# EuroDairy

## A collation of topics for future R&D

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## About EuroDairy

EuroDairy spans 14 countries, from Ireland to Poland, and from Sweden to Italy, encompassing 40% of dairy farmers, 45% of cows and 60% of European milk output. EuroDairy is an international network to increase the economic, social and environmental sustainability of dairy farming in Europe. EuroDairy fosters the development and dissemination of practice-based innovation in dairy farming, targeting key sustainability issues: socio economic resilience, resource efficiency, animal care, and the integration of milk production with biodiversity objectives.
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# Contents

# 1. Summary of deliverable

This report summarises collates research needs and opportunities captured during the course of the project. It draws from feedback obtained during workshops, farm biodiversity audits, farmer exchange visits and Operational Group interactions. This has involved farmers, but also on occasion stakeholders from policy, research, dairy supply chains and industry development bodies.

Topics are collated below under the four EuroDairy themes of Animal Care, Resource Efficiency, Biodiversity and Socio-economic resilience.

# 2.0 Animal Care

## 2.1 Welfare & welfare assessment

- Develop progressive welfare standards that are user-friendly, and fit for purpose
- Harmonize practical welfare protocols and standards
- Develop quantitative risk assessment methodologies, using animal based measures
- Define appropriate national hazard levels for welfare outcome measures (e.g. Targets for cattle sound on their feet should be greater than 95%)
- Develop business models conducive to improvements in animal welfare, such that benefits of using welfare assessment are evident, and accrue to the whole supply chain, including farmers
- Greater collation of data, to demonstrate and communicate welfare trends on farm
- Develop and deploy benchmarking tools so farmers can evaluate their performance on welfare measures against their peers

## 2.2 Positive welfare

Historically, much of welfare science has focused on the negative experiences of animals impacting on their welfare. Positive farm animal welfare is a relatively new concept, which focusses more attention on animals having a good life. Positive farm animal welfare is aligned with public opinion, and is supported by science. However, to become a more central feature in livestock farming, it must also benefit farmers and consumers. An evidence-based framework of positive welfare indicators in dairy cattle should be developed. Industry itself is already taking some steps in this direction, for example, ZuivelNL is cofunding a four-year research project looking for biomarkers of mood (positive welfare/happiness) in dairy cows.

## 2.3 Young stock welfare

Improved survival, growth rate and reduced risk of illness and poor welfare of young stock should be considered a priority. Topics identified for research and development include:

- Design practical on-farm welfare assessment protocols for dairy calves
- An evidence base for the development of advisory tools for young stock health and welfare risk management e.g. KalfOK in the Netherlands
- Investigating the impact of duration of cow-calf contact, on biological and behavioural functioning, health, productivity and economics
- Investigating the impact of different social grouping and accommodation type, on productivity, behaviour and welfare of pre-weaned calves
- Exploring the effectiveness of using Non-Steroidal Anti-inflammatory Drugs (NSAID's) with and without antibiotic use, as a treatment for calves with respiratory disease
- Improving the uptake of anaesthetic, and pain relief, during disbudding of calves

## 2.4. General health & disease

Further research in these areas would improve understanding of important disease issued and facilitate more focussed control:

- Lameness is one of the main reasons for culling in dairy cows, and is a significant contributor to other cases of culling, such as infertility. There are several gaps in knowledge around lameness, in terms the aetiology of claw horn lesions, role of the digital cushion, effect of NSAIDs and transmission of digital dermatitis on farm
- Developing a safe and effective vaccine for digital dermatitis control
- Exploring use of NSAID's for treatment of a variety of disease conditions e.g. lameness, mastitis (and respiratory disease, as above)
- Strengthening the evidence base for development of advisory tools for endemic diseases, which affect welfare, e.g. Mastitis Control Plan and Healthy Feet Programme in the UK. To underpin knowledge exchange, it is important to continue to publish the evidence base for the efficacy of interventions in scientific journals
- Developing activity campaigns to increase understanding of biosecurity principles, hygiene and disinfection amongst farmers. There are excellent examples within the pig and poultry sectors, which could be explored
- Stimulating cooperation between farmers and vets, which lead to more preventive, and less curative, approaches to disease control.

## 2.5 Mycoplasma bovis

Throughout the EuroDairy project, the challenges facing farmers in the management and control of *Mycoplasma bovis* was raised on several occasions. This disease has severe animal welfare consequences. There are a number of key gaps in our understanding of the disease:

- Identifying the strain type and establishing the prevalence of *Mycoplasma bovis* in European countries. We have a poor understanding of the national herd prevalence of *M. bovis*, lack full confidence in the identification of negative herds, and the range of disease presentations associated with presence of the organism in a herd. This knowledge is crucial to improve biosecurity screening, and disease eradication programmes.
- Exploring the impact the presence of the different strains of *M.bovis* has on productivity and economics.
- Development of a safe and effective commercial vaccine across the range of disease manifestations
- Improving awareness of *M. bovis* within the veterinary and dairy farmer communities. As there are many unanswered questions, even amongst experts, an international workshop should be considered, ensuring farmer experiences are also incorporated together with national and international experts. The objective would be to exchange knowledge, identify knowledge gaps, and produce recommendations/guidelines to prevent and combat M*ycoplasma bovis* at farm level

## 2.6 Data & accurate detection using precision technology

- Further research on developing objective precision technology to measure aspects of welfare (e.g. infrared and 3d sensors to detect early warning of lameness)
- Recent advances in sensing technology creates extra opportunities to monitor individual animals in group-housing systems not only with the aim to detect health problems sooner, but also as a predictor of interactions and future behaviours.
- Greater centralisation of databases where information on welfare assessment, sources of information and relevant documents can be stored and shared with farmers. This process should allow farmers to benchmark themselves against others

## 2.7 Future proofing housing and infrastructure

- Improving and future-proofing housing design, to optimise animal care, welfare, health, behaviour and productivity
- Identifying and testing alternative bedding sources on their suitability for cattle bedding. There is a current lack of sustainable, economical and sustainable bedding materials for both calves and adult cattle. Straw availability and price was a major issue in 2018/19 in some EU countries, and has negative implications on calf health & welfare.
- Assessing the impact of space allowances on cow productivity, welfare and behaviour

- Assessing the impact of housing design on manure quality and gaseous emissions. Depending on the bedding materials used, and whether urine and faeces are separated, the manure produced can have higher value for soil fertility, and result in lower emissions of ammonia and GHG. Assessments should take a whole system approach to minimising gaseous losses.

## 2.8 Responsible antibiotic usage on farm

- Developing benchmarks for responsible antibiotic use in young stock. This is currently hampered by the availability of varying systems
- Developing educational strategies to drive a reduction of prophylactic use of antibiotics
- Increasing vaccine usage for endemic disease
- Exploring the relationship between disease identification (e.g. lung lesions) at slaughter, in relation to antibiotic treatment records
- Exploring opportunities to improve early diagnosis, as well as the use of different treatments e.g. NSAID's instead of antibiotics
- Conducting research to identify and remove antibiotic compounds from waste milk, in order to reduce the risk of antimicrobial resistance developing in the environment. Waste milk must not be fed to calves, but it is unclear how farmers are safely to dispose of it.

## 2.9 Welfare labelling

Lobby groups are pressurising some Governments to direct more agricultural support towards public goods, such as higher standards of animal welfare and food safety. In addition, there are calls for mandatory labelling of meat and dairy products to indicate system of production. Industry are generally resistant to this, and currently are nervous of engaging in the dialogue. Any labelling should be evidence based, which requires further research funding.

- Explore how labelling on welfare outcomes, could be a more sensible measure to enhance transparency.

## 2.10 Training

The key driver of enhanced animal welfare is access to a skilled farm work force. Skilled labour is already scarce in many EU countries, and availability of good stock people can directly affect animal welfare. Areas for consideration are:

- Making information and resources more accessible, via different languages or sub-titled digital media
- Training to enhance stockmanship skills within different production systems, and on topics such as on-farm euthanasia and transport
- Greater help for dairy producers to understand current welfare legislation, be compliant and implement changes that improve welfare

## 2.11 Changing veterinary landscape and implications on animal care

In many countries, the veterinary community is going through a time of unprecedented change. Challenges facing the veterinary profession include recruitment and retention (particularly in large animal practice), consolidation and corporatisation of veterinary practices, selling consultancy to clients as opposed to relying on selling drug to drive revenue. This can also have an impact on centralised surveillance, as the corporate veterinary practices are moving to using private rather than state diagnostic laboratories. Good animal welfare relies on access to sound veterinary advice, tailored to the particular farm.

- Explore how delivery infrastructure, practice business models and training provision for young vets can be developed to service future health and welfare needs of the industry.

## 2.12 Knowledge exchange

- Identifying key levers to support behaviour change on farm through social science
- Creating international networks of high performing farmers, to gain and share insight into individual farm businesses. e.g. a network for welfare, based on two high performing dairy farmers (based on existing tools, like “Ask the Cow”(S), Welfare monitor (NL) and Red Tractor (UK)) per country, together with researchers/advisors, and a similar network for low antibiotic use. As the sharing of experiences should not be limited to the participating farmers, these farmers should also participate in national networks.
- Facilitating and stimulating countries to share experiences on national approaches, and tools to improve animal health
- Stimulating industry to go beyond the legal requirement, such as, recognition of animal care quality labels.
- Exploring wider and more effective use of tools such as webinars, which have considerable potential for international dissemination. Though EuroDairy organized farmer-oriented webinars with interesting and internationally renowned experts, the number of farmers participating was somewhat disappointing, especially farmers outside the UK. Probably language is one of the limiting factor. It could be useful to find out more why more farmers did not participate.

## 2.13 Communications

The dairy industry needs to continue to communicate proactively, in two-way dialogue with consumers and wider society, and in a more creative way, that is not perceived as defensive.

A responsible livestock farming industry is one that acknowledges its weaknesses, consumer concerns and pledges its duty of care to animals by striving for the highest standards of animal welfare, while respecting local communities and the need for good environmental stewardship. In order to achieve this, the evidence required to influence and combat negative social media campaigns and accusations from activist groups is required. There are models that currently exist in Canada and the USA e.g. http://www.foodintegrity.ca/.There are opportunities for EU countries to engage and potentially adopt the Food Integrity framework. Social acceptability of innovative solutions to some of the problems faced by livestock farming need to be carefully managed and communicated (e.g. genomics, gene editing, GMO). The Food Integrity model could provide the communication mechanism to consumers ensuring transparency and consistency of message.

Communication alone is not the solution. A successful strategy must recognise that operational practices and decisions have to be able to stand scrutiny of the ‘reasonableness’ test. The expectation is that farmers and others in the supply chain will do the ‘right’ thing and in return, the public freely give their trust. Many things influence consumer behaviour but emotion often over-rules logic. Government and industry need to work together to build better engagement by empowering key influencers through models such as Food Integrity.

- Develop a strategic vision focusing on ‘tackling transparency’ to help reassure consumers and those in the food chain delivering products consumers

# 3. Resource Efficiency

## 3.1 Feed and nutrient wastage in dairy farming

- **Key question**: How can we measure and monitor feed/nutrient wastage on a dairy farm?
- **Research gap**: There is a good availability of literature reporting the estimated losses from harvest to feed out, with general recommendations based on good practice for each phase. Each farm will have its own critical points and room for improvement, so the key is to invest in new technologies and innovations that can help measuring the amount of wastage and identifying the critical areas.
- **Time frame**: (medium-long-term)
- **Recommendation for future research directions**: New or improved technologies and innovations at the feed bunk, silage clamps and harvesters (i.e. sensors, innovative materials, analysers)

## 3.2 Dairy cow fibre intake

- **Key question**: How can we optimise the fibre intake of the dairy cow?
- **Research gap**: The role of fibre in ruminants and especially dairy cows has been studied for decades and new knowledge has been progressively added. On a practical perspective, though, we are still unclear about how to optimise the intake of fibre and its digestibility to maintain efficiency, health and productivity.
- **Time frame**: (medium - long-term)
- **Recommendation for future research directions**: New technologies to more precisely describe the physical and chemical characteristics of the fibre/feed (i.e. visual imaging), the interrelations with the other dietary components, and the role of gut microbiome

## 3.3 Grasslands N fertilization

- **Key question**: How can we improve precision of nitrogen fertilization of grasslands?
- **Research gap**: Grasslands are important carbon and nitrogen sinks but there is a lack of knowledge how to manage the nitrogen fertilization of various grasslands to maximize yields of dry matter, protein and energy while minimizing nitrogen losses and cutting costs.
- **Time frame**: (medium - long-term)
- **Recommendation for future research directions**: New methods of nitrogen fertilization applications and new technologies to monitor precisely dry matter yields, crude protein and energy contents of both short and long-term grasslands containing mixtures of grasses, legumes and/or herbs or monocultures of grasses.

## 3.4 Forage digestibility evaluation

- **Key question**: How can we, with cheap and simple methods, determine digestibility of forages?
- **Research gap**: The key for high productivity of dairy cows is highly digestible forages, of which fibre digestibility is the most crucial one as it limits energy intake of dairy cows. Moreover, fibre digestibility of forages varies greatly with maturity stage of the forage at harvest. However, the costs for fibre digestibility analyses are expensive and laborious. Therefore, we need to find quick and inexpensive methods to monitor the variations in fibre digestibility of forages.

- **Time frame**: (medium - long-term)
- **Recommendation for future research directions**: To find quick and inexpensive methods to monitor the variations in fibre digestibility of forages.

## 3.5 Evaluation of nutrient performance on dairy farms

- **Key question**: How to harmonize the calculation of the nutrient performance (nutrient cycle) in dairy farming systems in Europe?
- **Research gap**: Several approaches to quantifying nutrient management performance have made it possible to compare results between regions in EU. Not only focus on the nutrient balance of a farm or nutrient efficiency of a farm, but also the performance of the internal nutrient cycle on a dairy farm (herd, manure, soil/crop) is needed. Animal-soil-plant interactions are needed to provide better understanding of nutrient performance on dairy farms, and give farmers information on strong and weak points on a farm.
- **Time frame**: (medium/long-term)
- **Recommendation for future research directions**: Evaluate the different methods used in nutrient cycling assessment on dairy farms.

## 3.6 Benchmarking nutrient performance in different dairy farming systems

- **Key question**: How to benchmark nutrient performance on dairy farming systems in Europe, taking into account the local conditions?
- **Research gap**: Within Europe there is a huge diversity in dairy farming systems, and conditions (infrastructure, weather conditions, soil fertility, legislation, knowledge). To investigate the improvements which can be made on dairy farms, benchmarking which can take into account the local conditions is very important,
- **Time frame**: (short-term)
- **Recommendation for future research directions**: Setup benchmark values for nutrient performance on dairy farms, taking into account the local conditions (regions, legislation, etc.).

## 3.6 Investigate the scope for improvement in resource use efficiency in dairy farming systems

- **Key question**: What is the scope of improvements in the nutrient performance in dairy farming systems in Europe, taking into account the local conditions?
- **Research gap**: The improvements which can be made on dairy farms are dependent on options and constraints related to local conditions (infrastructure, weather conditions, and soil fertility) and legislation.
- **Time frame**: (medium long-term)
- **Recommendation for future research directions**: Evaluate the nutrient performance of dairy farming systems using national statistics, and investigate the scope of improvement in nutrient performance taking into account benchmarking values (for each type of dairy farming system)

## 3.7 Improve knowledge of fertilizer and carbon sequestration potential of slurry applied to soil

- **Key question:** Application of slurry to land can increase the carbon sequestration capacity of soils and have indirect effects on soil physical and chemical properties. It can also reduce the use of mineral fertilizers, which in turn reduces the $N_2O$ and $CO_2$ emissions associated with the production, use and transportation of these fertilizers. What is the magnitude of these effects in practice, and can they be managed to advantage.
- **Research gap:** To improve the characterization and management of dairy cattle slurry, by considering the entire chain involving the generation, storage and application on pasture/forage/crop land. The objective is to identify and introduce measures to optimize nutrient recycling inside the farms. ; To improve production and reduce costs, mitigate emissions of greenhouse gases (GHG) ($N_2O$, $CH_4$ and $CO_2$) and of ammonia ($NH_3$) and finally to improve the environmental sustainability of the system by increasing carbon sequestration in the soil and improving the soil chemical properties.
- **Time frame:** medium / long term
- **Recommendation for future research directions:** Evaluate the fertilizer potential of slurry/manure in relation to the type of farm (feeding, manure management, type of storage, and receiving crops in the farm). Identify, via experimentation and modelling, the best techniques that will lead to economic and environmental sustainability of the farm systems. Study in the medium-long term the effect of the type of fertilizer: Cattle slurry vs. mineral and the application technique of the slurry in the potential sequestration of C in the soil under forage crops.

## 3.8 Improve knowledge of the environmental role of legumes in forage rotations

- **Key question**: How can the use of legumes be optimized, particular when maize is grown for forage production
- **Research gap**: While the use of legumes in grassland mixtures is quite well documented, the effects of introducing legumes in forage rotations with maize on soil carbon sequestration, GHG emissions and supply of N to the following crops must be further investigated in order to define more sustainable dairy systems. This Issue proves to be even more important when there is a gradual change across Europe to cultural systems where maize silage predominates.
- **Time frame**: (medium / long-term)
- **Recommendation for future research directions**: To optimize the use of legumes in grassland meadows or maize rotations in order to increase yield of forage production, decrease the use of synthetic fertilizers and improve dairy system sustainability.

## 3.9 Common methodologies for carbon footprint determination in dairy farming systems

- **Key question**: How to harmonize the calculation on carbon footprint in dairy farming systems in Europe
- Research gap:
- **Time frame**: (short-term/long-term)
- Recommendation for future research directions:

## 3.10 Effect of new technologies on ammonia & GHG emissions

- **Key question:** How to evaluate the impact of the implementation of new technologies on the nitrogen and carbon cycles of the dairy systems?
- **Research gap**: New technologies introduced for the main purpose of reducing costs or improving efficiency and animal welfare can affect, directly or indirectly, on gaseous emissions. For example, compost barn techniques or the use of water sprays and ventilation fans to relieve thermal stress, can have important effects on ammonia and GHG emissions, which are necessary to investigate in more detail.
- **Time frame**: medium-term
- **Recommendation for future research directions**: Ammonia and GHG emissions and overall effects on nutrient cycling should be investigated in an integrated way, when new techniques and practices are implemented on dairy farms, because of the risk of pollution swapping or decrease of nutrient use efficiency.

## 3.11 Harmonising feed efficiency measures and definitions

- **Key question**: How to harmonize the definition of feed efficiency and its components?
- **Research gap**: several definitions of feed efficiency can be found in the literature, but it is not always clear which one is the best to use in different circumstances.
- **Time frame**: (medium-long term)
- **Recommendation for future research directions**: To evaluate the applicability of the different available measures to best fit the purpose in specific conditions (i.e. feeding groups, lactation phases, heifers vs dry vs lactating) and to reach a general consensus

## 3.12 Reliably estimating enteric methane emissions in different feeding systems

- **Key question**: How to derive reliable estimations of enteric methane-emissions in different feeding systems
- **Research gap**: Enteric methane-emissions are the main contributor to GHG-emission in dairy production. Calculations of the product carbon-footprint for milk are mainly influenced by enteric methane-production, which are derived from simple equations based on feed fibre content. How reliable are these derived values compared to real measured values? How comparable are enteric methane-emissions derived with different methods (e.g. controlled environment or SF6-based measurement). How reliable is the prediction of enteric methane emission with milk FTIR or NIR–based milk fatty acid profiles?
- **Time frame**: (medium/long-term)

- **Recommendation for future research directions**: For the production and marketing of climatic friendly milk, it is important to count on reliable methods for GHG-emissions. New technologies such as prediction of enteric methane emission with milk FTIR or NIR–based milk fatty acid profiles offer the possibility to derive farm specific product-carbon footprints and to better control it in contract periods. Before application, it is important to test the reliability of alternative methods.

## 3.13 Potential of intercropping as cheap and environmental beneficial forages

- **Key question**: Can intercrops act as cheap forage sources with positive contributions to the environment at the same time?
- **Research gap**: Catch crops are widely used to avoid soil erosion and nitrate leaching to ground water, and to increase soil fertility by adding organic matter. Species such as Westerwold ryegrass, forage rape, fodder kale and vetches allow intercropping for forage harvesting or grazing and are considered as very cheap forage, while offering the beneficial environmental effects of traditional catch crops. So far, research on intercrops mainly has focused on environmental aspects, too little knowledge is available about yield potential and forage quality of different species in different regions of Europe.
- **Time frame**: (medium - long-term)
- **Recommendation for future research directions**: Evaluation of intercrops as a multipurpose tool, combining cheap high-quality forage with reduced losses of plant nutrients, and positive contributions to biodiversity and soil fertility.

## 3.14 Mixed farming, and virtual mixed farming, in a collaboration involving different farm types

- **Key question**: What is the potential of mixed farming and cooperation between specialised dairy and specialised all-arable farms with the aim to increase resilience?
- **Research gap**: Recent intensification in European agricultural production has been followed by serious environmental trade-offs, questioning sustainability of current specialised production systems, for both arable crops and animal products. Mixed crop-livestock farming is considered as a strategy to enhance sustainability. Virtual mixed farming, cooperation between specialised dairy and specialised all-arable farms, can be seen as strategy to solve problems like e.g. nitrogen and phosphorous surplus on intensive livestock farms and upcoming problems of herbicide resistant weeds in all arable farms. There is too little knowledge available on the potential environmental effects and consequences on farm economics.
- **Time frame**: (medium - long-term)
- **Recommendation for future research directions**: Evaluation of reintroduction of mixed farming elements to specialised farms, or virtual mixed farming, as a collaboration between different farms. Aiming to solve negative environmental effects and to capture potential positive yield effects, in both forage and cash crops when being grown in extended crop rotations.

## 3.15 Evaluation of environmental performance of European Dairy production to support exports to other countries

- **Key question**: How well does milk produced in the European Union perform, with respect to environmental footprint and Farm Animal Welfare compared to milk produced in other regions of the world?
- **Research gap**: There is an increasing demand for dairy products in the world. Increased welfare in Eastern Asia also leads to increasing requests for environmentally responsible milk products, often combined with requests for dairy products with a guarantee of high animal welfare. Too little information is available of how European dairy production performs with respect to environmental effects, and animal welfare compared to other main milk producing regions of the world.
- **Time frame**: (medium - long-term)
- **Recommendation for future research directions**: Evaluate the performance of European dairy production with respect to environmental footprint and farm animal welfare compared to milk production in other regions of the world, in order to secure export of European high value dairy products.

## 3.16 Potential of multispecies mixtures for sustainable forage production

- **Key question**: What kind of contribution to resilience of forage production can be made through integration of herbal forage plants and secondary legumes?
- **Research gap**: Herbal forage plants like: plantain, chicory, sheep's burnet, caraway and the secondary legume birdsfoot trefoil, are rich in positive secondary plant compounds, vitamins and minerals. Due to high palatability, they help to enhance forage intake. They are deep rooting and can increase water-use and plant nutrient-use efficiency, contributing positively to soil fertility. Multispecies mixtures make an active contribution to biodiversity. Mainly research has been carried out with single species, too little is known about yield and forage quality potential of mixed swards, for both low- and high input dairy farming systems in different regions of Europe.
- **Time frame**: (medium - long-term)
- **Recommendation for future research directions**: Evaluation of multispecies mixtures as tools to combine high-quality forage production with drought resistance and biodiversity.

# 4.0 Biodiversity

## 4.1 Metrics

Well-developed standard metrics are available for GHGs and water use efficiency, but not yet for biodiversity. Assessing biodiversity directly can be problematic – which species or indicator to measure, a full on-the-ground audit is expensive and time consuming. For this reason, it is necessary to develop assessment methods and metrics that are comparable, robust, easy to use and credible.

The Biotex tool is an intermediate approach to addressing these challenges, assessing features on the farm which are known to have a positive impact on biodiversity, and drawing comparison with priorities for biodiversity in that locality.

However, consideration of biodiversity impacts beyond the farm gate are not taken into account. Adding impacts beyond the farm gate could significantly alter the wider biodiversity performance of different production systems. Another limit is that a 'one size fits all' tool doesn't always work for biodiversity, as demonstrated by the Finnish farm assessments, which didn't account for specific northern climatic influences and farm circumstances.

Technology has the opportunity to offer future solutions, including assessment of biodiversity at a national scale. Aerial imagery is capable of distinguishing habitat with an accuracy of 96%, and in identifying the type of habitat with an accuracy of around 80%. Once sufficient data has been processed, and validated on the ground, machine learning can be used to automate the process and to increase the level of accuracy. This would enable the extent, type and quality of habitat to be calculated for parcels of land, specific farms, geographic areas, supply chains and at national levels.

Recommendations

- There is a need to start measuring; otherwise, biodiversity will always be ignored in sustainability assessment, leading to wrong decisions. Aerial mapping can provide a lot of useful quantitative and qualitative information.
- Continue to improve and expand tools and techniques (including Lifecycle Analysis) that describe better the biodiversity impacts within, and beyond, the farm boundary.
- Development and refinement of remote measurement techniques to assess habitat presence and quality, adapted to the local context.
- Develop simple, comparable, metrics which can be applied at the farm level to describe baseline biodiversity potential, and to measure/direct future improvement
- Refine and improve the biodiversity tools like Biotex, in particular regarding specific local conditions. Test and develop the entire Biotex tool with its seven indicators at the EU level to capitalize on dairy farm practice that favours ordinary biodiversity.

## 4.2 Implementation

Gaps in current knowledge on biodiversity and barriers to implementation were identified, which might be addressed by further research, such as:-

- Demonstration projects which show the practical integration of biodiversity objectives into profitable production
- Better understanding of farmer attitudes to biodiversity, and from that, knowledge exchange needs
- More collective projects that bring together multiple stakeholders. Many practices that favour biodiversity need collective work and consequently more organisation at different scales, between farmers but also between farmers and municipalities, environmental and hunting associations, for example. The public actors have an important role to facilitate this collective work, and the main stakeholders in a region should be easily identified.
- Broaden the biodiversity issue and its topics: soil biodiversity, dairy breed diversity, the impact of livestock buildings etc. Develop research about the social, political and economic dimensions of the regional biodiversity in a region or locality.

# 5. Additional feedback from farmer exchange visits

From the feedback received from exchange visits participants (pilot farmers, operational group members, advisors and researchers), a list of potential topics requiring further research and knowledge exchange activity is set out below.

## 5.1 WP3 Resource efficiency

- Improving milk from forage
- Optimising grass utilisation to reduce dependence on purchased feed
- Re-establishing the use of pasture in an intensive system
- Grazing management for a large herd
- Improving grass production and maximising dry matter intake of fresh grass during grazing
- Breeding schemes to help improve utilization of grazed grass
- Seasonal calving with a greater focus on fertility and longevity
- Farm infrastructure improvements, to maximize grazing opportunities
- Adoption of useful decision support tools for grassland management
- The potential role of Jersey cows in a pasture-based system
- Integration of robotic systems within a pasture-based system
- Integration of arable and dairy enterprises
- Home-grown protein to improve self-sufficiency in terms of protein
    - Mixed species swards to improve productivity and robustness
    - Lucerne cropping techniques and best practice guide
    - Crop rotation systems for cereals, maize silage and lucerne
    - On-farm assessment to determine how improvement in protein self-sufficiency can be achieved
- Biogas plants as an option for farmers to help improve slurry management, and produce energy for farm use
- Reducing ammonia emissions, improving cow comfort and welfare through the use of high welfare floors.

## 5.2 WP4 Biodiversity

- Commercial vision and opportunities i.e. organic milk, GMO-free milk, to exploit biodiversity at a farm level.

## 5.3 WP5 Animal care

- Reducing the use of antimicrobials through benchmarking criteria, investigating the role of veterinarians/farmers, implementation at farm level
- Reducing the use of antibiotics before the dry period
- Herd health and comfort with an emphasis on reducing the need for antibiotics
- Crossbreeding to improve health, fertility and longevity
- Housing and bedding innovation and best practices including floor types, bedding systems etc.
- Standards of animal welfare in relation to building design to prevent lameness
- Further investigation into calving boxes and the idea of ‘cuddle boxes’ to keep calves with cows longer
- Deep bedding with sand or recycled manure, including management of biosecurity risks

- Precision technologies to improve cow health, comfort and welfare.

## 5.4 WP6 Socio economic resilience

- How to address social and environmental issues
- Public perception towards dairy farmers, the sector and large herds
- Resilience of the whole dairy sector, and adaption of the system to price volatility
- Effective tools and techniques of financial management
- Risk management and practical solutions in dealing with on-farm risk
- Adopting lean management onto large herds to improve workflow and organisation
- Organising training and knowledge transfer on-farm
- Monitoring and interpretation of economic figures and data on-farm
- Enhancing the attractiveness of dairy farming as a career
- System sustainability in relation to labour input, hours worked, quality of life, sustaining personal and family life
- Commercial vision and opportunities: organic milk, GMO-free milk
- Using innovation to add value and develop a closer connection with consumers
- Producing high-specification milk, including the use of regional/traditional breeds
- Adding value through on-farm processing of milk
- Breeding crosses to improve milk protein for cheese producing contracts
- Integration of biogas plants into milk production systems.

## 5.5 Cross cutting issues

- Test and demonstrate practical solutions to improve **the technical efficiency of the dairy production systems,** across a large variety of soil and climatic conditions in Europe, **namely:-**
    - improving protein self-sufficiency
    - the protein conversion rate in the feeding systems
    - limiting the competition between feed and food
    - GMO-free animal feeding systems.

- Test and demonstrate practical solutions to **improve animal welfare** and the image of the dairy sector
    - cow-calf separation
    - access of cows to pastures
    - fate of bull calves etc.

- Explore solutions, disseminate testimonies to demonstrate how to **improve transmission of knowledge and opportunities to young dairy farms entering the industry.**
    - Facilitate easier entry for young farmers
    - develop new business models

- Implement innovative methods to manage large herds with a big team of staff members.

- Test and demonstrate practical solutions **to implement low carbon footprint and low emissions dairy production systems.**
    - Farmers rarely listed these topics as an important issue and only questioned the regulations implemented in the different countries. It shows that they still lack information and technical practical solutions to improve mineral resource efficiency on-farms without endangering the resilience of dairy enterprises. This remains a major challenge for the dairy sector in coming years.

- Improve the use and valorization of the **digital tools and technologies** on farm
    - better use of collected data
    - development of easy-to-use indicators for farmers and advisers.

- Develop specific **regulation tools and solutions** for the whole dairy chain to limit risks related to **volatility** due to fluctuating milk prices.