewer & Shepherd, 1995) or specific products (Bredahl et al., 1998).

By their nature, this literature focuses on a preselected number of determinants why consumers may accept or reject biotechnology. In terms of room of acceptance these studies can confirm whether preconceived dimensions matter and give some insight into boundaries of acceptance. By necessity, these methods will not be able to provide all dimensions in a single study, although by aggregating the literature many dimensions are likely to be identified. As most of these studies only include a few dimensions they are not able to capture the nuanced trade-offs the public makes.

Although most studies on gene technologies focused on plant breeding, a substantial amount of research into societal acceptance of gene technologies towards animals have been conducted. Meta-analyses have attempted to consolidate the scattered evidence and have shown some dimensions at a high level of abstraction that often matter in acceptance. But as not all potentially relevant dimensions have been studied equally frequently, and even less frequently in combination, even these meta-analyses give a limited view on the domain. Taking a strictly mathematical-statistical view on how all relevant dimensions may be traded off against each other may in any case not be the most relevant way forward given the complexity and volatility of the possible interactions within this set of dimensions. Surveys are particularly suited to collect specific, narrowly defined data from large potentially representative samples.

5.1.2 Citizen involvement and other qualitative empirical approaches

A second group of studies takes a more open paradigm by involving participants in more open ways. While this can give more insight into the nuanced decision making of the public, these methods tend to be labour intensive and hence report on relatively few participants. Therefore such approaches are not able to give a representative overview of all consumers (cf. Bain et al., 2020; Middelveld & Macnaghten, 2021). Nevertheless, exploratory methods are more likely to identify a broader range of dimensions as well as complex combinations of boundary conditions for the room of acceptance. Focus groups, open interviews, citizen engagement and similar approaches are common ways to gain insights from the public this way. Within this group there is a subgroup of studies where experts reflect on their preconceived ideas on public opinion, which may or may not be in line with the actual public opinion.

Scenario studies, and the creation of imaginaries take the approach to develop specific ideas of how society might deal with an innovation. Such imaginaries or scenarios often depict extreme developments in society that may lead to acceptance or rejection of a technology in abstracta. The focus in these is often more on how society deals with a technology than with the specifics of the technology.

5.1.3 Normative and ethical approaches

A third group of studies is reflective in nature and considers ethical arguments why the public may or may not accept gene technologies. The studies take a normative stance on what is fair, rather than trying to understand public response in the primarily empirical stance taken in both survey style and interview type approaches. Such studies can, through their analytical depth, bring underlying ethical issues to light that may not initially feature in the mind of the public. Nevertheless, even if such ethical issues are not saliently reported using an empirical approach, they still may cause public unrest if they become known when gene technologies are introduced in society.

5.2 Initial insights from the field of gene technologies

Based on an initial screening of the literature and discussions within the Rumigen WP2 team, initial dimensions were identified that might play an important role. We predefined these dimensions to seed the initial workshops.

(1) Aim of intervention and application domain: *Aim*: saving human life, increasing sustainability, increasing economy, generating profit *Domain*: Food, Military, Industry (primary production, processing, biomaterials – durables / fuels / chemicals), Medicine (pharma, transplantable organs).

Selected as we expect that saving life is preferred and profit is disliked. Similarly, we anticipate food is disliked and medicine like.

(2) Which organism is targeted: Yeast, bacteria other microbial, fish, mammals (and if so which), humans.

Selected as we expect that the closer to humans the less acceptable it is

(3) Intrusiveness of the intervention:

Selected as we expect Alien or cross species DNA transfer is expected to be less acceptable then within species DNA transfer. Gene-editing is expected to be somewhat more acceptable than any gene transfer.

(4) Natural and traditional versus advanced:

Selected as we expect that the more natural an intervention is perceived to be (regardless of actual naturalness) the more acceptable.

(5) Magnitude of Benefits: In economic / monetary terms, or in environmental, health or other societally relevant terms

Selected as we expect societal benefits are considered more acceptable than economic benefits

(6) To whom the benefits: Individual consumer, peers to the consumer, society at large, local industry (breeders, farmers), multinationals/foreign industry.

Selected as we expect that industrial/multinational profit is largely disliked

(7) Magnitude of Cost/Risk/Uncertainty: In monetary terms, or in environmental, health or other societally relevant terms. Includes uncertainty on long term, or unchecked side effects (e.g., escape to the wild populations)

Selected as we expect: long term effects, and uncontrolled effects are deemed very negative

(8) To whom the risks/costs: The modified organism, consumers, nature, specific countries, companies using the tech, companies creating the technology

Selected as we expect: That risks to humans and animals who have no control on the situation are less acceptable than to agents involved in the innovation.

(9) Legal and institutional checks and balances: national safety authority, EU safety authority, global agreements, trade agreements, free market

Selected as we expect: European citizens demand a high level of governmental control over admitting and checking such technologies

(10) Institutional Responsibility across time and environment

Selected as we expect: European citizens have shown concern for long term effects

(11) Aesthetics.

Selected as we expect: The current conventionally breed beef cattle (Belgian blue) and fast-growing broiler may be considered unacceptable for the animal species they represent. Gene-editing may also result in unacceptable animal shapes.

6 Information streams utilised

Based on the insights from section 5, we engaged in a more systematic use of accessible information. Therefore, we collated information from 3 streams of information. (1) Insights from Rumigen partners, who are experts in the field (2) A review of the literature (3) Insights from the Eurobarometer on biotechnology, being the most extensive survey on the topic across Europe.

We analysed each of these information streams in a bottom-up way, to capture the broadest possible range of emerging outcomes without being constrained by structures from the other information streams. Section 6 reports on these findings. In section 7 we subsequently align these findings to reduce redundancies and arrive at more integrated insights.

6.1 Workshop with Rumigen partners

In April 2022, a face-to-face consortium meeting of the Rumigen partners was held at the INRA facilities in Jouy-en-Josas (close to Paris, France). During this meeting, a workshop was conducted.

In the plenary meeting a brief introduction of the idea of a room of acceptance was presented. After the introduction participants of the meeting were divided into 4 breakout groups.

Each breakout group was moderated by an expert in such workshops and were asked to discuss 3 questions. The moderator also took notes on the discussion on (1) What dimensions, relevant to the room of acceptance, could the participants raise themselves (2) To what extent did they agree that the initially scoped dimensions were relevant, sufficiently complete, and were not ill-defined (3) (if time allowed) at what level/score on each dimension would they consider a technology to become unacceptable (against that dimension).

This resulted in a lively discussion in all 4 groups of about 90 minutes. Groups generally did provide additional dimensions, or particularly provided in depth insights into the specifics of dimensions (question 1) and generally agreed with the predefined dimensions (question 2) but did not manage to get in depth insight into where acceptance ended (question 3). After a short break, the notetakers of the 4 groups provided a short debriefing. Notes for all groups were collected and collated.

The collated notes were analysed. First codes for each breakout group were grouped into themes (e.g., economic) that were labelled main dimensions and were as much as possible similar to themes identified in the desk research. The content of these themes was then compared across all 4 groups (see annex). Based on this comparison it was determined whether next to the main dimension (e.g., economic) relevant additional subdimensions were contained in the results that would be lost at the high level of the main dimension. For example, ‘food security in poorer countries’ and ‘acceptable price level for (European) consumers’ were both part of the main dimension Economics but were interpreted as sufficiently different to include as separate subdimensions.

The resulting main and subdimensions from this workshop are presented in table 6.1.

Table 6.1: Dimensions and additional subdimensions identified in the April 2022 expert workshop (alphabetical order)

Main Dimension	Additional Subdimensions
Animal Welfare	
-	agrochemical use
-	biodiversity loss
-	intensified animal keeping
-	objectification of animals
Economic	
-	acceptable price level
-	desirability of market power
-	food security for poorer countries individuals
Environmental impact	
-	land use requirements
-	pollution
Natural	
-	deviation from tradition
-	monstrification (creation of “monsters” or caricatures of deviating too much from the (assumed) Platonic true form of the animal)
-	religious worry about creation of animals
-	science surpassing limits
-	unnaturalness
Necessity	
-	are there alternatives
-	food application (not necessary)
-	medical application
Ownership	
-	Corporate power
Science Communication needs and application	
Unforeseen risks	
-	coevolution of diseases
-	long term risk
-	risk for animals
-	risk for human
-	uncertainty
-	uncertainty on specific issues
-	weaponization potential
-	wider societal consequences

6.2 Desk research

6.2.1 Published literature

Published scientific literature was accessed through the general scientific data base Scopus[1] (Elsevier). Next to peer reviewed literature, Scopus also contains (some) governmental reports, book chapters and peer reviewed conference proceedings.

For the room of acceptance, we required a query to addressed gene-editing or genetic modification. In addition, we required the query that includes societal response or acceptance. In addition, given the thousands of publications on genetic modification from the 1990's onwards (see e.g. the multitude of papers identified by Frewer et al., 2013) and the scope of Rumigen on ruminants, we decided to focus on Ruminant species. As we realised this might exclude relevant literature on for example triploid salmon or plant directed gene technologies, we decided that we would relax this search term towards animals in general, or even plants if insufficient documentation would be found. For consistency in the project, we utilised the same composite search term for ruminants as in Rumigen's deliverable 5.1 (henceforth D5.1) and we used a slightly adjusted version of gene editing (more inclusive for classical GM) compared to D5.1. Search terms for societal response or acceptance were developed from previous literature reviews on technology acceptance (e.g. Fischer et al., 2011; Frewer et al., 2013; Gupta et al., 2012; Ronteltap et al., 2011).

A Boolean query was created where within each construct composite search terms was created capturing the combination of keywords and key-phrases (using the Boolean OR operator).

When constructing the query, we deliberately did not include a number of keywords from the search that could be considered relevant to the topic. These included the specific terms for the (classical) GM versions transgenic and cisgenic, as the debate on cis versus transgenesis has been focussed on plant breeding. For societal response, we did not include the term "opinion" as that specific term resulted in extremely many false positives on expert opinions that did not relate in any way to societal responses (note that a narrower key phrase like "societal opinion" is already be captured through the keyword "soci*"). In line with the specific scope of Rumigen we further narrowed the search to ruminant applications (using the specification as used in D5.1 leaving out "does" as omnipresent conjugation of the verb "do")

As we expected that insights from the introduction of the first-generation genetic modification might be relevant, we did not set a limitation on publication date, nor did we specify a source (as reports and conference proceeding might provide additional insights compared to the often more consolidated and compacted scientific papers.).

The query (see table 6.2) was finalised and applied to the title, abstracts and keywords fields in Scopus in June 2022 and yielded 425 references. Given this number we decided there were sufficient reports to maintain the narrowed scope imposed by the concept ruminant species.

[1] www.scopus.com – subscription required.

Table 6.2: Query for identification of published literature

Concept	Composite search terms
Gene editing (also including Genetic modification)	(“base edit*” or bioengineer* or CRISPR* or “gene* edit*” or “genetic* alter*” or “genetic* engineer*” or “genetic* enhance*” or “genetic* manipulat*” or “genetic* modifi*” or “genom* edit*” or “ genom* engineer*” or GMO or knock* or off-target or “genetic” or GM) AND
Ruminant species	(bovine or bovines or buffalo or buffaloes or bull or bulls or calf or calves or cattle or cow or cows or ewe or ewes or goat or goats or lamb or lambs or livestock or ovine or ram or rams or ruminant or ruminants or sheep) AND
Societal response and or acceptance	(Soci* or Citizen* or consumer* or stakeholder*) AND (attitud* or respons* or accept* OR "perceived risk" OR "risk perception" OR "perceived benefit" OR "benefit perception")

Initial quick screening on abstract and titles was conducted. We excluded papers if (1) the query had picked up on alternative use of the relevant key word (e.g., GM in the context of General Motors and Ram in the context of the Dodge brand of vans and SUV’s) (2) societal issues were merely mentioned as a context specification in the setup or for future research.

This resulted in exclusion of 339 papers and the retention of 86 papers for which (if available) the full text was downloaded. For 15 papers the full text could not be accessed because the library did not hold a subscription, it referred to an out-of-print paper-only book chapter or a no longer accessible (or erroneous) “Doi” reference or weblink. The remaining 71 papers were then screened on information relevant to the room of acceptance. Papers were retained if they included information on at least one determinant for or factor influencing public response to gene-technologies. This reference could be in the introduction / literature sections, in the discussion or in the original results. We retained all papers with such reference which introduced information non-ruminant applications (e.g., triploid salmon and plant gene-technologies) when we deemed the conclusion at least to some extent relevant to ruminant studies. Papers merely looking at a single measure (e.g., willingness to pay) and experimental manipulation that had nothing to do with the specific gene application (e.g., communication strategy) were excluded. This resulted in 27 papers that at least provided some relevant information on dimension of interest for the room of acceptance.

The 27 retained papers were content analysed. First relevant fragments were identified. These fragments were then coded in relation to content relevant to the room of acceptance. A fragment could be assigned multiple codes. The codes were subsequently thematically grouped across papers into main dimensions (see annex). Based on the specific underlying codes for the themes it was determined whether next to the main dimension, the source reported on relevant additional subdimensions (level 1) or even sub-subdimensions (level 2) that would be lost at the high level of the main dimension. If such subdimensions were present, they were recorded next to the main dimension. The resulting main and subdimensions from the review are presented in table 6.3.

Table 6.3: Dimensions and subdimensions from the published literature

Main dimension	Subdimension level1	Sub dimension level2	Source(s)
Aim – application domain	Application animal welfare	polled cow more natural than dairy protein	(Eriksson et al., 2018)
Aim – application domain	Application animal welfare	reduced disease burden animal	(Mora et al., 2012)
Aim – application domain	Application food	-	(Finucane, 2002; Frewer et al., 2013; Mora et al., 2012; Small et al., 2005; Smith & Skalnik, 2003)
Aim – application domain	Application food	efficiency increase	(Mora et al., 2012)
Aim – application domain	Application food	productivity increase	(Mora et al., 2012)
Aim – application domain	Application food	quality – taste	(Mora et al., 2012)
Aim – application domain	Application food	versus other	(Montossi et al., 2013)
Aim – application domain	Application food	domain (food production versus other purposes)	(Eriksson et al., 2018)
Aim – application domain	Application medicine	-	
Aim – application domain	Application medicine	pharmaceutical production	(Montossi et al., 2013; Mora et al., 2012)
Aim – application domain	Application medicine	xenotransplantable organs (negative)	(Finucane, 2002; Frewer et al., 2013; Mora et al., 2012; Olynk Widmar et al., 2017; Small et al., 2005; Smith & Skalnik, 2003)
Aim – application domain	Consumer health	-	(Kilders & Caputo, 2021; Mora et al., 2012; Olynk Widmar et al., 2017; Ufer et al., 2019)
Aim – application domain	Consumer health	compared to conventional product	(Schnettler et al., 2015)
Aim – application domain	Consumer health	nutritional benefits	(Mora et al., 2012)
Aim – application domain		-	(Busch et al., 2022)
Animal welfare	-	-	(Eriksson et al., 2018; Hendricks et al., 2022; Martin-Collado et al., 2022; McConnachie et al., 2019; Mora et al., 2012)
Animal welfare	Animal dehorning	-	(Hendricks et al., 2022; Yunes et al., 2021)
Animal welfare	Animal effect on other animals	-	(Eriksson et al., 2018)
Animal welfare	Animal freedom	Access to outdoors	(Ufer et al., 2019)
Animal welfare	Animal freedom	express natural behaviours and instincts	(Ufer et al., 2019)
Animal welfare	Animal freedom	Movement	(Hendricks et al., 2022)
Animal welfare	Animal health	-	(McConnachie et al., 2019; Mora et al., 2012)
Animal welfare	Animal health	clean and hygienic living conditions	(Ufer et al., 2019)
Animal welfare	Animal health	Concern for inbreeding	(Eriksson et al., 2018; Long et al., 2003)
Animal welfare	Animal health	extreme heavy musculature	(Yunes et al., 2021)
Animal welfare	Animal heat resistance	-	(Hendricks et al., 2022; Yunes et al., 2021)
Animal welfare	Animal humane treatment	-	(McConnachie et al., 2019)
Animal welfare	Animal humane treatment	including a humane slaughter	(Ufer et al., 2019)
Animal welfare	Animal integrity	-	(Martin-Collado et al., 2022; McConnachie et al., 2019; Yunes et al., 2021)
Animal welfare	Animal integrity	individual animals	(Eriksson et al., 2018)
Animal welfare	Animal integrity	inhumane unnatural gene editing	(Hendricks et al., 2022)
Animal welfare	Animal integrity	loss of essence / purpose	(Ishii, 2017)
Animal welfare	Animal integrity	mother and unborn offspring	(Eriksson et al., 2018)
Animal welfare	Animal offspring	mortality and abnormality in offspring	(Ishii, 2017)
Animal welfare	Animal offspring	unborn and young animals	(Eriksson et al., 2018)
Animal welfare	Animal pain	-	(McConnachie et al., 2019)

Animal welfare	Animal quality of life	-	(McConnachie et al., 2019)
Animal welfare	Animal welfare	deterioration as risk	(Martin-Collado et al., 2022; Yunes et al., 2021)
Animal welfare	Animal welfare	improvement	(Eriksson et al., 2018; Kilders & Caputo, 2021; Mora et al., 2012; Ufer et al., 2019)
Benefits	-	-	(Smith & Skalnik, 2003)
Benefits	Application nutritious foods	-	(Uzogara, 2000)
Benefits	Application pharma	-	(Uzogara, 2000)
Benefits	benefit perception	-	(Busch et al., 2022; Frewer et al., 2013)
Benefits	Better quality of (consumer/citizen) life	-	(Smith & Skalnik, 2003)
Benefits	feeding the world	-	(Smith & Skalnik, 2003)
Benefits	Freshness	-	(Runge et al., 2018)
Benefits	Improved protein quality	-	(Uzogara, 2000)
Benefits	Improvement in quantity and quality of meat, milk, and livestock	-	(Uzogara, 2000)
Benefits	Increasing product quality	-	(Busch et al., 2022)
Benefits	Positive effect on farming	-	(Uzogara, 2000)
Benefits	Risk benefit trade-off	-	(McConnachie et al., 2019)
Benefits	tangible consumer benefit, environment,	-	(Ufer et al., 2019)
Benefits	tangible consumer benefit, health	-	(Ufer et al., 2019)
Economy	-	-	(Montossi et al., 2013)
Economy	Consumer price	-	(Charlebois et al., 2019)
Economy	Consumer price	discount	(Mora et al., 2012; Schnettler et al., 2015; Ufer et al., 2019)
Economy	Efficiency in production	-	(McConnachie et al., 2019)
Economy	Fair Benefit in chain	-	(Hendricks et al., 2022)
Economy	Fair Benefit to consumer	-	(McConnachie et al., 2019)
Economy	Fair Benefit to farmer	-	(McConnachie et al., 2019)
Economy	Local production	-	(Runge et al., 2018)
Economy	Possible disruption of socioeconomic systems (e.g., power shift to large farms)	-	(Spencer, 1999)
Economy	Uncertainty cost efficiency gains	-	(McConnachie et al., 2019)
Environmental impact	-	-	(Montossi et al., 2013; Mora et al., 2012; Runge et al., 2018)
Environmental impact	Benefit	-	(Kilders & Caputo, 2021)
Environmental impact	biodiversity	-	(Uzogara, 2000)
Environmental impact	Concern – escape into natural populations	-	(Ishii, 2017; Uzogara, 2000)
Environmental impact	Concerns	-	(Uzogara, 2000)
Environmental impact	Long term risk	-	(Montossi et al., 2013)
Environmental impact	Public benefit	-	(Ufer et al., 2019)

Environmental impact	reduced need for fodder	-	(Mora et al., 2012)
Environmental impact	reduced need for chemicals	-	(Mora et al., 2012)
Environmental impact	uncertainty	-	(Martin-Collado et al., 2022)
Ethics and worldviews	-	-	(Montossi et al., 2013; Mora et al., 2012; Uzogara, 2000)
Ethics and worldviews	Animal welfare	-	(Montossi et al., 2013)
Ethics and worldviews	Animal welfare	Improved heat resistance	(Yunes et al., 2021)
Ethics and worldviews	Animals	Integrity	(Martin-Collado et al., 2022; McConnachie et al., 2019; Yunes et al., 2021)
Ethics and worldviews	Animals	Integrity - (GE inhumane unnatural)	(Hendricks et al., 2022)
Ethics and worldviews	Animals	Integrity – (loss of essence of the animal)	(Ishii, 2017)
Ethics and worldviews	Animals	Integrity - Objectivation - animals as technological production unit	(Yunes et al., 2021)
Ethics and worldviews	Animals	Integrity – Objectivation animals Perversity in society – animal integrity for profit	(Yunes et al., 2021)
Ethics and worldviews	Animals	Integrity tampering with the animals' genetics for human profit has negative moral implications for society	(Yunes et al., 2021)
Ethics and worldviews	Animals	Offspring mortality and abnormality	(Ishii, 2017)
Ethics and worldviews	Consumers	Cultural values differences	(Finucane, 2002; Montossi et al., 2013; Mora et al., 2012)
Ethics and worldviews	Consumers	Freedom of choice	(Ufer et al., 2019)
Ethics and worldviews	Consumers	Heterogeneity	(Schnettler et al., 2015; Ufer et al., 2019)
Ethics and worldviews	Consumers	Heterogeneity (demographics)	(Ufer et al., 2019)
Ethics and worldviews	Consumers	Heterogeneity (demographics)	(Martin-Collado et al., 2022)
Ethics and worldviews	Consumers	Heterogeneity (geographical location)	(Frewer et al., 2013; Mora et al., 2012)
Ethics and worldviews	Consumers	Heterogeneity (technology attitude)	(Small et al., 2005)
Ethics and worldviews	Consumers	Right to be informed	(Uzogara, 2000)
Ethics and worldviews	Overextended human power	-	(McConnachie et al., 2019)
Ethics and worldviews	Reglious	-	(Finucane, 2002; McConnachie et al., 2019; McCullum, 1997; Montossi et al., 2013; Uzogara, 2000)
Ethics and worldviews	Religious	differences major religions	(Busch et al., 2022; Montossi et al., 2013)
Ethics and worldviews	Religious	Playing God	(Finucane, 2002; McConnachie et al., 2019; Yunes et al., 2021)
Ethics and worldviews	Values	-	(Smith & Skalnik, 2003)
Ethics and worldviews	Values	Attitude towards nature	(Busch et al., 2022)
Ethics and worldviews	Values	greed and profit as societal values	(Yunes et al., 2021)
Institutional responsibility	Confidence in regulatory institutions	-	(Finucane, 2002)
Institutional responsibility	Mandatory labelling	Responsible Labelling	(Charlebois et al., 2019; Montossi et al., 2013; Runge et al., 2018; Ufer et al., 2019; Uzogara, 2000)
Institutional responsibility	Perceived control	-	(Smith & Skalnik, 2003)
Institutional responsibility	Responsibility	burden of proof of safety	(Spencer, 1999)
Institutional responsibility	Responsibility –	damaging alternative use	(Eriksson et al., 2018)

Institutional responsibility	Responsibility –	keeping back information	(Hendricks et al., 2022)
Institutional responsibility	Responsible	burden of proof of safety by further testing	(McConnachie et al., 2019)
Institutional responsibility	Traceability	-	(Runge et al., 2018)
Natural	-	-	(Eriksson et al., 2018)
Natural	Aesthetics	Monstrification of animals	(Yunes et al., 2021)
Natural	Aesthetics	pink slime (in food product)	(Runge et al., 2018)
Natural	Natural-Unnatural balance (nuance)	-	(Yunes et al., 2021)
Natural	Sceptical of change (does it work as assumed)	-	(Long et al., 2003)
Natural	speeding up possible natural breeding can be natural	-	(Yunes et al., 2021)
Natural	speeding up possible natural breeding can be natural	-	(Yunes et al., 2021)
Natural	Unnatural	-	(Finucane, 2002; Frewer et al., 2013; Kilders & Caputo, 2021; McConnachie et al., 2019; Ufer et al., 2019)
Natural	Unnatural	animal integrity of loss of essence of the animal	(Long et al., 2003)
Natural	Unnatural	artificial	(Ufer et al., 2019)
Natural	Unnatural	immoral	(Montossi et al., 2013)
Natural	Unnatural	integrity of nature	(McConnachie et al., 2019)
Natural	Unnatural	tampering with nature	(Busch et al., 2022; Eriksson et al., 2018; Yunes et al., 2021)
Natural	Unnatural	unfamiliar	(Finucane, 2002)
Natural	versus conventional	-	(Schnettler et al., 2015)
Necessity	-	-	(Smith & Skalnik, 2003)
Necessity	Medical	-	(Busch et al., 2022; Mora et al., 2012)
Necessity	versus conventional	-	(McConnachie et al., 2019; Yunes et al., 2021)
Necessity	versus conventional	Economic necessity for farmers	(Mora et al., 2012)
Necessity	versus conventional	Improved conventional animal welfare keeping	(Hendricks et al., 2022; McConnachie et al., 2019; Yunes et al., 2021)
Necessity	versus conventional	Improved working conditions of dairy workers	(McConnachie et al., 2019)
Necessity	versus conventional	Providing enough sustainable consumer choices	(Yunes et al., 2021)
Organism applied to	-	-	(Ufer et al., 2019)
Organism applied to	Application to animals	-	(Busch et al., 2022; Frewer et al., 2013; Martin-Collado et al., 2022; Montossi et al., 2013)
Organism applied to	Application to animals	Conscious animals	(McConnachie et al., 2019)
Organism applied to	Application to microorganisms	-	(Martin-Collado et al., 2022)
Organism applied to	Application to plants	-	(Busch et al., 2022; Frewer et al., 2013; Martin-Collado et al., 2022; McConnachie et al., 2019; Montossi et al., 2013)
Organism applied to	Species comparison	-	(Mora et al., 2012; Olynk Widmar et al., 2017)
Organism applied to	Species comparison	grain fruit vegetable	(Olynk Widmar et al., 2017)
Organism applied to	Species comparison	Order (worst) Fish, Pork, Fruit, dairy (best)	(Charlebois et al., 2019)
Organism applied to	Species comparison	plant versus animal	(Ufer et al., 2019)
Ownership	Patents	equitable to developing countries	(McCullum, 1997)

Risk perception	-	-	(Busch et al., 2022; Eriksson et al., 2018; Frewer et al., 2013; Kilders & Caputo, 2021; McConnachie et al., 2019; Smith & Skalnik, 2003; Ufer et al., 2019)
Risk perception	animal welfare	health	(McConnachie et al., 2019)
Risk perception	animal welfare	inbreeding	(Long et al., 2003)
Risk perception	animal welfare	uncertainty	(Martin-Collado et al., 2022)
Risk perception	assessment	-	(Turnbull et al., 2021)
Risk perception	consumer health	-	(McConnachie et al., 2019)
Risk perception	consumer health	allergenicity	(Montossi et al., 2013; Uzogara, 2000)
Risk perception	consumer health	reduced nutritional quality	(Mora et al., 2012; Uzogara, 2000)
Risk perception	consumer health	uncertainty	(Martin-Collado et al., 2022)
Risk perception	Emotion	Fear	(Finucane, 2002; Uzogara, 2000)
Risk perception	Emotion	Gut feeling	(McConnachie et al., 2019)
Risk perception	environment	-	(Mora et al., 2012)
Risk perception	environment	uncertainty	(Martin-Collado et al., 2022)
Risk perception	safety	-	(Montossi et al., 2013; Uzogara, 2000)
Trust	-	-	(Charlebois et al., 2019; Runge et al., 2018; Yunes et al., 2021)
Trust	Distrust	-	(McConnachie et al., 2019)
Trust	Distrust in multinationals	who benefits	(Martin-Collado et al., 2022)
Trust	Distrust in regulators	-	(Ishii, 2017)
Trust	Distrust in researchers	-	(Ishii, 2017)
Trust	in academia / science	-	(Small et al., 2005; Yunes et al., 2021)
Trust	in industry	-	(Yunes et al., 2021)
Trust	in institutions	-	(Finucane, 2002)
Trust	in regulators	-	(Small et al., 2005)
Trust	In companies	-	(Small et al., 2005)
Unforeseen risks	Farm worker welfare	Farm workers welfare	(Runge et al., 2018)
Unforeseen risks	Long term risk	-	(Spencer, 1999; Ufer et al., 2019; Yunes et al., 2021)
Unforeseen risks	Long term risk	availability of broad food assortment	(Spencer, 1999)
Unforeseen risks	Long term risk	disruption of socioeconomic systems (e.g., power shift to large farms)	(Spencer, 1999)
Unforeseen risks	Long term risk	Future animal generations	(McConnachie et al., 2019)
Unforeseen risks	Long term risk	harm and risks (from animal to consumer)	(Yunes et al., 2021)
Unforeseen risks	scepticism about promised benefits	-	(Small et al., 2005)
Unforeseen risks	Uncertainty random mutations (botch genome)	-	(McConnachie et al., 2019)
Unforeseen risks	Uncertainty side effects	-	(Martin-Collado et al., 2022; McConnachie et al., 2019; Yunes et al., 2021)
Unforeseen risks		-	(Eriksson et al., 2018; McConnachie et al., 2019)
Used technique intrusiveness	Foreign DNA	-	(Martin-Collado et al., 2022)
Used technique intrusiveness	Foreign DNA	-	(Ufer et al., 2019)
Used technique intrusiveness	Foreign DNA	Intrusiveness (intrinsic traits/ non foreign genes)	(Kilders & Caputo, 2021)
Used technique intrusiveness	Intrinsic DNA	Intrusiveness (intrinsic traits/ non foreign genes)	(Kilders & Caputo, 2021)
Who benefits	Developing world	-	(Kilders & Caputo, 2021)

Who benefits	Developing world	Nutritional food in developing countries	(Montossi et al., 2013)
Who benefits	Developing world	Who gains the benefits rich vs poor countries	(Spencer, 1999)
Who benefits	in production chain	consumer vs retail vs industry vs producers	(Runge et al., 2018)
Who benefits	in production chain	Distribution of benefits production chain – fair distribution of profits along the value chain	(Hendricks et al., 2022)
Who benefits	in production chain	farmer vs consumer	(McConnachie et al., 2019)
Who benefits	in production chain	farmers vs industry	(Spencer, 1999)
Who benefits	in production chain	innovative farmer vs traditional farmers	(Uzogara, 2000)
Who benefits	in production chain	large producers vs small producers and consumers	(Yunes et al., 2021)
Who benefits	in production chain	who covers the need for high investment	(Yunes et al., 2021)
Who benefits	in society	-	(Finucane, 2002; Yunes et al., 2021)
Who benefits	in society	lack of larger societal benefits	(Yunes et al., 2021)
Who benefits	in society	Power balance in the production chain (multinational to farmer and Gov)	(Uzogara, 2000)

6.2.2 Eurobarometer reports

Between 1991 and 2010, 7 Eurobarometers included data collection on biotechnology and life sciences. Although this survey had closed questions (ranking of options, rating of desirability) by necessity could only focus on few, predetermined dimensions it may provide some insights. We draw on the relevant websites of the EU and the 2010 report by Gaskell et al. (2010). Next to information on acceptance of genetic modification, we include insights from synthetic biology, as this is a related technology which was just emerging in 2010. Hence some of the insights from synthetic biology may be of relevance for other emerging technologies in the field.

From the 7 Eurobarometers we extrapolated the important issues for acceptance of future technology (ranked by priority with 1 having most support) and relevant dimensions for the room of acceptance (table 6.4).

In addition to the dimensions listed in table 6.4, the Eurobarometer also shows substantial differences in acceptance across the European countries. This emphasises that next to the properties of the gene-technologies and their application also national, cultural, and individual characteristics play a role in acceptance.

Table 6.4: Issues from Eurobarometer and proposed associated room of acceptance dimension

Ranked (1= high priority)	Issue	Potential dimension for room of acceptance
	GM, trans and cisgenesis	
1	Unnatural	Naturalness
2	Harmful for the environment	Environmental Impact
3	Safe / risky	Risk
4	General support	N.A.
Specific additional for Trans- Cis-genesis comparison (not ranked)		
	Intrusiveness of the technique	Intrusiveness of the technique
	Makes me feel uneasy	Intuitive repulsion
	Synthetic Biology	
1	What are the potential risks	Size of risk
2	What are the benefits	Size of benefit
3	Who benefits and who will bear the risk	To whom risks. To whom benefits
4	What is the science behind it	Transparent communication
5	What regulatory oversight will be in place	Legal and institutional checks and balances
6	Who is funding and why do they fund it	Aim of intervention
7	Are sufficient measures in place to deal with societal and ethical dimensions.	Responsibility across time and environment

7 Synthesis of dimensions and subdimensions

Comparison between the initial list created by the Rumigen WP2 team, the workshop amongst Rumigen partners, the literature review and Eurobarometer show substantial overlap. Notably, the literature and the workshop added the dimensions trust and individual differences as key dimensions to the discussion and respecified or subdivided some notions to show more nuance.

After harmonising the specific themes across the different information streams this resulted in 16 main dimensions (for the more specific dimensions and subdimensions from each data stream see the relevant subsection). These are (alphabetical order):

(1) Aim and application domain (e.g., food, medicine)
(2) Animal welfare
(3) Benefits caused
(4) Economic effects
(5) Environmental impact
(6) Ethics and worldviews
(7) Institutional responsibility
(8) Intrusiveness of the use technique
(9) Naturalness
(10) Necessity
(11) Organism the technique is applied to
(12) Ownership
(13) Risk perception
(14) Trust
(15) Unforeseen risks
(16) Who benefits

The question remains where the boundaries lie, and whether underlying subdimensions are sufficiently distinct that consolidating the findings to these 16 dimensions oversimplifies.

After collating the dimensions and subdimensions we realised that not all dimensions would contribute in the same way to the contours of the room of acceptance in the way presented in figures 4.1 and 4.2. These special dimensions constitute what we will label as “contextual” dimensions. In the current listing of dimensions these constitute trust, and those subdimensions of ethics and values that refer to heterogeneity across and within societies.

Based on these findings we consolidated the findings by reviewing the main and subdimensions for potential relevance.

At this stage we describe the dimensions without going into depth into at what level a dimension indicates a boundary between acceptable and unacceptable applications. This question was partially addressed in the Copenhagen workshop described in section 8. Section 7.1 gives the main dimensions. In section 7.2 we introduce the anticipated influence of the contextual dimensions and present the contextual dimensions trust and ethics and values.

7.1 Main dimensions and essential subdimensions

7.1.1 Aim and application domain

The most common discussion about the aim of genetic intervention concerns the finding that the public tends to be less favourable to applications in the food domain. Applications on consumer health (nutrition) and medicine are generally perceived more positively. Applications for animal welfare are somewhat more positively regarded than to food. As the main distinction remains on food versus medicine, we retain this as a single dimension, albeit a dimensions with discrete levels ranked in a specific order.

- *Application to food (negative)*

7.1.2 Animal welfare

The animal welfare dimension contains a number of relevant subdimensions that are not necessarily (cor)related. We identified subdimensions related to animal health, i.e., when these interventions were used to improve the healthiness of animals by overcoming inheritable health issues, or even to apply to dehorning or heat resistance to overcome climate change. Two other animal welfare issues were mentioned that touched more upon ethical implementation. The first one was the violation of the integrity of the animal by making too large adaptations to what is considered normal and the second one was the concern that adaptations to animals could be used to justify currently unfavourable husbandry practices. As these subdimensions are interrelated yet require specific design choices we maintained them as separate subdimensions

- *Animal welfare – improved health (positive)*
- *Animal welfare – integrity (negative)*
- *Animal welfare – justification of poor husbandry (negative)*

7.1.3 Benefits caused

Benefits are often specific. Considering the subdimensions two themes emerged that appear to be relevant to retain. The first theme focusses on product properties that directly benefit the individual consumer; the second theme is about benefits to sustainably feed the world.

- *Benefit – product quality (positive)*
- *Benefit – sustainable food security (positive)*

7.1.4 Economic effects

Economic effects can be grouped into two themes. One specified towards price discounts for consumers, the second towards power and profit concentration in the agrifood chains, particularly towards large companies.

- *Economy – consumer price discount (positive)*
- *Economy – profit concentration at large companies (negative)*

7.1.5 Environmental impact

Environmental impact holds two conflicting themes. On the one hand there is concern about gene-edited creatures escaping to the wild with potentially negative consequences for biodiversity and other unforeseen consequences. On the other hand, reduction in amount of fodder, chemicals and animal medicine could have a positive impact on the environment

- *Environment – long term biodiversity effects (negative)*
- *Environment – reduced need for agrochemicals and medicine (positive).*

7.1.6 Institutional responsibility

Particularly in the literature, there is high demand that governmental institutions take responsibility for a safe and transparent introduction of gene-editing techniques. First, there is the demand that extensive risk assessments are conducted, and that the technique and its application are shown to be safe by trusted governmental agencies, before they are allowed to be used. Secondly, even if the technique is shown to be safe enough, products and created through such techniques should remain traceable through production and value chains. Thirdly, to allow consumer freedom of choice, products in the market incorporating genetically modified produce should be labelled as such. The societal demand for these checks and balances exists independently from the technical feasibility or even possibility of such measures.

- *Institutional – responsibility for proof of safety taken (positive)*
- *Institutional – traceability (positive)*
- *Institutional – mandatory labelling (positive)*

7.1.7 Intrusiveness of the used technique

The intrusiveness of the used technique particularly focuses on the amount of genes changed and whether foreign DNA is implanted. The discrete levels can be ranked along a single dimension (from conventional breeding through gene-editing to cis and transgenesis to synthetic biology).

- *Intrusiveness (negative)*

7.1.8 Naturalness

Within naturalness at least two relevantly different subdimension can be distinguished. The first is to what extent the looks of the animal will change and the extent to which these changes are aesthetically displeasing. A second subdimension is about the extent to which the gene change could have been achieved by conventional breading. As such it appears to be on the other end of the subdimension labelled unnatural intervention. Hence, we retain 2 subdimensions

- *Natural – aesthetic changes (negative)*
- *Natural – achievable by conventional means (positive to ambiguous)*

7.1.9 Necessity

The dimension necessity names a few specific needs that cannot be created in other ways. Most frequently mentioned are medical applications, sustainability of primary production in the agri-section is also raised repeatedly.

- *Necessity – medicine (positive)*
- *Necessity – agri-sector (positive to ambiguous)*

7.1.10 Organism the technique is applied to

The dimension organism applied to consists of several discrete, ranked levels where microbes are considered least problematic, followed by plants, animals, with mammals (or even monkeys/apes or humans) are considered most problematic. As the different organisms can be ranked along a single dimension, we keep it as one dimension.

- *Organism applied to: Microbe-Mammal (negative)*

7.1.11 Ownership

Ownership concerns centre around equitable use of the technology across countries and companies. There is resistance against patenting by multinationals.

- *Ownership – Multinationals (negative)*

7.1.12 Risk perception

The dimension risk perception contains several subdimensions (consumer health, animal welfare, environment) that are endpoints of other dimensions. To avoid redundancy these are not included for this specific dimension. The uniquely remaining subdimension related to risk is that of negative emotions like fear.

- *Risk perception – emotion: fear (negative)*

7.1.13 Unforeseen risks

Unforeseen risks centre on 3 key issues. Negative long-term effects and uncertain side effects. Both these consider the lack of a sufficiently long history to make gene adaptation to be generally regarded as safe a potential issue for rejection. A third subdimension was the uncertainty about achieving promised societal benefits. In this subdimension there was outright scepticism that promises about societal benefits would not be achieved, often based on experiences with previous introductions of biotechnologies.

- *Unforeseen risk – long term (negative)*
- *Unforeseen risk – Uncertain side effects (negative)*
- *Unforeseen risk – Broken promises (negative)*

7.1.14 Who benefits

The dimension who benefits consists of 3 themes. To what extent developed or developing world benefits, to what extent all partners versus the larger / dominant partners in production chain benefit, and the extent to which society at large, or only the chain partners benefit.

- *Who benefits – developing countries (positive)*
- *Who benefits – largest chain partner (negative)*
- *Who benefits – society at large (positive)*

7.2 Contextual dimensions

Contextual dimensions are assumed to influence the acceptability level of each dimension in the specified room rather than provide an additional dimension that an application is scored upon. Thus, in contrast to most dimensions, contextual dimensions influence the "**size"** of the room rather than the **"shape"** of the room (figure 7.1).

These contextual dimensions are important as they present a gradient between those who would reject the application out of hand (and hence have an infinitely small room of acceptance) compared to those who would accept it without reservation. In all likelihood, the majority of the population will be somewhere in the middle, while the polarised debate between opponents and supporters represents the end points of these dimensions.

In the ensuing debate it is likely that both opponents and supporters will try to pull the majority towards their positions (i.e., a small or a large room of acceptance). Pulling population groups to a given point of view has, however, the risk of creating reactance – a tendency to actively resist communication and even adopt an opposite view. Reactance occurs when people feel they are coerced to accept something they are not convinced about, or if their concerns are ridiculed. We would expect that such effort is more likely to succeed for opponents as they may tap into feelings of neophobia (e.g. Pliner & Hobden, 1992) and technophobia (e.g. Cox & Evans, 2008); while supporters of new technologies may more likely be considered to be pushing too fast and hence create reactance. This is in our view what happened with introduction of the first-generation GM technologies in Europe in the 1990's. We observe that those countries where supporters took most account of concerns and opinions of society (such as Denmark) experienced fewer extreme protests. Hence, we warn supporters of gene-technologies against efforts to convince the public to adopt the largest possible room of acceptance.

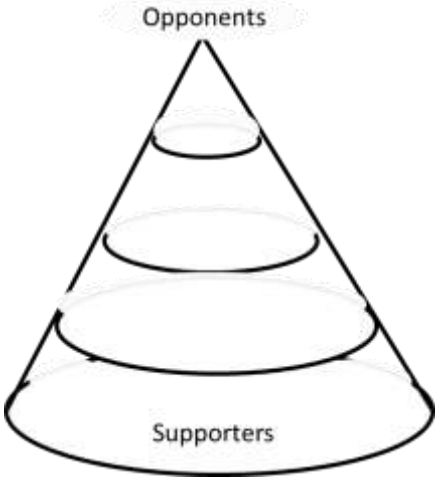


Figure 7.1: Size of a hypothetical circular room of acceptance ranging from a large room of acceptance to a small (to negligible) room based on a contextual dimension such as levels of trust, or other differences between population groups.

7.2.1 The contextual dimension trust

Higher trust in those responsible for implementing gene-adapted ruminants is likely to lead to a larger room of acceptance for the trusting individual or group in society. This implies on the one hand that responsibility should be given to a trusted party and on the other hand that trust in that agent needs to be monitored. While lack of trust may not overly reduce the size of the room of acceptance, it is important to realise that lack of trust is not the same as active distrust. Active distrust is likely to create a negative view on any proposition by the distrusted actors, which closes venues for communication and in extreme cases may lead to conspiracy theories.

Relevant stakeholders to the adoption of gene-technologies for whom trust has been shown to be of influence are:

- Companies. Companies are generally not trusted very much by society to take responsibility. Multinationals are even generally actively distrusted. Hence, we would expect with increasing multinational involvement a reduction in the size of the room of acceptance.
- Trust in regulators is mixed and there is even some distrust.
- Trust in institutions and in scientists/academia is generally fair but not very high.

The relatively low scores on trust imply that trust management throughout the introduction of gene-adapted ruminants is critical to avoid active distrust to develop. We point at two ironic effects of trust here. First, increasing levels of trust are only likely to extend acceptance (growing room size) to a small extent, while increasing levels of distrust are likely to create rejection (shrinking room size) much more rapidly. Hence investing in trust is more an insurance against the negative effect of distrust than a way to readily increase acceptance. Secondly, as the Dutch proverb "Trust comes on foot, but leaves on horseback" illustrates, it takes a long time to build trust, but it can be destroyed easily. In addition, trust in a technology is likely to be based on the entire sector and only one or a few operators in such a sector that behave in an untrustworthy manner can destroy trust for the entire sector.

We point at the substantial literature on trust from the 1990's and 2000's that generally reported findings along the lines that for a stakeholder to be trustworthy the stakeholder has to be perceived as: Honest (they should tell the entire truth, be transparent and not lie), Competent (they should be certain about claims and live up to promises) and Benevolent (they should use their agency to better society as a whole above all else).

7.2.2 The contextual dimension ethics and values

The ethics and values dimension contains several subdimensions that indicate heterogeneity within and between societies that may result in different room sizes.

Important subdimensions are differences in

- *Cultural values*. Societies share (somewhat) different cultural values that can influence the room of acceptance. Cross country differences in values like openness to change (Schwartz & Bilsky, 1987) or uncertainty avoidance (Hofstede & Hofstede, 2005) may inform differences between countries in acceptance by their society. This would suggest that acceptance of technologies differs between countries, which would provide complicated regulatory negotiations for an EU policy. Despite difference in cultural values across the EU, the actual differences within the EU are often relatively small. Nevertheless, some attention to these differences should be paid.
- *Demographic groups in society.* These differences are probably more substantial than differences between societies, and entail age, gender, and education level effects. Effects of demographics account for different responses within a single country or even region and therefore need to be carefully kept track of by local initiatives.
- *Religion*. The level of religiosity may differ between people within a single society. In addition, the point of view of a specific religion may further influence how those who are members of said religion respond to technologies. Within Europe such differences may relate to differences between different Christian denominations (Catholic (Roman and Eastern Orthodox) and a diversity of Protestant churches) but also Islam, Judaist, and Hindi (and other) religious points of view may have influence. It is of note that large parts of Europe have an irreligious majority (either atheist, agnostic, or non-practising church member). This in contrast to the US, where, for an industrialised country, religion has a major role.
- Specifically mentioned psychographics are: "*general technology attitude*" which distinguishes between individuals that are generally positive towards technologies and the "*acceptance of the ethical value of neoliberalism"* (greed and profit are good).

7.3 Ex ante list of sub-dimensions of relevance to the room (comprehensive)

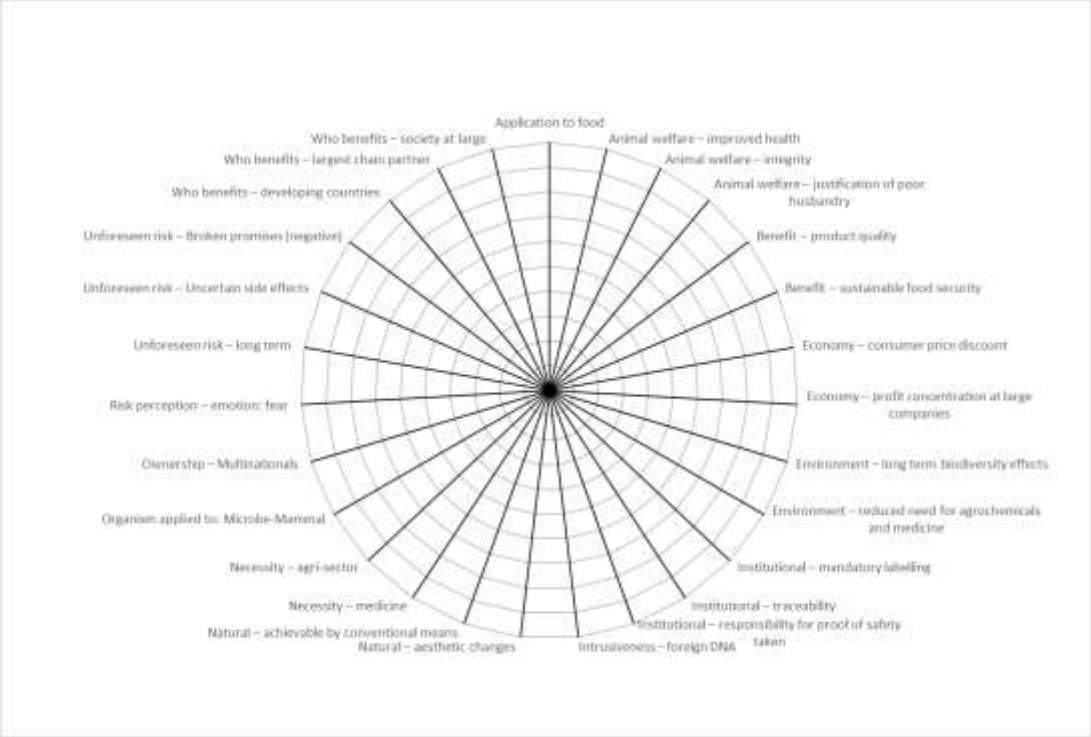
After we identified the main dimensions and the most important subdimensions, the next steps were to identify the most acceptable level for each of these dimensions as well as the least acceptable (or most unacceptable) level. When doing so it was also important to indicate whether a dimension represents a continuum – for example how much biodiversity is supported or reduced. Alternatively, a dimension may consist of discrete (ordinal) levels, for example which organism is affected such as resistance against gene adaptation ranging from humans, through primates, mammals, other animals, plants to microbes (table 7.1).

The subsequent room of acceptance can then be plotted into a space spanned by the retained dimensions as depicted in figure 7.2a. Figure 7.2b gives an example of an (unvalidated) ex-ante room where there is little acceptance of fearful, inferior quality, high priced, non-sustainable and non-labelled products.

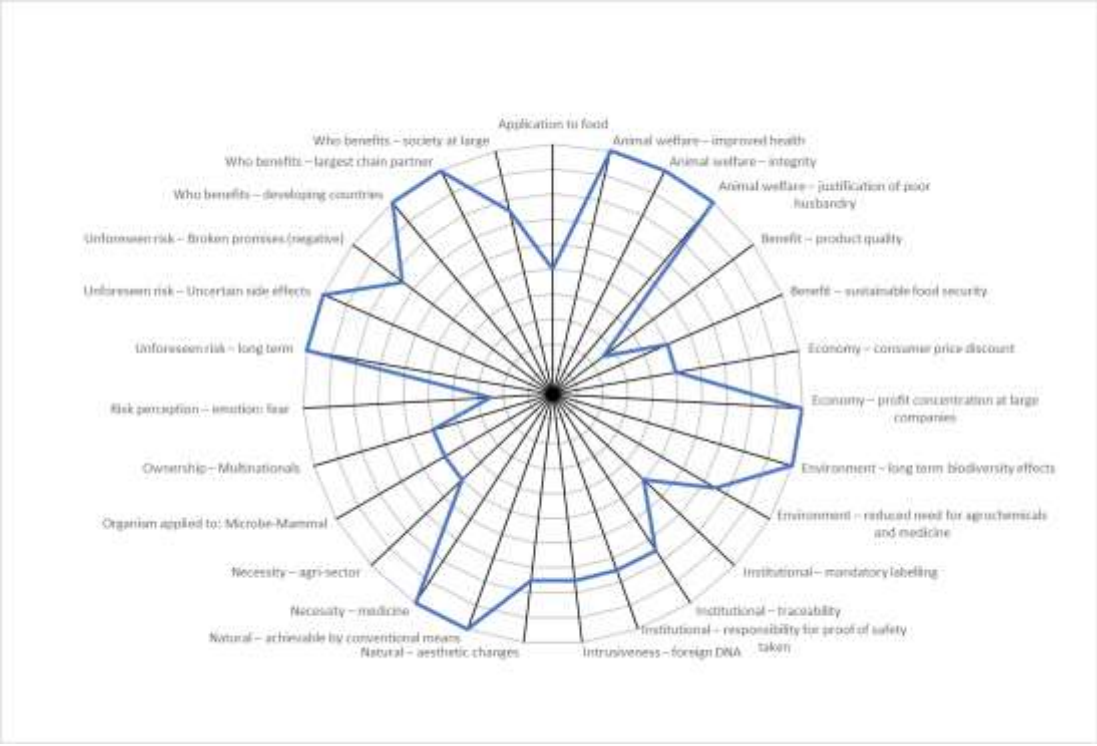
Next to such profiles as suggested in figure 7.2b the influence of the contextual dimensions on the size of the room of acceptance for different populations and population groups needs to be considered. Increasing demands on the application of gene technology in a population induced by lower levels or trust or increasing value and ethics differences is likely to reduce the size of the room of acceptance (figures 7.1 and 7.3). At this stage we only considered reduction on all dimensions similarly as a starting point, we do however keep in mind that boundaries of the room of acceptance may not equally change across all dimensions for all population groups. In this case the shape of the room might start to “morph” next to the size of the room (figure 7.3b). Current information does not suffice to model this at any sensible level. In addition, it remains unclear whether the subsequent complexity is justified by the additional insights. Starting from a pragmatic and parsimonious position, initially we assume a room that is isomorphic when shrinking or growing across contextual dimensions.

Table 7.1 Retained dimensions with initial end points

Dimension	Type	Positive end	Negative end
Application to food	Different discrete levels	Medicine	Food
Animal welfare – improved health	Continuous	Health improvement	No health improvement
Animal welfare – integrity	Continuous	No violation	Violated
Animal welfare – justification of poor husbandry	Continuous	Improved husbandry	Deterioration in husbandry
Benefit – product quality	Continuous	Better products	Worse products
Benefit – sustainable food security	Continuous	Improved food security	Reduced food security
Economy – consumer price discount	Continuous	Cheaper food	More costly food
Economy – profit concentration at large companies	Continuous	Profit to small local players	Profit to multinationals
Environment – long term biodiversity effects	Continuous	Increased biodiversity	Reduced biodiversity
Environment – reduced need for agrochemicals and medicine	Continuous	Reduced chemical / medicine use	Increased chemical / medicine use
Institutional – mandatory labelling	Continuous	Mandatory labelling	No labelling required
Institutional – traceability	Continuous	Detailed traceability enforced	No traceability
Institutional – responsibility for proof of safety taken	Continuous	Strong safety evidence before introduction	No safety tests
Intrusiveness – foreign DNA	Different discrete levels	Minor edits, no DNA insertion	Insertion of synthetically created DNA
Natural – aesthetic changes	Continuous	Changes toward idyllic image	Monstrified animals
Natural – achievable by conventional means	Continuous	Identical to conventional breeding	Distinct from conventional breeding
Necessity – medicine	Continuous	Life saving medicine	Other uses
Necessity – agri-sector	Continuous	Improves economic sustainability Agri sector	Reduces viability of production chain
Organism applied to: Microbe-Mammal	Different discrete levels	Microbes	Mammals (humans)
Ownership – Multinationals	Different discrete levels	Open source / science	Patented by multinational
Risk perception – emotion: fear	Continuous	Relaxing, enthusing	Scary
Unforeseen risk – long term	Continuous	Guaranteed no long-term effects	Like long term effects
Unforeseen risk – Uncertain side effects	Continuous	Guaranteed no side effects	Like side effects
Unforeseen risk – Broken promises (negative)	Continuous	Promises met or surpassed	Promises broken
Who benefits – developing countries	Continuous	Developing countries	Rich countries
Who benefits – largest chain partner	Continuous	All / small partners	Larges partners
Who benefits – society at large	Continuous	Society	Business

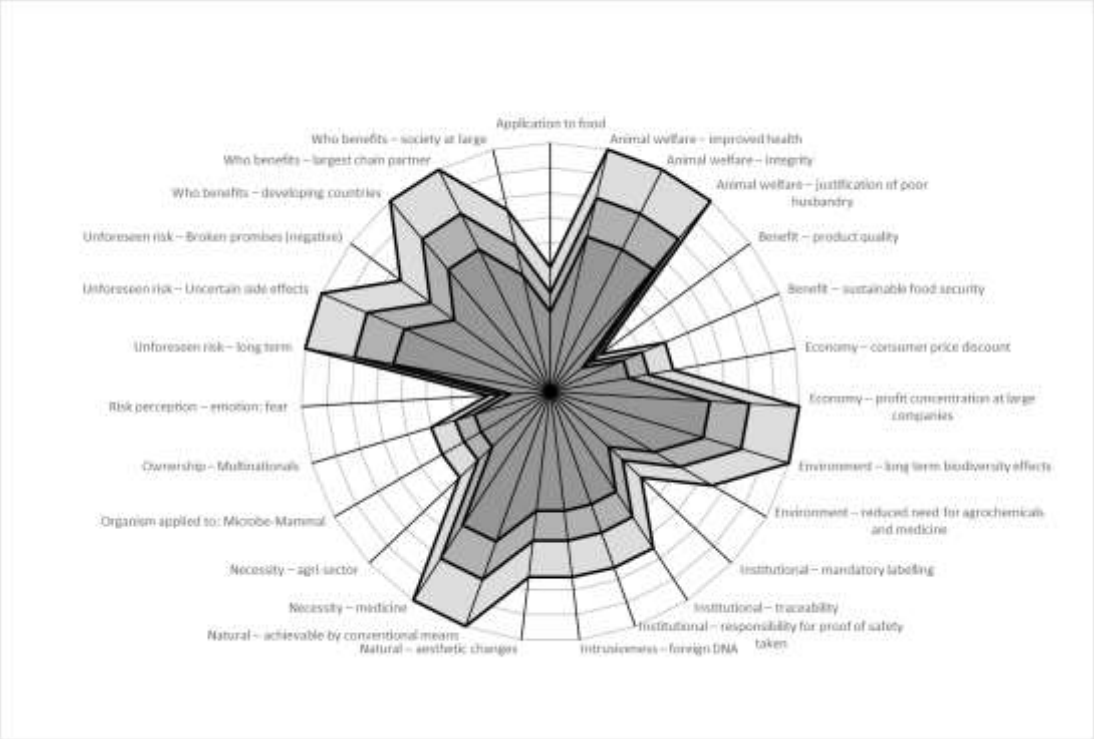


a)

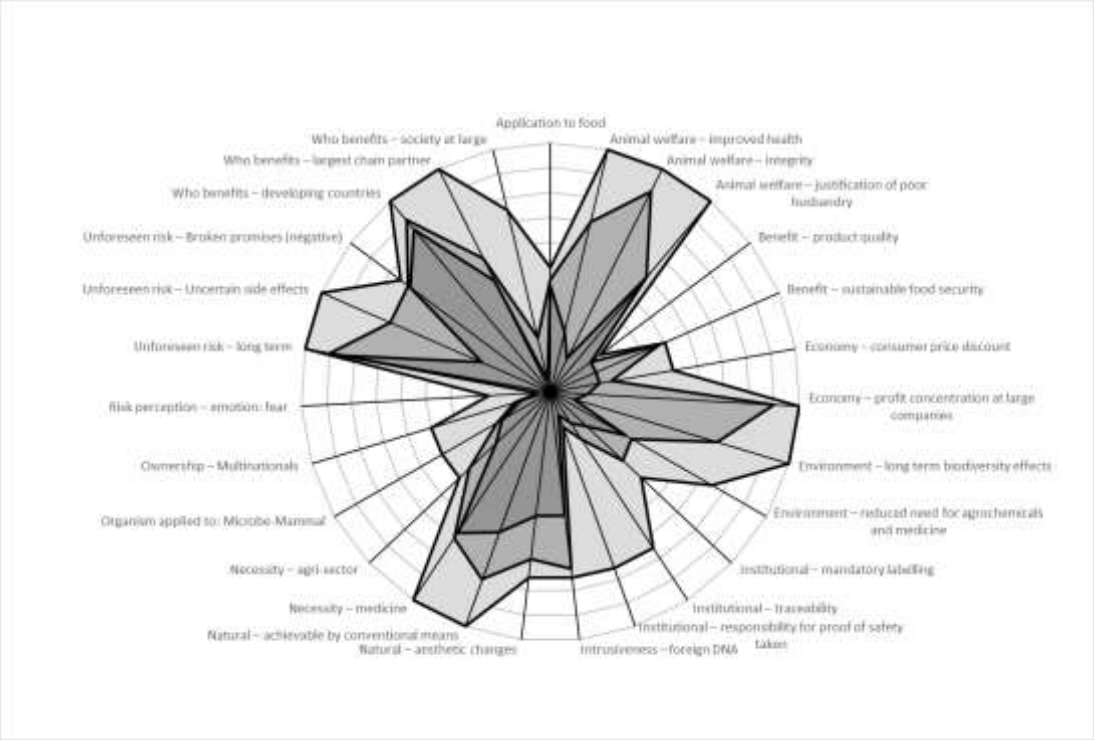


b)

Figure 7.2 a) The dimensional space for the ex-ante room of acceptance. b) Hypothetical room of acceptance based on common societal prioritisation insight (e.g., construal level)



a)



b)

Figure 7.3: a) A (fictitious) room that reduces for 3 distinct levels of contextual dimensions. b) The room that now both reduces and morphs for these levels.

8 Prioritising subdimensions and initial boundaries. The Copenhagen Workshop

The next step in the development of the room of acceptance was to subject the identified dimensions and subdimensions to a mixed audience of experts at a workshop in Copenhagen. The expert group was recruited to represent a wide diversity of expertise and perspectives. The sample included stakeholders such as farmers, breeders, consumers, and animal welfare advocates, as well as academic experts including Rumigen researchers who have expertise in genetic adaptation of animals, and independent ethicists. This sample ensured that the concepts of the room of acceptance ex-ante, the dimensions and the subdimensions could be discussed and evaluated based on well-founded insights into scientific limitations and possibilities, consumer behaviour, policy, and ethical expertise. Further, there was wide geographic representation in the sample from across most of Europe, although the sample lacked representation from Eastern Europe, and skewed towards North-Western Europe.

8.1 Methods

The workshop was convened in Copenhagen on 1 and 2 September 2022. The format was “a dinner and a day” format. After participants arrived in the early evening of 1 September an introduction of the Rumigen project and issues the project aims to solve was given. This was followed by an introduction of the concept of the room of acceptance and the setup of the workshop. Participants were then invited to get to know each other and casually talk about the topic over diner.

The next morning the actual workshop started. The dimensions were introduced in some more detail and a plenary discussion on the dimensions was conducted. After a coffee break, the participants were invited to comment on the prepared sheets with the main and subdimensions using sticky notes to add additional issues or suggest changes to the dimensions. Then participants were distributed into 4 mixed breakout groups. Each breakout group received 2 of the 16 main dimensions (i.e., 8 out the 16 in this session). The 2 dimensions for each group had similarities and/or had been identified as complementary during the previous session. Groups were asked to raise prominent issues and prioritise subdimensions and other issues related to those dimensions on prepared sheets (see appendix for an example). After lunch, the same group considered the most salient subdimensions and provided a worst case (unacceptable) situation on the subdimension, a best case (acceptable) situation on the subdimension as well as an indication at what level the shift between acceptable and unacceptable occurred. We deliberately asked participants to first define worst- and best-case scenarios to identify the entire distribution of the dimension before setting an intermediary boundary condition. We also asked participant to provide a description of the best case, worst case, and boundary condition to have a meaningful description of the content rather than a numeric score. Subsequently groups were redistributed into different constellations and the remaining 8 dimensions were prioritised followed by a boundary setting session. As an additional question to the 2nd boundary setting session participants were asked to discuss whether they considered the identified boundary a hard or soft boundary (see figure 4.2 b). After the second session, there was a short wrap up session where participants could voice unspoken deliberations after which the workshop ended.

While the selected method made it impossible to discuss all subdimensions in equal depth given participant fatigue and interrelatedness of dimensions, we deliberately chose for more in depth discussion on a few dimensions rather than a quick scaling of all dimensions. This way we aimed to

get a grip on the complexity or ease with which such dimensions could be reviewed, and to take advantage of the deep knowledge that the experts possessed.

8.2 Results

8.2.1 Global conclusions

Participants appreciated the idea of the room of acceptance and its use of a multidimensional space. Although they indicated this might not lead to their point of view to shift in favour (or disfavour) of gene-adaptation of ruminants the inclusion of the many dimensions was considered a potential way to improve discussion beyond single criterion approaches.

Participants also recognised trust and ethics/world view as contextual dimensions that have a different role and place in the room of acceptance compared to the room shaping dimensions.

Participants indicated that some dimensions were closely interrelated with others and might easily overlap or influence each other.

Defining boundaries was often considered difficult/ In many cases, participants ended up with soft boundaries where a set of criteria together constituted the boundary. This also represents the diversity of perspectives present in the workshop

8.2.2 Specific conclusions aggregated to ex-ante list of sub-dimensions

The outcomes of the discussion on the main dimensions are summarised in table 8.1. Some of the subdimensions were considered and discussed, but not rated. This was either because they were not prioritised for discussion or omitted due to time constraints. In several cases, the boundaries could be applied to more than one, or to different subdimensions compared to those they were discussed against, during coding we have assigned boundaries to the most closely related dimension(s) based on justification on the topic. Therefore, several boundaries have more than one operationalisation. This suggests there are non-trivial interrelations between dimensions and stakeholder points of view across dimension. We allowed the subsequent existence of more than one boundary condition for some dimension in the current ex-ante room as the diversity of descriptions may inform further development of the room and its application in scenario studies.

Table 8.1 (sub) Dimensions with priority end points and boundaries specified based Copenhagen workshop or desk research (indicated with *).

Dimension	Priority	Unacceptable	Boundary	Best case
Application to food *	-not rated-			*Medicine*
Animal welfare – improved health	High-to-medium	Absence of animal health and welfare, immense suffering, problems intrinsic to life	Positive and painless with good health of animals	Best positive welfare in good health
		Breeding programme has a side effect severe negative consequences for individual animals in terms of health and wellbeing	Current situation is already below acceptable boundary and should not be used as benchmark. Boundary should be derived from farm to fork strategy	Intentional application to improve animal health (disease resistance) for other reasons than to legitimise production / intensity increases
Animal welfare – integrity	High	Animals as machines, brainless	Current situation	Animal full integrity with minimum interference
		Animals without sentience or removed organs and/or body parts (horns are ambiguous)	Impaired physical and mental integrity/wellbeing. (Soft boundary given	Animals with positive mental state and being able to exhibit natural

			benchmarks current practice). 5 domains of wellbeing tor specify the range	behaviour (related to that mental state). Animals can adopt and cope with environmental stress themselves
		Industrialisation of animals (life devoid of positive experience)	Five domains (sufficient: nutrition, environment, health, behaviour, mental state)	Animals cared for as individuals (life comprising its value)
Animal welfare – justification of poor husbandry	Very high	Changes in animal breeding significantly worsens intensiveness and welfare	Soft boundary: intensiveness increases, and welfare decreases should not go beyond present day (present day may already be below acceptable)	Changes reduce intensiveness and increase animal welfare
		Animals made fit for extreme conditions in terms of disease resisting, stress, etc. Treating animals as machines	Application to fit animal to its changed (climate) environment, but only as part of a comprehensive approach also involving farm practice improvement	Animals supported in healthy/high welfare existence. Treatment of animals as individuals. Minimising environmental stress
Benefit – product quality	High-to-medium	*Worse products than current status quo*		*Better products than current status quo*
Benefit – sustainable food security	High-to-medium	Dependency on monocultures famines	Most promising options are available access to sufficient food to avoid adverse health outcome / restricted choice	All valued options are available Choice of food
Economy – consumer price discount *	Low	*More expensive food*		*Cheaper food*
Economy – profit concentration at large companies	High	Farmers unable to work	Negative impact on farmers, reduction of farm profitability	content famers, making a living and have room for own ideas. healthy animals
Environment – long term biodiversity effects	High-to-medium	Irreversible damage to the gene pool of both farmed animals and wildlife		Increased diversity of gene pools without adverse effects
Environment – reduced need for agrochemicals and medicine	High	Profound negative impact on the health and welfare of animals, humans, and the environment	for some groups moratorium until sufficient research is done this will not reduce current welfare levels	Profound positive impact on the health and welfare of animals humans and the environment
		Areas become barren, migration of populations		Successful climate change adaptations
		Massive disturbance of eco-systems	Compliant with current goals	Thriving eco-system beyond policy goals
Institutional – mandatory labelling	High-to-medium	No product information	Only information relevant to consumer health is available	Clear, accurate and accessible product information available to consumers
		No access consumer to information		Full and encouraged access to information
Institutional – traceability	High-to-medium	No transparency	adequate level of transparency on decision process and outcome	Full transparency and publicity of key decisions in accessible language to the public
Institutional – responsibility for proof of safety taken	Very high	Assessment on only few criteria proposed by a minority in society	Blurred: lower end must include current Health and Environment regulation, higher end - with additional input from important stakeholders	Risk assessment is improved and made transparent against the criteria proposed by a majority
		Exclusively political decisions	Decisions made based on view of expert and stakeholder contribution	Robust open process where all actors' viewpoints contribute to

				decisions. Views of those most affected are actively sought
		Decision set in stone and can never change	Institutions respond and adapt decisions in response to major changes in point of view by stakeholders	There is a recognised and clear process for revision of decisions
		No control by regulators	The most prominent issues (human health & Animal welfare) are dealt with	Effective action is taken against those who infringe regulations
		No institutions established	Institutions meet minimal requirements	Institutions are regularly and independently audited and found to be very effective
		Regulators never held to account	Worst institutional failures are dealt with	Institutions are seen to be held to account for failures
Intrusiveness – foreign DNA	High	All traits controlled by synthetic genes	for some groups moratorium until sufficient research is done this will not reduce current welfare levels / rearranged genome (but not entirely new)	Organisms with an unchanged genome (undistinguishable compared to conventionally bred) through new gene technologies
Natural – aesthetic changes *	Medium to low	*Monstrified animals*		*Change toward idyllic image*
Natural – achievable by conventional means *	Medium	*Distinct from conventional breeding*		*Identical to conventional breeding*
Necessity – medicine *	-not rated-	*Other uses*		*Life saving medicine*
Necessity – agri-sector *	high	*Reduces viability of production chain*		*Improves economic sustainability of agri sector*
Organism applied to: Microbe-Mammal	-not rated-	*Mammals (primates / humans at extreme)*		*Microbes*
Ownership – Multinationals	high	Monopoly 100% dominance by single actor	All current options remain available for all actors at a particular chain link	Variety of options, greatest for everyone, affordable
Risk perception – emotion: fear	High (contextual)	*Scary*		*Relaxing, enthusing*
Unforeseen risk – long term *	-not rated as such-	*Likely long-term effects*		*Guaranteed no long-term effects*
Unforeseen risk – Uncertain side effects *	High-to-medium	*Likely side effects*		*Guaranteed no side effects*
Unforeseen risk – Broken promises (negative)	Very high	Promises are vague, intangible and are window dressing for hidden objectives	Promises are clear, reasonable, and open for scientific assessment	Promises are clear and measurable and are in actual application delivered or surpassed
Who benefits – developing countries *	High	*Rich countries only*		*Developing countries*
Who benefits – largest chain partner	-not rated as such-	concentration of benefits on another location than concentration of cost Vulnerable chain actors outcompeted	No increase in relative disadvantage from current status quo Increase dependencies with the chain, decrease of value generated in the chain	No one is disadvantaged
Who benefits – society at large *	Medium to high	*Only businesses*		*Society at large*

* Subdimensions not discussed in depth in the Copenhagen workshop due to time constraints. Dimension endpoints based on desk research

9 Discussion

9.1 Ex ante room

The ex-ante room was specified by 16 dimensions. Fourteen of these dimensions, representing a total of 27 subdimensions, that are relevantly different to justify their separate inclusion define the shape of the room of acceptance. The remaining two dimensions Trust, and Ethics and Worldview are considered contextual dimensions that define difference sizes of the room of acceptance across all dimensions. It should be noted that the ethics and worldviews dimension consist of several subdimensions.

Across the 27 subdimensions that define the shape of the room of acceptance, an estimate is provided of what would constitute a best case (acceptable) and a worst case (unacceptable) application of gene-adaptation in ruminants. Initial estimates of boundaries for most dimensions were generated, which give a qualitative indication of when an application shifts from being acceptable to being unacceptable.

The two contextual dimensions are assumed to increase or decrease the size of the room of acceptance across all dimensions. Contextual dimensions differed between stakeholder groups and segments in the population, rather than properties of the technology and its application.

Dimensions were, at this stage, interpreted as unrelated / unconstrained with each other to present as simple as possible a depiction of the room.

An initial graphical representation of the room of the ex-ante room of acceptance was provided to support discussions.

9.2 What needs to be confirmed, consolidated to make usable as ex-post

In the ex-ante room, we have assumed that all subdimensions are unrelated and that all are equally important. We have also assumed that contextual dimensions have an isomorphic influence on the size of the room. These simplifications allowed us to create a straightforward representation of the room. In the resulting room of acceptance boundaries are estimated, but whether these are compensatory or absolute has not yet been established in the context of Rumigen.

Towards developing the ex-post room of acceptance, several steps have to be taken. These include further validation of the identified dimensions as well as further development of the role of the contextual dimensions that emerged during the development of the ex-ante room. More in detail we need to:

(1) Validate the ex-ante room
    a. Check the completeness and relevance of the dimensions identified against citizen samples in the EU populations.
    b. Further develop and validate the boundary conditions for the retained dimensions.
(2) Include the contextual dimensions Trust and Ethics and Worldview
    a. Estimate the effect on room size of the positions of different stakeholder groups on these dimensions
    b. Define the endpoints and middle points for these dimensions ranging from strongly supporting stakeholder groups to strong opponents, taking good account of the often silent middle groups.

Although in the ex-ante room we maintained many subdimensions, for actual use of the room of acceptance as a discussion aid, it may be desirable to reduce the number of dimensions. Through initial use in Rumigen scenarios and citizen engagement it should be investigated whether it is necessary and possible to reduce the number of dimensions to simplify the ex-ante room towards the ex-post. Against this, the ex-ante room has not included interrelatedness of (sub)dimensions, nor the possibility that contextual dimensions not only change the sizes but also the shape of the room. While these simplifications make the application of the room of acceptance in discussions and scenarios easier, the influence of these potential effects should not make the discussion irrelevant. Therefore in the applications in Rumigen it should be explored whether these simplifications are sufficiently justified to retain in the ex-post room. Hence, we will:

(3) Balance relevance and ease-of-use (parsimoniousness)
    a. Develop graphical or otherwise relevant presentations of the room to facilitate use in societal debate
    b. Consider a reduction of (sub)dimensions if possible
    c. Consider the inclusion of interrelatedness of dimensions, but only if it improves the relevance of the room of acceptance sufficiently to justify the added complexity
    d. Consider whether contextual dimensions should not only influence the “size” of the room of acceptance but justify the more complex option they may also change the shape of the room.

In parallel to further developing the room of acceptance through use in the Rumigen studies, aimed at an ex-post room of acceptance, we will also consider the usefulness of the multidimensional Room of Acceptance in responsible research and innovation. In particular we will investigate to what extent the use of the Room of Acceptance supports established methods for stakeholder involvement as we will:

(4) Consider the usefulness of the Room of Acceptance approach in
    a. Developing scenarios that give realistic development options
    b. Engaging citizens
(5) Investigate whether the specification of contextual dimensions can shed light on, and help managing the potential controversies between supporters and opponents of gene-adapted Rumigen.

9.3 Concluding remarks

In this deliverable we have developed the idea of the Room-of-Acceptance for gene-adapted ruminants. The Room-of-Acceptance includes dimensions based on the properties of the technology and its application. In specifying these, we concluded there are also societal, or contextual dimensions that influence the entire room of acceptance based on differences in stakeholder opinion. In developing the ex-ante room, we have been fairly comprehensive in including dimensions, yet very restrictive in allowing interrelations between dimensions. Initial use of the room of acceptance in Rumigen studies will show the useability and usefulness of the room and will provide us with insights to further develop and fine-tune the room towards the ex-post Room of Acceptance. Through discussions with stakeholders, we found appreciation for the idea of specifying a multidimensional discussion tool such as the Room-of-Acceptance, which gives good hopes for our approach.

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11 Annexes

11.1 Search of published literature

Data base used Scopus (general) – by Elsevier

11.1.1 Query

Concept	Search terms
Gene editing (also including Genetic modification)	(“base edit*” or bioengineer* or CRISPR* or “gene* edit*” or “genetic* alter*” or “genetic* engineer*” or “genetic* enhance*” or “genetic* manipulat*” or “genetic* modifi*” or “genom* edit*” or “ genom* engineer*” or GMO or knock* or off-target or “genetic” or GM)
	AND
Ruminant species	(bovine or bovines or buffalo or buffaloes or bull or bulls or calf or calves or cattle or cow or cows or ewe or ewes or goat or goats or lamb or lambs or livestock or ovine or ram or rams or ruminant or ruminants or sheep)
	AND
Societal response and or acceptance	(Soci* or Citizen* or consumer* or stakeholder*) AND (attitud* or respons* or accept* OR "perceived risk" OR "risk perception" OR "perceived benefit" OR "benefit perception")

Terms deliberately not included:

- Gene editing:
  - “Transgenic, cisgenic”
- Ruminants:
  - “Does” (plural of doe): omnipresent as conjugation of the verb “do”
- Societal response
  - Opinion gives many false positives on expert opinions of the application not on the societal dimensions

11.1.2 Data storage

- Records: Endnote library and excel sheets for desk study
- Workshops: Excel spreadsheets of workshops outcome (main outcomes in Annex 11.2)

11.2 April 2022 Categorised notes of the workshop with Rumigen partners

-	-	Notes from Breakout Groups sorted into themes representing the most relevant main dimension (from group moderators/reporters)			
Main Dimension	Subdimensions	Group #1	Group #2	Group #3	Group #4
Animal Welfare	objectification of animals	animal welfare --- environmental impact biodiversity	Animal welfare -exploitation. – this includes multiple welfare / exploitation forms how do we select. Also note the animal welfare in traditional breeding can be poor (e.g., Belgian blue). And is the natural option best (over caesarean?) --- Tricky as this involve reproduction welfare, animal welfare related to any technology, is not only for GM… Make sure whether you talk about perception or actual welfare (see Belgian Blue caesarean probably better than trying to get them born naturally)	Animal welfare	Animals not being treated as objects but as sentient beings
-	intensified animal keeping	-	-	Intensity of farming	-
-	biodiversity loss	-	-	Welfare change induced by the breeding technology	Promotes intensification of agriculture
-	agrochemical use	-	-	-	Link with agrochemicals
-	-	-	-	-	Animal welfare
Natural	unnaturalness	Health – sociocultural practice / beliefs, natural unnatural	Artificial-natural – where natural is complex to define. It is important for citizens at first glance but often over estimated. In discussions the relevance of natural seems to reduce for consumers over the discussion time (but initially very important)	Unnatural	Pushing the limits of productivity even further
-	monstrification	-	-	”I would not accept monsters, such as a two-headed cow.” We agreed that a two-bodies cow with 1 head would be more probable from an economic point of view 😊	Surpassing limits
-	deviation from tradition religious worry	-	-	“Unnatural is a subjective thing, I know – for me it is something that I cannot relate to what I know already.” Something not compliant with your culture and habits	“Dr Strangelove”: Not being understood / mastered by society
-	about creation of animals science	-	-	Traditions is an important dimension. And it maybe has to do with what we think of as aesthetics (or are aesthetics more individual than culture??).	Artificialness versus naturalness
-	surpassing limits	-	-	However, non-gmo breeding is “traditional,” but often includes bigger change than gmo breeding would – for example x-ray induced mutations	-

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-	-	-	-	Spiritual/religious thinking can also be related to the "natural" – "playing God" has a connection to the doing something unnatural	-
Economic	food security for poorer countries individuals	Economy – food security vulnerability	Can we afford it / can we pay for it. Poor people may accept more if it is cheaper, will it be available to both high- and low-income countries? Alleviate costs to implement at less rich parts of the world?	Market ideologies versus regulation – versus the regulated market	Makes food cheaper
-	acceptable price level	-	What is the cost – Price – including moral costs of slaughtering animals	People have a very wide spread of standpoints some fully believing in the freedom of choice, others strongly in a collective regulation	-
-	desirability of market power	-	Relevance to market	Can labelling help? In a RUMIGEN new breeding case, then the label should say "GMO is generally not allowed, but this product has been produced with a gmo-related technology after deep scrutiny, and blablabla. = Very difficult to label case-by-case systems	-
Science Communication	-	Science innovations – crises, wars (possible linked to food security)	-	-	Semblance to communication around GMOs
-	-	-	-	-	Public perception of breeding as being a form of genetic modification
Ownership	corporate power	Ownership	Open or controlled (by big company) who owns the new breeds? Small farmers / small scale breeders in control probably better accepted than owned by large biotech	-	Corporate power
-	-	-	-	-	-
-	-	-	-	-	-
Unforeseen risks	risk for animals	-	Unexpected consequences / riskiness for humans and/or animals	Risks	Closeness to potential application in humans
-	risk for human	-	Personal safety for humans	Tendency to look at immediate risks – long term risks tend to show up as a societal cost eventually. So, the costs are exported away from the producer.	Weaponization potential
-	long term risk	-	Safety for humans, safety for the environment, safety for the animals	Is it possible to document the precision of change in a gmo breed?	Lack of control (for a low-key technology)

-	coevolution of diseases	-	Safety / risk by introducing possibility for co-evolution of potentially hazardous viruses?	How will “problematic off-target changes” be defined?? How do we compare such off-targets with the off-targets incidents in traditional breeding?	-
-	uncertainty	-	-	Uncertainty	-
-	Weaponisation potential	-	-	By experience the uncertainty about the wider societal consequences is important in citizens’ assessments	-
-	uncertainty on specificity	-	-	To this comes the uncertainty of risks – which (Ulrich Bech) would call for deep societal engagement to reach a collective stand about how to deal with this uncertainty	-
-	wider societal consequences	-	-	-	-
Environmental impact	pollution	-	Pollution – sustainable – can be important mainly for methane, seems to be more important in policy debate than societal.	Environmental impacts	Environmental footprint
-	land use requirements	-	-	pollution	-
-	-	-	-	Land use	-
Necessity	medical application	-	For what purpose (medical <-> food)	What are the alternatives?	-
-	food application	-	-	Is the radicality of the change in proportion with the imagined benefits, compared to the existing alternatives?	-
-	are there alternatives	-	-	Are there already good solutions?	-
-	-	-	-	Is there a real problem – that is, basically no alternatives?	-
-	-	-	-	What are the cost differences between alternatives?	-
-	-	-	-	Technological flexibility	-
-	-	-	-	Are we using fast or slow breeding techs? This may mean something for the ability to react in a crisis, e.g., a health crisis among cattle.	-
Equitable distribution of benefits	Welfare	-	Who gets the benefits / who gets the risks	Societal welfare	Farmers’ affection (for example, family farming versus

					industrial farming)
-	Job creation	-	-	Job creation	Mutual benefit for humans and animals
-	Consumers	-	-	Price of products, +/- consequences for the low-income consumers?	Beneficial for the consumer
-	Low-income groups	-	-	View on price is different when we assess as “shoppers” and as “citizens.” Shoppers know that they maybe should take the product that is a bit more expensive but environmentally much better, but they take the cheap product. Citizens know that, and there fore they as for regulation, to manage themselves as shoppers.	-
-	farmers	-	-	-	-
-	animals versus humans	-	-	-	-
Affected Species	Humans	-	(genetic) diversity – probably not so important to the public at first, although it may become important after discussion with them	Which organisms are we dealing with?	Genetic biodiversity / diversity
-	Mammals with positive association with the pubic	-	Number of animals affected – scale of role-out where limited application for specialised high benefit purposes might be more acceptable than mainstream uptake	Microbes / plants / cold blooded animals / warm blooded animals / intelligent animals / humans	-
-	Mammals with negative public association (e.g., rats)	-	Species (plant more acceptable than animals and bacteria) Sensitivity of species – do they have a central nerval systems or similar parameter	Which species inside these groups – rats more accepted than cows?	-
-	Intelligent animals	-	-	-	-
-	Cold blooded animals	-	-	-	-
-	Plants	-	-	-	-
-	Microbes	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

History of use	familiarity	-	Historic use / long term use – this is likely to make a product technology more societally acceptable even if on other dimensions it scores poor (e.g., Belgian Blue but also other technology)	-	Unfamiliarity
Disconnect from nature	-	-	Level of disconnection between final product (processed) versus recognisable animal	-	Further estranges people from animal husbandry
Trust	-	-	-	Trust	-
-	-	-	-	There is a baseline defined geographically because of political history – e.g., low baseline trust in eastern European countries	-
-	-	-	-	Additionally, there is a trust issue connected to the sole case – for example, are proper control mechanisms in place, can we trust producers with strong economic interests, etc?	-
-	-	-	-	Sensing that there is "spin" in place – over-strategic / dishonest communication – produces immediate negative response	-
Regulation	standardisation of processes	-	-	Ideas about if the product or the process should be regulated	-
-	-	-	-	In RUMIGEN the logic must be that an opening up for concrete cases of new processes could be a good solution. That is, still a GMO-process regulation, but with exemptions on a case-to-case base	-
-	-	-	-	Would standards of process be a solution – as the label for organic products, which is a process label	-
Group norms	pro environmental group membership	-	-	Group pressure	-
-	-	-	-	Are you in a veggie group? In an area with farming? …. You may suffer from social exclusion because of you take on GMO animals	-

11.3 Copenhagen workshop

Examples of materials after use

11.3.1 Transcripts of prioritisation sheets

Dimension

Affected organism	Ethics and worldview	Risk	Risk (contextual)	Uncertainty	Economic impact	Benefits	Animal welfare	Environmental impact	Governance	Trust	Who benefits	Ownership	Intrusiveness	Naturalness	Necessity /emergency	Aim application domain
	General ethics	Sufficient quality risk assessment in place	Emotions and Feelings / gut feelings with specific application will affect risk	not delivering promised benefits	Food security / safety	Farmer and animal well being	integrity / treatment - increased industrialisation of animals	Land use requirement for feed	Trusted institutions	(Relates to all governance actions)	Fair distribution of benefits		Manufactured materials		Availability and affordability of food (emergency)	
	Animal integrity	Risk of intensivation of animal keeping	Magnitude of risk will change its position	choice security - can I still buy diverse products	Equity	Food security safety quality	integrity welfare not making animals that do not have a mind	Pesticide use in feed production	Transparency of decisions		Protecting those who are most vulnerable		Naturalness		animal welfare improvement	
	Freedoms of consumer/farmers/breeding companies	Risk of mixing new genes into other animal populations		side effects	Market power concentration	Quality of farmer life	Increased production at the extent of animal freedom, impossibility to engage in social behaviour	Biodiversity in feed farms	Views are actively and openly considered for all actors		Increasing net benefit across the system		Foreign DNA		Maintain reduction under change climatic conditions	
	Animal welfare and health	Environmental risk of gene escape		Co-evolution of diseases	Environmental		Animal health of individual animals	soil quality in feed farms and due to increased amount of manure	Adaptability of regulations -flexible change is evidence changes		Effect on diversity of actors		in principle cross breeding		Reversibility / availability of alternatives (in emergency)	
	sustainability	Environmental risk of intensivation of production (greenhouse gas etc)		Gene-environment interactions	Nutrition protein cost / lactose cost		Animal freedom (from mutilation and industrialised circumstances)	Pollution in general through more feed need and more animal stabling	Accessibility of product information (traceability / labelling)				intrinsic DNA		Breed diversity improvement	
	Transparency	Risk of need for experimentation on animals / protest against animal testing		Livelihood of farmers			Animal health at level of population of animals (inbreeding)		Effective action is taken against those who infringe regulation				aesthetic / monsters		precaution	
	Harm reduction	Consumer health		Socioeconomic effect			Indirect effects on animal health (offspring)		Clear accountability for regulation				deviation from tradition			
	Ethical culture			Botched genome			Heat resistance, dehorning more examples of mitigating current problems		Institutions are competent and knowledgeable							
	Allocation of power								Regulatory system (from regulation to surveillance to legal) is adequately funded							
	Role of humans in the world															

Note: Thick borders indicate combined discussions. In some discussions the two main dimensions were discussed as one. Sometimes fewer subdimensions were discussed in more depth, hence a somewhat different pattern across discussions.

11.3.2 Transcripts of boundary setting sheets

Dimension	Unacceptable	Boundary	Ideal
Ethics	Animals as machines, brainless	Current situation	Animal full integrity with minimum interference
Ethics	Monopoly 100% dominance by single actor	All current options remain available for all actors at a particular chain link	Variety of options, greatest for everyone, affordable
Ethics	Absence of animal health and welfare, immense suffering, problems intrinsic to life	Positive and painless with good health of animals	Best positive welfare in good health
Ethics	Massive disturbance of eco-systems	Compliant with current goals	Thriving eco-system beyond policy goals
Ethics	No access to information		Full and encouraged access to information
Risk	Assessment on only few criteria proposed by a minority in society	Blurred: lower end must include current Health and Environment regulation, higher end - with additional input from important stakeholders	Risk assessment is improved and made transparent against the criteria proposed by a majority
Risk	Changes in animal breeding significantly worsens intensiveness and welfare	Soft boundary: intensiveness increases, and welfare decreases should not go beyond present day (soft boundary as some present day may already be below acceptable)	Changes reduce intensiveness and increase animal welfare
Uncertainties	Promises are vague, intangible and are window dressing for hidden objectives	Promises are clear, reasonable, and open for scientific assessment	Promises are clear and measurable and are in actual application delivered or surpassed
Economy	Increased productivity at the cost of everything else	Increased productivity and nutrition value of food against some cost to animal health and/or welfare	Increased productivity combined with increased animal welfare
Economy	Farmers unable to work	Negative impact on farmers, reduction of farm profitability	content famers, making a living and have room for own ideas. healthy animals
Animal welfare	Animals without sentience or removed organs and/or body parts (horns are ambiguous)	Impaired physical and mental integrity/wellbeing. (Soft boundary given benchmarks current practice). 5 domains of wellbeing could further specify the range	Animals with positive mental state and being able to exhibit natural behaviour (related to that mental state). Animals can adopt and cope with environmental stress themselves

Animal welfare	Animals made fit for extreme conditions in terms of disease resisting, stress, etc. Treating animals as machines	Application to fit animal to its changed (climate) environment, but only as part of a comprehensive approach also involving farm practice improvement	Animals supported in healthy/high welfare existence. Treatment of animals as individuals. Minimising environmental stress
Animal welfare	Breeding programme has a side effect severe negative consequences for individual animals in terms of health and wellbeing	Current situation is already below acceptable boundary and should not be used as benchmark. Boundary should be derived from farm to fork strategy	Intentional application to improve animal health (disease resistance) for other reasons than to legitimise production / intensity increases
Governance	Complete distrust in governmental institutions	(Soft boundary) a broad series of contestation from political and stakeholder groups	Widespread confidence in governance system (decision generally uncontested)
Governance	No transparency	adequate level of transparency on decision process and outcome	Full transparency and publicity of key decisions in accessible language to the public
Governance	Exclusively political decisions	Decisions made based on view of expert and stakeholder contribution	Robust open process where all actors view contributes to decision and views of those most affected are actively sought
Governance	Decision set in stone and can never change	Institutions respond and adapt decisions in response to major changes in point of view by stakeholders	There is a recognised and clear process for revision of decisions
Governance	No product information	Only information relevant to consumer health is available	Clear, accurate and accessible product information available to consumers
Governance	No control by regulators	The most prominent issues (human health & Animal welfare) are dealt with	Effective action is taken against those who infringe regulations
Governance	No institutions established	Institutions meet minimal requirements	Institutions are regularly and independently audited and found to be very effective
Governance	Regulators never held to account	Worst institutional failures are dealt with	Institutions are seen to be held to account for failures
Governance	Institutions insufficiently funded		Funding for institution is fit for purpose
Benefits	concentration of benefits on another location than concentration of cost	No increase in relative disadvantage from current status quo	No one is disadvantaged
Benefits	Vulnerable chain actors outcompeted	Increase dependencies with the chain, decrease of value generated in the chain	

Benefits	Dependency on monocultures	Most promising options are available	All valued options are available
environment	Profound negative impact on the health and welfare of animals, humans, and the environment	for some groups moratorium until sufficient research is done this will not reduce current welfare levels	Profound positive impact on the health and welfare of animals humans and the environment
environment	All traits controlled by synthetic genes	for some groups moratorium until sufficient research is done this will not reduce current welfare levels / rearranged genome (but not entirely new)	Organisms with an unchanged genome (undistinguishable compared to conventionally bred) through new gene technologies
environment	Irreversible damage to the gene pool of both farmed animals and wildlife		Increased diversity of gene pools without adverse effects
necessity	famines	access to sufficient food to avoid adverse health outcome / restricted choice	Choice of food
necessity	industrialisation of animals (life devoid of positive experience)	Five domains (sufficient: nutrition, environment, health, behaviour, mental state)	Animals care for as individuals (life comprising its value(
necessity	Areas become barren, migration of populations		Successful climate change adaptations