FACCE-JPI & ERA-NET Cofund SusAn Joint Exploratory Workshop on

Phenotyping/Genotyping and Novel Breeding Techniques for adaptation and mitigation to Climate Change in the livestock sector

Brussels, 21 November 2019

SUMMARY REPORT

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1. Introduction to FACCE-JPI and ERA-NET SusAn and aims of the Workshop

The **Joint Exploratory Workshop on Application on Phenotyping/Genotyping and Novel Breeding Techniques for adaptation and mitigation to Climate Change in the livestock sector** was organized under the FACCE-JPI & ERA-NET Cofund SusAn and hosted by INIA in Brussels on 21st November 2019. The event brought together 36 participants from 14 countries representing the sector.

The workshop participants were first welcomed by **Pablo Gomez**, European Research, Development and Innovation Projects Manager from the Spanish National Agricultural and Food Research and Technology Institute (INIA).

Hartmut Stalb, Chair of the **Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI)** from the **German Federal Ministry of Food and Agriculture (BMEL)** gave an introduction to the JPI. It was then reminded that FACCE-JPI's mission concerns the promotion, integration, and alignment of national research resources to address the diverse challenges in agriculture, food security and climate change conciliating the need to reduce greenhouse gas (GHG) emissions while responding to increasing demands for food associated to greater global populations. The animal production is no exception contributing to 80% of the emissions from the agricultural sector in Europe. FACCE-JPI also contributes to science-policy dialogues and ensures that results can be accessed by stakeholders and society through communication and dissemination activities. As part of this joint-action workshop, **Hartmut Stalb** welcomed participants and thanked them for contributing to a more sustainable animal production identifying relevant research priorities and gaps.

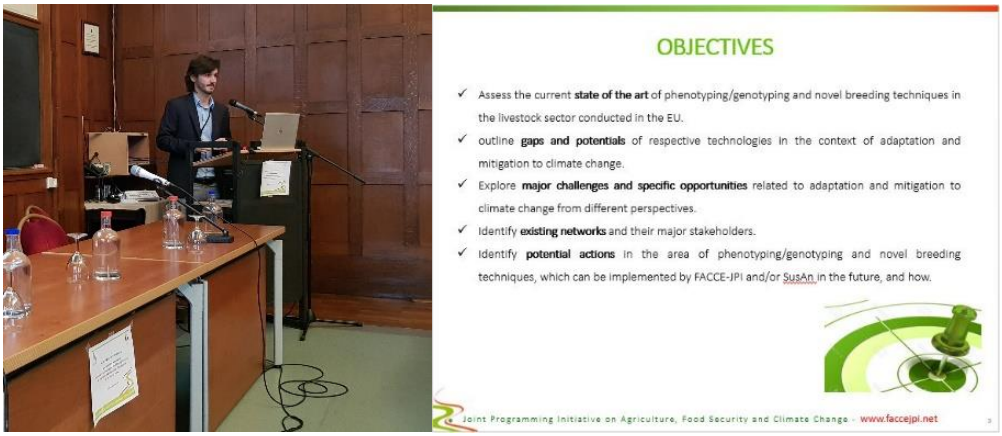
Babette Breuer from the Coordination Team of **ERA-NET Cofund on Sustainable Animal Production (SusAn)** at the **German Federal Office for Agriculture and Food (BLE)** then introduced ERA-NET SusAn. SusAn applies a systems approach to animal production based on three sustainability pillars and as such, a sustainable animal production system must be economically valuable, environmentally friendly and sociably acceptable. SusAn supports the change to a more sustainable animal production with targeted research actions involving 38 partner organisations from 22 European countries. For the first EU cofunded call, 14 projects with a total of 16 Mio € national and EU funding were selected to perform research on a wide range of topics and species. Among future actions planned, there is the development of a Common Strategic Research and Innovation Agenda including future livestock production scenarios, an Early Career Scientists Workshop as well as explorations for a third call with other ERA-NETs on the common topic of circularity. In order to address the particular challenge of GHG emissions, SusAn collaborated with the ERA-NETs ERA-GAS and ICT-AGRI in two Joint Workshops which lead to the "2018 Joint Call" where 8 research projects were selected with 8,4 Mio € national commitment. The present workshop in Brussels deals with the challenge on another level and **Babette Breuer** thanked participants for their commitment to join the workshop and explore options for GHG mitigation and adaptation.

An introductory presentation about FACCE-JPI and SusAn was given by Hartmut Stalb (left) and Babette Breuer (right).

Pablo Gomez presented the aim of the exploratory workshop: the identification of possible **gaps** in research in Europe, of **existing initiatives, actions and organizations** in Europe and the major stakeholders acting in the field, of **needs and challenges** of different stakeholders including policies, and the exploration and identification of **possible roles of FACCE-JPI / SusAn** to address them. The focus was on genetic entry and the role of breeding to reduce GHG emission: methane but also NO2

emission, feed efficiency especially in case of low quality feeds. He further explained the workshop concept which started with three sessions of key speakers' introductory lectures to address the research, stakeholders', and policy perspectives. In the subsequent breakout sessions participants were to discuss in small groups gaps, needs, potential and priorities. The wrap-up after the presentation of the discussion results, was to summarise first recommendations of needs and requirements for FACCE-JPI and SusAn future contributions and actions in this field.

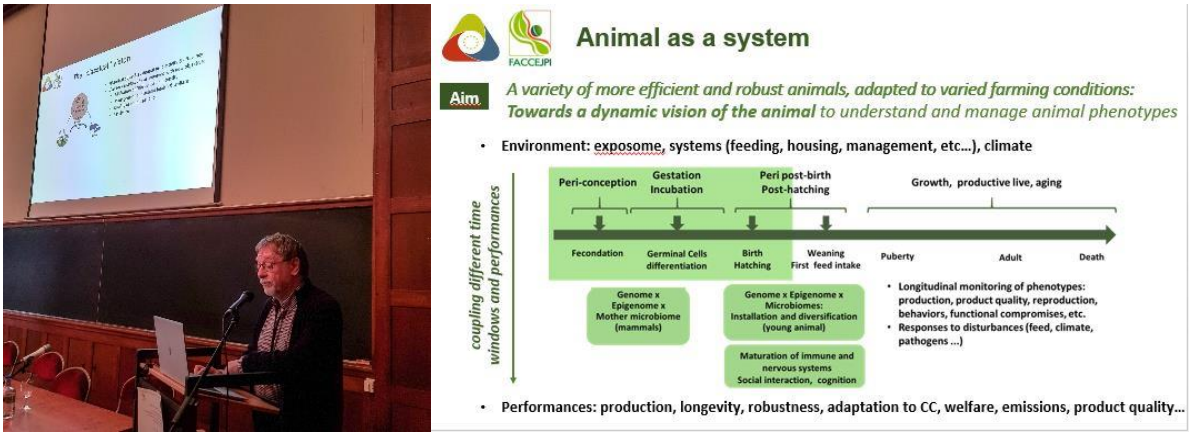
The event structure and session distribution can be consulted in the workshop agenda included in annex 1.



Pablo Gomez (left) closed up the introduction with a reminder of the structure of the workshop along its main objectives (right).

2. Setting the scene: research perspective session

Jean Louis Peyraud, Deputy Scientific Director from the **French National Institute for Agricultural Research (INRA)**, started this session talking about **the future of animal research from a global perspective**.



Jean Louis Peyroud (left) reflected on the need of a new paradigm for livestock production in Europe which also needs to consider different time windows and peformances (right).

The classical vision has been to increase productivity and efficiency. Some of the problems of animal production have emerged as new research objectives such as the mitigation of GHG emission intensity, the management of animal health and welfare, the quality of animal products and the livestock resilience. There have been considerable productivity gains under a linear thinking approach (resource – production - product- waste) but issues such as the amount and origin of mobilized resources and the degradation of health ecosystems have not been properly considered causing and a legitimacy loss of livestock farming to the society. Therefore, there is need of a new paradigm for the future of livestock, **where animal production systems can also be part of the solution as part of circular agri-food systems,** rethinking the links between livestock, crop production, soil fertility and the

environment. There is a need of **varieties of more efficient and robust animals** adapted to varied farming conditions, which implies moving towards a more **dynamic vision of the animals** to understand and manage animal phenotypes. As such, there is need to consider different **time windows** (e.g. peri-conception, gestation, peri- and post-birth, productive live and aging) and **performances** (e.g. production, longevity, robustness, adaptation to climate change, welfare, emissions, product quality). This can be done by **addressing the holobiont scale** where advances can be achieved by:

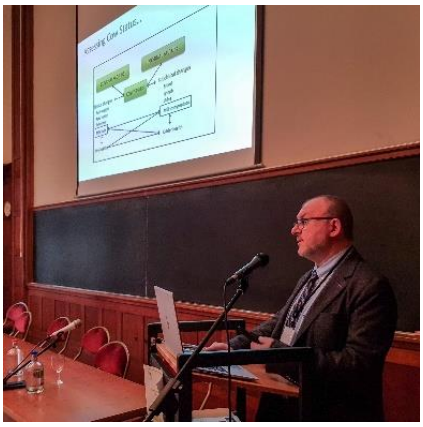
» using novel breeding technologies (NBT) to improve the knowledge on genome regulation,
» intergenerational tracking of epigenetic deterministic traits in farmed animals,
» advancing our understanding on the quality and control of implantation of the (intestinal) microbiome and the multiple role of microbiome,
» advancing research on neuronal network regulating functions and behaviours involved in learning and cognitive processes, besides cell differentiation mechanisms, and development of tissues of interest.

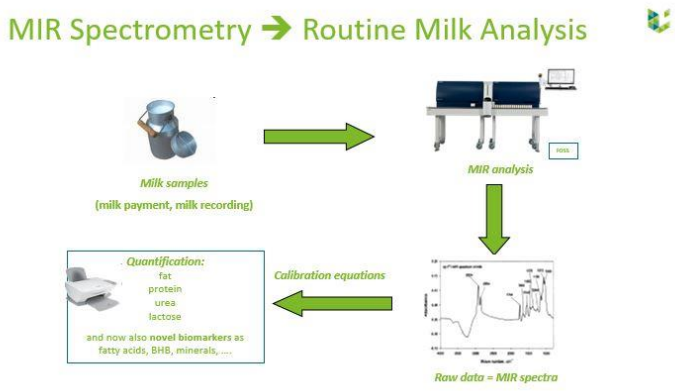
On a more practical approach we need to think about:

» **multi-performing animals** increasing their efficiency at the digestive and metabolic levels,
» developing behavioural robustness concerning positive and negative emotions,
» understanding the relationship between animal welfare, animal health (immune potential) and feed efficiency,
» decreasing emissions (ruminants),
» their capacity to adapt to heat waves,
» the compromises between live function and productive function in various environments,
» the impacts of genetic and physiological processes on the products' nutritional and organoleptic quality.

As an example, thinking of low emitting animals could be addressed at **several levels** such as the **microbiome level** (e.g. management of ruminal microbiome at an early stage), the **animal level** (solving for the synergies and trade-offs between methane emission and digestive efficiency or methane emission or metabolic efficiency) also taking into account feeding strategies (e.g. forage quality and food additives), and **herd level** (animal health, renewal), to finally address a **global** level with innovative scenarios (at the European scale, should meat be produced from the dairy sector or from a specialized beef sector?). **Currently the drivers are the animal level (50%) and the global level (50%) but there is need to consider all levels**. In this context, **high throughput phenotyping** and **proxies** concerning efficiency and CH_4 production can be a useful tool.

Nicolas Gengler, from the **Gembloux-Agro Bio Tech, University of Liege**, gave a talk on the potential to use milk infrared based tools as an example how phenotyping can **contribute to climate smart breeding**.



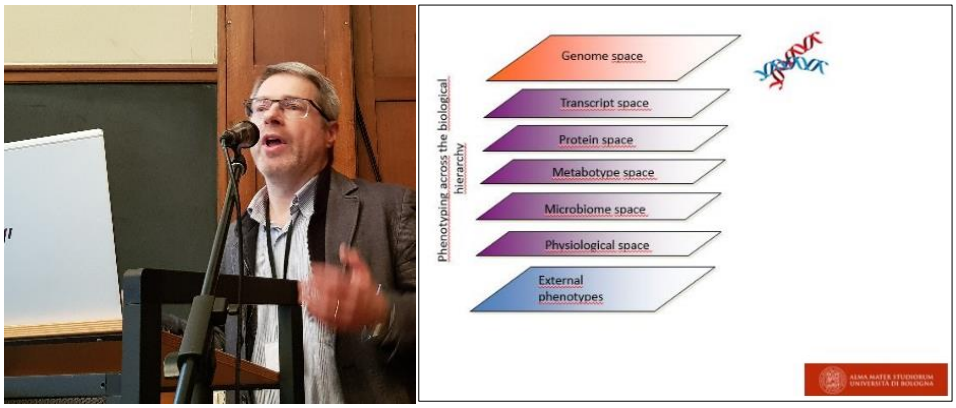


Nicolas Gengler (left) presented MIR Spectrometry as a value tool for mitigation and adaptation to climate change in the dairy industry (right).

Climate change and climate variability has its effects on exposed and vulnerable animal production where there can also be autonomous adaptations. Policy can address the impacts and vulnerabilities

through mitigation (e.g. GHG sources and sinks) or planned adaptation to the impacts and vulnerabilities. As an example, in the context of dairy production, mitigation measures could address reducing GHG emissions of the animals (e.g. methane) by breeding, whereas adaptation could be achieved by increasing genetic "resilience" to climate change (e.g. heat stress). **Milk yield** and **milk composition** data can be helpful for **mitigation** policy purposes as they are related to cow stress, whereas **milk composition** can be useful in the context of **mitigation** as it relates to ruminal fermentation of fibre and methane emissions. Getting **extensive milk composition data is costly** but mid-infrared (**MIR**) spectral data can be used **as a proxy** to quantify fat, protein, urea, and lactose, and novel biomarkers such as fatty acids, BHB and minerals through calibration. Accessing MIR data is a first challenge but there is already a positive example, the 'Futurospectre consortium' from the southern Belgian Walloon region, which has taken advantage of science and industry joining forces. There is need for strong transnational funding to generate relevant and expensive reference data and to harmonize procedures, methods and measures. It is important to **coordinate research and development priorities through a transnational bottom-up approach**. To perform final milk composition assessments, **near-infrared (NIR) spectral data seem to be more appropriate than MIR data**. However, there are many challenges to apply it as there is **not yet an existing NIR** (as for MIR) **experience going from the cow level to the farm and the breeding structures**. Besides, some industry players have a closed approach and there are no public transnational initiatives.

The research perspective section was closed by **Luca Fontanesi** from the **Department of Agricultural and Food Sciences of the University of Bologna** who gave a presentation on how **molecular phenotyping illuminates the pig genome for the development of new breeding strategies**.



Luca Fontanesi (left) talked about the molecular phenotyping potential to develop complex traits which could also be useful in the context of climate change (right).

Luca Fontanesi highlighted the **need of new phenotypes related with disease resistance, animal welfare, environmental footprint and adaptation to climate change**. **Between the genotype and the external phenotype**, which are the production traits of interest, there are several internal layers along a biological hierarchy that could link the genome space to the external phenotypes. As such, **there is a transcript space which is close to the genome space, a protein space, a metabiotype space, a microbiome space and a physiological space which is located closer to the phenotype space.** These spaces can be used **to fill the gap between the genome space and the external phenotypes**. An example was given of an analysis performed through the **physiological space** which had access to 20,000 performance tested Italian Large White pigs, and 10,000 performance tested Italian Duroc pigs from the national pig farmers association. From those pig populations, 1,000 pigs of the first breed and 400 pigs of the second breed were selected comprising about 300 phenotypes for each one of the subgroups. The physiological analysis focused on phenotyping through 30 haematological and clinical-biochemical traits. Concerning heritability, it was found that these parameters are quite variable as they relate more to the physiological stage of the animals. Some interesting genome regions could be picked up in relation with basophils, which are involved in inflammatory reactions and the immune system. Therefore, studies such as this could be useful to provide greater resistance to animal populations. Some other examples performed in the physiological space concerned clinical-

biochemical traits, where gene associations were found in relation with cholesterol and alanine aminotransferase, which is part of a blood test used frequently to detect liver damage. Getting closer to the genome space, **the metabotype space is quite challenging,** as only some data can be grasped from the enormous metabotypes and metabolites present in an organism (in the order of the 1M scale). The research focused on near 200 metabotypes (e.g. aminoacids, biogenic amines, acylcarnitines, glycerophospholipids, and sphingolipids) present in body fluids per population of selected pigs. This information can be used to analyse the difference between traits, to calculate estimated breeding values, and improve the breeding routings for complex traits. It is also possible to build some predictive relationships in terms of differences between the sexes. There are also possibilities to relate to the genome space by overlapping the signals from all aminoacids of all different traits as these aminoacids are in some way affected by one, two, or more genes. By analysing together snips and the metabotypes, some relations between some of them can be found. It is possible then to identify the biochemistry looking at the factors of the genome or the different parts of the metabolomics pathways. Across these examples, we can understand what all parts of the genome can do in the different layers. From all what was exposed the following question is raised: new phenotypes for new breeding goals? **If genomics and molecular phenotypes are placed together, there is possibility to perform predictions in terms of basic biologic systems. If molecular phenotypes are used, new predictive models that could explain in some way more complex phenotypes can be developed for disease resistance, animal welfare, environmental footprint or adaptation to climate change.** The **challenge** is then to include **environmental perturbations** to see how these internal phenotypes can react and could modify the external phenotypes. The presented omics study in pigs including the different levels of phenotypes is a hypothesis generating approach because based on what it can be observed, there is the possibility to explain or explore nutrigenomics, aspects of pig breeding or behaviour, or resilience traits which are important but difficult to analyse. In conclusion, Luca Fontanesi stressed the **relevance of molecular phenotyping** as it is a technology becoming cheaper with time, and can be used to study internal phenotypes which are closely linked with genomics. In this way, a greater understanding of basic biological mechanisms can be achieved. This opens new possibilities to understand complex traits and new breeding opportunities.

Questions & Answers in session 1:

Q *From an audience participant: How far are we from measuring climate-related traits?*

A **Nicolas Gengler**: There have been advancements in the last years but there is need of more data as they are quite variable. There is also need of collaboration. MIR and NIR spectra data are very useful to assess the status but we also must keep in mind that these tools are proxies. Still they are very good as they yield information about thousands of metabolomics status including efficiency. NIR can be considered to assess the status of the cow and the methodology is advancing very quickly.

Q *From an audience participant: We are talking about proxies, but we know that there is collaboration in Europe and also international to put together methane records in genome selection to evaluate breeding values. As proxies have limited accuracy, would it be possible to use methane measurements instead?*

A **Jean Louis Peyraud**: proxies are not as good as direct measurements but they are the most reliable alternative to direct measurements which are unfeasible because they are very expensive. However, they also need validation against well established techniques.

Luca Fontanesi: we have not found ways to apply non-invasive methods of analysis for pigs. We need to analyse the blood or serum. Therefore, for a large scale study, blood from slaughter houses would have to be routinely taken but that might bring many aspects to take into account such as medical issues, the organization of the sampling etc.

Q *From an audience participant. Would it be possible to use urine or fecal samplings?*

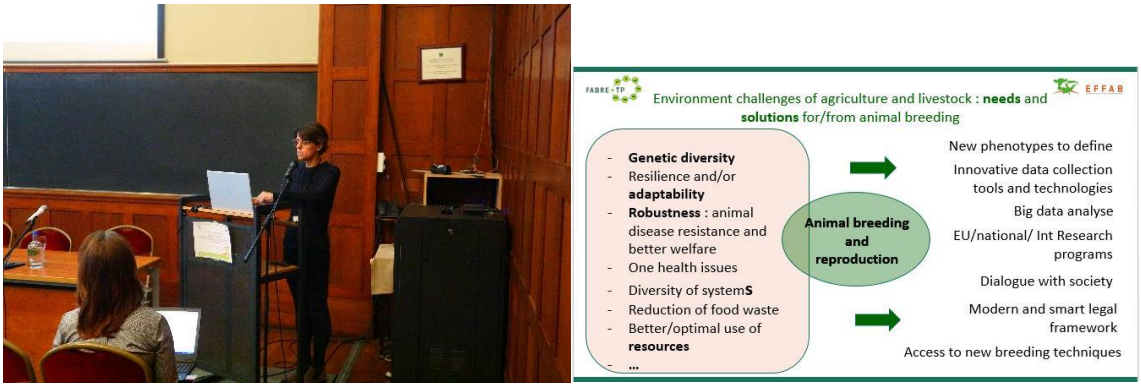
A **Nicolas Gengler**: there is a broad field of research concerning NIR use with faeces and urine status.

Q *Could the research be made in terms of systems instead of only animals?*

A **Nicolas Gengler**: If there is access to a greater number of data, the scope of the research could broaden.

3. Setting the scene: the stakeholders' & end users' perspective

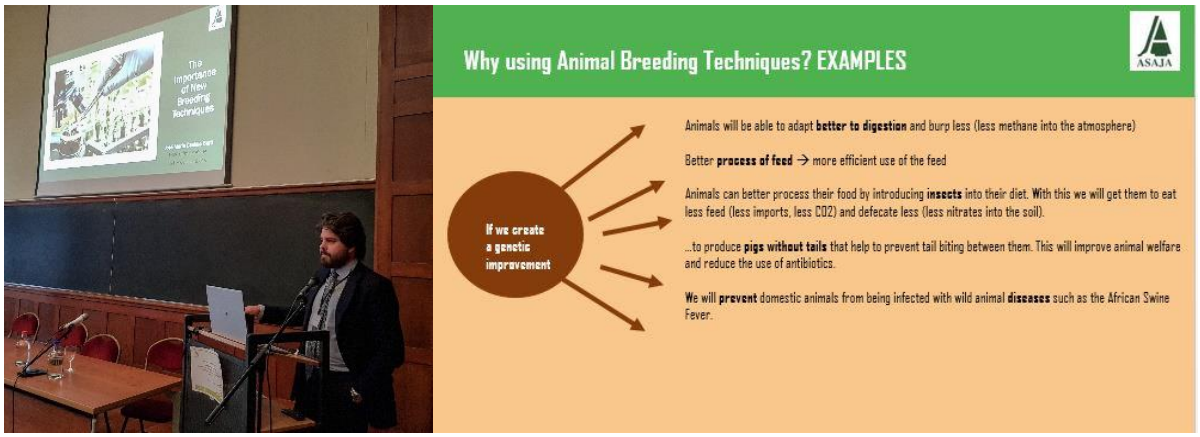
This session was opened by **Ana Granados**, Director of the **European Farm Animal Breeders (EFFAB)** and the General Secretary of the **Animal Breeding and Reproduction Technological platform (FABRE TP)** who gave a talk on **needs, solutions, and perspectives from the EU breeding sector**.



Ana Granados (left) talked about needs and solutions concerning enviromental challenges of the livestoc sector from the perspective of the EU breeding sector (right).

Ana Granados presented first EFFAB, which is an independent European forum representing farm animal reproduction and selection organizations including cattle, pigs, poultry and aquaculture. It is composed by 43 companies and cooperatives from Europe although there are also some members from Canada. EFFAB plays a supportive role in ensuring that Europe provides the perfect environment for animal breeding and reproduction companies. FABRE TP also includes academic institutions and has a role in promoting animal breeding and reproduction research in the EU research agenda and colaboration at the EU level between industry and research. As such, both EFFAB and FABRE TP have been involved in may EU projects at the dissemination level. There are **several challenges related to animal breeding and food and livestock systems related to genetic diversity, resilience and/or adaptability, robustness (animal disease resistance and better welfare), reduction of food waste, better/obtimal use of resources, animal health and reduction of antibiotic use, and the diversity of systems.** As such, there are several **ways to address these challenges** such as **new phenotypes** to define**, innovative data collection tools** and **technologies** to be applied**,** developement of **big data analysis procedures, integration of national and international research at the European level, a better dialogue with society,** a clear **pragmatic and science based legal framework,** and **access to new breeding techniques**. The **legislative** and **political aspect** is a big context where there are many aspects to conciliate such as the future **European Green Deal plan** to reduce GHG emissions, the legal framework for implementation, the animal breeding, welfare and health regulations, the risk assessment procedures, the common agricultural policy and the trade rules. In this context, there is need to have **objective figures** and consider possibilities for implementation **before taking decissions at the EU level** taking into account different conditions (local/regional/national/EU/international) and a proper dialogue with society. Concerning EU/national research programs, there is also need of a **strong Horizon Europe with easier rules, less complex projects and more opportunities for collaboration and involvement of the private sector**, knowledge institutes and stakeholders, paying also adequate attention to the dissemination of results. Ana Granados concluded her presentation reflecting on the need for clear and smart regulations and frameworks to tackle the climate challenge, which should also leave an open door for genome editing, as this technology can offer possibilities for genetics and sustainable livestock. Responsible Research and Innovation (RRI) and strong and smarter research programmes can also play a key role. Finally, it is also important to increase dialogue and transparency with the public sector, consumers and other stakeholders.

The stakeholder and end users perspective session was closed by **Jose Maria Castilla**, Head Office of the **Agrarian Association of Young Farmes (ASAJA)** who gave a presentation on the **importance of new breeding techniques**.



Jose María Castillo (left) gave a presentation on the importance of new breeding techniques for the livestock sector (right).

Jose Maria Castilla explained that, as income increases, the demand for greater food variety grows. The demand for **higher-value** and **quality foods such as meat, eggs and milk** also rises, compared with food of plant origin such as cereals. These changes in consumption, together with sizeable population growth, have led to **large increases in total demand for animal products in many developing countries**, and this trend will continue. The **objective of using animal breeding techniques would be using more with less**, a better use of resources and better adaptation to the regions, capacity for adaptation and mitigation to climate change, less use of antibiotics by eliminating certain diseases, and preservation of native breeds (biodiversity) as a stock of traits that could become better adapted and more profitable in the future. Some objectives to pursue by animal breeding techniques are to improve animal digestion (less methane to the atmosphere), increase feed efficiency, improve animal welfare (e.g. breed pigs without tails in order to prevent tail biting and also aiming to reduce the use of antibiotics), and resistance to infections from wild animal diseases (e.g. African swine fever). **Improper regulation of NBTs could cause a competitive disadvantage,** and **innovation with associated businesses and jobs could migrate from Europe to other countries**. Jose Maria Castilla concluded that breeding techniques can provide solutions to the numerous challenges such as climate change, and that **NBTs could also help to provide vitality for the whole EU farming model,** which is striving for increased sustainability. Therefore, Europe should embrace breeding innovation and make sure it does not fall behind the rest of the world in terms of development of new plants and animals, and the societal and environmental benefits they can bring. In this sense, ASAJA calls to the European institutions to take appropriate action as quickly as possible.

Questions & Answers in session 2:

Q *<u>Comment</u> from an audience participant: There is agreement on the relevance of dissemination activities from the beginning of the project and not focusing only on academic papers. There is need to use different terms concerning breeding technologies other than GMOs if we aim to have greater acceptance by society.*

Q *<u>Comment</u> from an audience participant: NBTs are exciting but are not yet to the level to contribute to climate change adaptation and mitigation as they cannot deal with several genes as those involved in complex traits.*

Q *<u>Comment</u> from an audience participant: There are NBT contributions in the field of disease resistance. There should be an open door left for NBT technologies as companies will be generating products from them which wouldn't be possible detected by border controls with the current technologies.*

A **Ana Granados**. From a survey made by FABRE it appears that about 85% of livestock research addresses animal health issues, but that there is not much work concerning climate change. **Concerning dissemination activities, they launched a "Meat the facts" campaign** in September 2019 about the importance of the livestock sector for society.

4. Setting the scene: the policy perspective

The policy perspective was addressed by **Frank Swartenbroux**, from **Directorate General Health and Food Safety – Unit E3 – Biotechnology** at the European Commission.

Frank Swartenbroux (left) gave a policy perspective concerning novel genomic techniques for the livestock sector (right).

Frank Swartenbroux brielfy explained the European legislation on genetically modified organisms (GMO) and its objectives concerning directive 2001/18/EC on deliberate release of GMOs, directive 2009/41/EC on contained use of genetically modified micro-organisms (GMM), and EC regulation nº 1829/2003 on genetically modified food and feed. The Court of Justice of the European Union (CJEU) ruling C 528/16 has only exempted classical mutagenesis due to a long history of safe use. The current focus is on enforcement with discussions with Member States and work by the European Network of GMO Laboratories (ENGL), the European Food Safety Authority (EFSA), and the European Group on Ethics in Science and New Technologies (EGE) (e.g. detection). The Council Decision (EU) 2019/1904 requested the Commission to submit a study regarding the status of novel genomic techniques under the Union Law by April 2020. If appropiate, in the view of the outcome, a proposal or other measurement and an impact assessment should be submitted. There is a need of a targeted consultation to collect substantiated contributions. This is planned for early 2020 (March). In this context, some of the questions that could be addressed by this workshop could contribute to understand how animal breeding can contribute to tackle climate change (how can these techniques be useful and why are they needed), what is in this for the farmer, the consumer and the citizen, how the high expectations will be met, and what the impact of C 528/16 would be on the envisaged solutions.

Frank Swartenbroux closed his presentation with recommendations to review communication strategies. Nowadays everybody is flooded with information and in order to reach the targeted audience, information needs to be carefully processed. This goes even more for the very specific topic of animal breeding, which is difficult to communicate outside a scientifically pre-informed audience. In the end, all communication on this topic is also lobbying for animal production and the benefits it has for society in general. He finally recommended not to raise hopes which NBT (like GMO before) cannot fulfil.

Questions & Answers in session 3:

Q *<u>Comment</u> from an audience participant. Breeding techniques are not a solution for all of the challenges but a toolbox.*

5. Breakout sessions

The following sections summarise the discussions in the breakout sessions.

5.1 Topic 1: Identification of possible gaps in research in Europe

In these sessions, the participants were asked to discuss along the following leading questions:

- How are phenotyping/genotyping currently used in the livestock sector?
- Which breeding techniques are currently used, what are their limitations/challenges?
- How to achieve a multi-disciplinary and multi-stakeholder approach, not only to improve novel breeding techniques development and knowledge, but also favour the implementation of existing technologies and approaches?
- Which data issues must be considered?
- What is needed to translate research into applicable solutions for end users?
- Which ethical considerations must be taken into account?
- To address the role of FACCE/SusAn: what kind of action is needed to address the identified questions (e.g. research call, knowledge hub, etc.)?

Genotyping was considered to be far advanced technically, with well-established methods and cost-efficient procedures. Other than some issues related to the routine collection of biological material, no urgent research gaps were identified.

Instead, participants identified phenotyping as the area with relevant research gaps:

- future production environments need to be assessed,
- new phenotypes / “phenotypes of future scenarios” need to be defined accordingly,
- parameters / traits useful to answer questions related to climate change have to be identified,
- their interaction with climate change needs further exploration,
- in order to define the traits relevant for GHG mitigation or adaptation, information is needed from different disciplines, e.g. concerning feed efficiency, big data analysis, genetics etc.,
- trade-offs at the animal level need to be taken into consideration,
- a different concept is needed for monogastric species and ruminants:
  - there is an imbalance of research activities between large ruminants and monogastric species related to climate change issues with more discussions currently concentrating on large ruminants,
  - methane is a main issue but it should not be the only topic,
  - phenotypes-equations for methane production in the field needs improvement,
  - nitrogen is important for monogastric species,
  - monogastric species may face a problem of changing diet – driven by problems caused by climate change – and competition with human food: a solution could be sought in alternative feed for the monogastric rather than in genetic improvement.

Technology gaps and collection of data

- solutions for utilisation and evaluation of (big) data are needed for:
  - definition of the required data,
  - data integration procedures,
  - storage of data,
  - extraction of data,
  - IP rights challenges / data ownership,
- exploration of available analytical tools , e.g. digital techniques for phenotyping,
- multidisciplinary approach and/or interdisciplinary teams / networks are needed to evaluate what needs to be and also what can be measured,
- evaluation of direct measurements vs. use of proxies:

- > proxies are especially useful for expensive/difficult traits and to substitute invasive measurements that may collide with animal welfare issues and public opinion,
- > ethics appraisal are needed before using proxies,
- > develop simple proxies to enable routine (on-farm) measurements (by the farmers themselves),
- > establish experimental populations in which to collect (reference) data.

Suggestions for FACCE-JPI and SusAn

- » development of Technical Guidelines or policy briefs which could give orientation for researchers, stakeholders and policy makers.
- » recommendations to revise call procedures related to topic identification and dissemination/exploitation of results:
  - > reconsider if the topic benefits from a bottom up approach,
  - > stakeholder involvement should start at an earlier stage in the ERA-NETs, ideally already when developing a call, e.g. with workshops or other feasible consultation methods,
  - > in order to address specific needs, (ad hoc) funding of small projects could be more effective than large projects resulting from ERA-NET calls, which usually have a rather long preparation phase too,
  - > thematic networks / hubs / platforms could help facilitate the exploitation and knowledge transfer after the projects end,
  - > explore other options to support exploitation and knowledge transfer (for instance, after projects end and there is no time and projects' money left to follow up, e.g. after the PhD)
- » policies and political decisions must be based even more on scientific facts,
- » when policies are put into action, the different economic, societal and environmental realities within Europe have to be taken into account (no "one policy fits all 28"),
- » local (regional) levels in directing the funds might be needed, but balance should be considered for potential problems working at this level in different regions of Europe.
- » differentiate communication on regional, national or international levels, e.g. communication to farmers = local dissemination, communication to consumers = multiple levels and addressees (define who is "the" consumer)

5.2 Topic 2: Identification of needs and challenges of different stakeholders including policies

In a best case scenario, all stakeholders in a particular area are identified, and common ground is well established between different initiatives so that they can work together on achieving a specific aim, in this case "breeding for GHG mitigation". This session was meant to explore from the perspective of different stakeholders:

- » What is expected from specific novel breeding techniques in the livestock sector?
- » What or where are the possibilities for public-private research?
- » What are the near and far future expectations for phenotyping/genotyping and novel breeding techniques in the livestock sector in relation to the EU legal/policy framework?
- » Could the potential for adaptation and mitigation to climate change in the livestock sector be also associated to conservational or rural development issues?
- » To address the role of FACCE/SusAn: what kind of action is needed to address the identified questions (e.g. exploratory action, workshop, policy brief, etc.)?

Research on Climate Change (CC) adaptation/mitigation: there is a need of new phenotypes to determine the impact of CC and identify resistant genotypes as currently recorded data is mostly based just on animal production and food efficiency. Besides, CC is not just a cow being heat stressed, as it entails new challenges for the whole production system. For instance, the area of distribution of vectors for various animal diseases is expanding, posing a novel risk for farming. To address CC, the system must be seen as a whole; as an example, the transport of raw materials such as soy from third countries (mostly South America) to produce animal food, generates a carbon footprint that probably

outweighs that produced by the animal production per se. Other topics discussed were genetic selection towards protein efficiency in pigs, the need for easier calls (i.e. with less requirements) by ERA-NETs, and the importance of local breed preservation as their associated genetic resources are also valuable tools to adapt the production systems to CC.

In relation to phenotyping, there was a common consensus about the need to standardize phenotype measurement, as currently different countries produce non-compatible data, which impairs to join them in a common recording/analysis effort. That occurs on different phenotypes, but specially focussed on CC, methane emission is recorded by very diverse ways or inferred by proxies. There is a gold standard (incubation chamber), but other alternative methods allow in-farm analysis. In this sense, a comparison between different methods and correlation between different proxies and actual methane emission is needed. A similar problem derives from the private sector being reluctant to share their data: an anonymous data repository for these projects could help to open the access to those data.

Finally, in relation to New Breeding Techniques, particularly genome editing, the common consensus of researchers and stakeholders is to **not close the door to those techniques as: 1) they are being approved outside EU, and 2), there is no way to detect a genome edited animal from one carrying the same allele produced by conventional breeding**.

Good communication to the consumer is crucial for acceptance of these technologies. In the same line, genome editions aimed to confer disease resistance, improve animal welfare or **even farmer welfare are more likely to be accepted than those focussed on improving productive traits.** Intellectual property of genome editions was also discussed, highlighting that this kind of protection would be negative for the sector as it will impair innovation.

5.3 Topic 3: Identification of existing initiatives, actions and organizations in Europe and the major stakeholders acting in the field

ERA-NETS and JPIs contribute to developing the European Research Area (ERA) integrating the scientific resources of the European Union (EU) and its Members States, using synergies and avoiding duplication of research efforts. In order to achieve this aim, an overview of the main players in a specific research domain is important. In this breakout session the participants were asked:

- to name the most important initiatives,
- which (research) questions are already addressed by which initiative,
- what kind of synergies could be used in collaborating towards the common goal of mitigation of GHG,
- the possible role FACCE-JPI and ERA-NET SusAn could play in this context and
- what kind of actions are needed to address the identified questions (e.g. exploratory action, workshop, communication and dissemination activity, etc.).

The groups identified breeding organisations, biotech companies and umbrella organisations on European and international level e.g. the Global Research Alliance (GRA) and the Food and Agriculture Organisation of the United Nations (FAO) as relevant initiatives. However:

- there is no overview of existing initiatives at the European level, let alone a comprehensive list,
- relevant players are known but are not or cannot be prioritised,
- more involvement could come from consumer and farmer organisations, technology platforms and organisations involved in big data.

The groups felt they have a good overview of initiatives and collaboration potential in their immediate environment, and connections mainly to organisations that are either involved in research themselves or which profit from uptake of results directly, or vice-versa, profit from input to the projects. Connections “outside the ordinary” may still work on the national level, but engagement with e.g. policy makers or end-users and consumers, even more so at the European level, where there is no obvious connection or benefit of involvement, is difficult.

The discussions revealed that the overview of existing initiatives in the field is only the first step that leads to successful communication and/or exploitation of research outcomes.

The following critical points were mentioned from the research projects' point of view:

» The obligation in ERA-NETs or EU funded projects to develop and carry out extensive communication, dissemination and exploitations plans, impact assessment and the multi-actor approach e.g. by stakeholder involvement, was considered unproductive in some respects:

> There seem to be ever more deliverables ideally to cover a research topic from basic research to final application in the field which clearly contrasts with the three year project duration.
> It does not make sense for all projects to communicate results along the whole "information chain – from local end-user to international policy makers" but communication must be targeted.
> Impact assessment of the projects results is another challenge: three years can be too short for researchers to e.g. bring a product to market, but too long for stakeholders or farmers who expect short-term solutions for specific problems.
> It was felt that obligations, mainly concerning communication and stakeholder involvement, diverted efforts from the research in question.
> The input: benefit ratio seems lopsided, i.e. a lot of effort is put into the "extra" work with little to no scientific reward. Also, it seems unclear how the outcomes are processed after the projects ends. An intermediate between research and the next level, especially when the connection is not obvious to the projects but seems relevant for the Funding Parties, could be a solution. It is really the job of the funding organisations to pick up the results and use them for their purposes.
> There is a difference between involvement from the research project perspective and the ERA-NET perspective: it may be worth to share good connections rather than establish them at all levels.

» The "informed public" is not defined:

> who is "the consumer",
> how do you link the breeding topic to "the consumer",
> transparency of animal production in general ("breeding = GMO") – who is doing that, who is responsible.

» The language barrier: results developed in European projects are mostly in English. Though it is fairly well established as a foreign language, results may not be picked up by the general public or the consumer or at the farm level.
» There are no communication experts involved in the projects. Instead, communication is mostly done by researchers with another scientific background, and they have learn who to do it as they address this task.
» Targeted communication:

> flexibility is essential when presenting results – e.g. which audience (research or policy or consumer).
> differentiate between communication - dissemination - exploitation
> differentiate basic research (e.g. lab) from applied science.
> differentiate between push ("broadcast" = sender is in control, determining who receives the information, how and when) and pull ("self-service information" open and convenient access to information, accessible by a recipient on his terms)
> select appropriate communication channels (social media, website, mailing, etc.).

6. Conclusions

The following conclusions are drawn from the above sessions as summarised above:

6.1 Research gaps

The systems approach became evident in the discussion.

Research gaps were mainly related to **phenotyping** which in comparison to genotyping is still much more complicated and expensive. The following topics could be taken into consideration:

» development of future livestock scenarios to define the phenotypes needed to perform best, including GHG mitigation and adaptation,
» definition of relevant, new traits / phenotypes of interest in future scenarios, e.g. CH4 per kg of milk and meat, dry matter intake, etc.,
» differentiate new traits of interest according species - N more important for monogastrics, CH4 and N (NH3…) for ruminants,
» define the new traits of interest for GHG mitigation or adaptation based on information from different disciplines, e.g. concerning feed efficiency,
» multidisciplinary approach and/or interdisciplinary teams / networks to evaluate what can be measured, and thus, be used to define new traits,
» better understanding of the underlying mechanisms to make selection on the right direction,
» new research to know the biological significance of a physical signal,
» adaptation to climate change:

> monogastric problem with climate change = more competition with human food
> local breed preservation / genetic resources : identify breeds adapted to e.g. hot climate and/or relevant traits and associated genes for future use in other breeds

» consider trade-offs (or at least the interactions between different performances, factors):

- trade-off between CH4 and NO2 at system level
- trade-off efficiency and resilience (animal, system level)
- trade-off between GHG mitigation and biodiversity
- etc.

» tackle the trade-offs at different levels: microbiome - organ – animal – herd – farm – sector / landscape etc.

In order to advance with phenotyping, the relevant **technology** and **data collection** needs further improvement:

» reference data and proxy for any phenotype which may lead to on-farm phenotyping (macroscopic view)
» proxy definitions

- for expensive/difficult traits (ex “easy to manage”) –
- to change scale of observation by a factor 100 / 1,000
- correlation between different proxies and actual methane emission

» digital technologies as breakthrough technology in this area : new gaps,
» there is need to either develop new sensors, or apply already existing new sensor methodologies (e.g. NIR as presented in this workshop). With the sensors generating more data than ever, ways to analyze them through big data techniques or machine learning algorithms should also be explored. IP right challenges and big data questions such as data ownership, storage, sharing – also between different applications etc – need also to be addressed.

Further consideration in the field of **New Breeding Technologies** include:

» re-examine coherence of public policies and market needs,
» proof of concept / advantage for animal improvement before introducing these NBT,

» reconsider genetic improvement in the light of consumer acceptance: how to communicate the need for any additional technological application in a system which is criticised for animal welfare issues related to technological applications,
» management of polygenic traits.

6.2 Cooperation with other initiatives and communication and dissemination issues

The following topics could be taken into consideration:

» list and prioritise (European) initiatives
» exploration of funding options for thematic networks / hubs / platforms to facilitate communication, the exploitation of results and knowledge transfer at the ERA-NET level, and not so much at the project level.
» engage with stakeholders at an early stage to establish a long term relationship, best even before a call is launched

» explore funding options for one "synthesis project" in each call to avoid information loss. This "synthesis project" could collect results and take care of knowledge transfer from the research projects, identify the gaps and develop the basis for a follow-up call.
» develop targeted communication and dissemination strategies including:

> options to carry out communication and dissemination by experts outside the research projects,
> considering the language barrier and how to overcome associated communication barriers,
> exchange of success stories and best practice of (vertical) communication and stakeholder involvement.
> communication of progress in terms of GHG mitigation due to research funding

7. Further proceedings

FACCE-JPI becomes self-sustainable with more independence and a long-term perspective to continue working on research questions in the food and agriculture context and joint funding actions. The results from this exploratory workshop will be included in FACCE-JPIs Implementation Plan.

ERA-NET Cofund SusAn will take the recommendations regarding the research topics into consideration for the development of its **Common Strategic Research and Innovation Agenda**. The statements regarding stakeholder involvement and communication, dissemination and exploitation will be taken into consideration in the **updated communication and dissemination plan** and when working towards **collaboration with other initiatives**.

This report will be published as an outcome of this exploratory workshop and both initiatives, FACCE-JPI and ERA-NET SusAn may be in touch with participants in the future to follow-up.

Organization Core Team:

Pablo Gómez (FACCE/INIA), Babette Breuer (SusAn/BLE), Daniel Blanco (SusAn/INIA), Elena Rodriguez (SusAn/INIA)

On behalf of FACCE-JPI and ERA-NET Cofund SusAn, the organisation committee thanks all participants for their contribution in this exploratory workshop.

Annex 1: Agenda

FACCE-JPI & ERA-NET Cofund SusAn Joint Exploratory Workshop on
Phenotyping/Genotyping and Novel Breeding Techniques for adaptation and mitigation to Climate Change in the livestock sector

Brussels, 21 November 2019

VENUE: University Foundation (*link*) *Rue d'Egmont 11, Brussels* - How to reach it? (*link to map*)

9:30 - 10:00		**Welcome coffee & Registration**
10:00 - 10:15	**10'**	**INTRODUCTION** **Welcome, introduction to FACCE/SusAn** *Hartmut Stalb (FACCE-JPI Chair) / Babette Breuer (ERA-NET SusAn Coordination Team)*
	5'	**Introduction and aims of the workshop** *Pablo Gómez Grande (INIA/FACCE-JPI Secretariat)*
10:15 - 11:15		**RESEARCH PERSPECTIVE**
	15'	**Setting the Scene: Future of livestock research in a global perspective** *Jean Louis Peyraud (INRA)*
	15'	**Milk infrared based tools as an example how phenotyping can contribute to climate smart breeding** *Nicolas Gengler (ULiege-GxABT)*
	15'	**Molecular phenotyping illuminates the pig genome for the development of new breeding strategies** *Luca Fontanesi (University of Bologna)*
	15'	Q&A
11:15 - 12:00		**STAKEHOLDERS & END USERS PERSPECTIVE**
	15'	**Needs, solutions and perspective from the EU breeding sector** *Ana Granados Chapatte (EFFAB/ FABRE-TP)*
	20'	**Producer's perspective : Europe cannot miss the innovation train again** *José María Castilla Baró (ASAJA)*
	10'	Q&A
12:00 - 12:15		**POLICY PERSPECTIVE**
	10'	**Policy Perspective Presentation** *Frank Swartenbroux (DG SANTE Unit E3 – Biotechnology)*
	5'	Q&A
12:15 - 13:15	**60'**	**Lunch**
13:15 - 15:00	**105'**	**BREAKOUT SESSIONS** **NBT contribution to more resilient livestock systems** **Gaps, needs, potential and priorities** Work in Groups
15:00 - 15:30	**30'**	**Coffee break**
15:30 - 16:15	**45'**	**PRESENTATION OF DISCUSSION RESULTS** **Gaps, needs, potential and priorities** Plenary
16:15 - 16:45	**30'**	**WRAP UP** **Prioritize needs / requirements** Plenary
16:45		**End of the workshop**

Event Organised by FACCE-JPI and ERA-NET SusAn and coordinated by INIA. Organiser Contact: pablo.gomez@inia.es

Annex 2: List of Participants

Last Name	Name	Organisation	Country
Altay **	Mahur	TUBITAK	Turkey
Bengtsson	Christian	VikingGenetics	Sweden
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Breuer *	Babette	BLE	Germany
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Castilla Baró	José María	ASAJA	Spain
Cobo Gonzalez	Concepcion	EC DG SANTE	Belgium
de Koning	Dirk Jan	SLU	Sweden
De la Figuera	Ramón	Perm rep of Spain in EU	Spain
Dorigo	Martina	AHDB	UK
Fontanesi	Luca	University of Bologna (UNIBO)	Italy
Garcia	Aser	Neiker	Spain
Gengler	Nicolas	ULiege-GxABT	Belgium
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Acknowledgment: Thanks to the organization committee members (*) and contributors (**), including rapporteurs and moderators.