# Farm-level in Pig Production

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Specialist systematically mapped the scientific literature on the sustainability of pig production at farm-level. Sustainability was considered holistically, i.e. economic, environmental, and social dimensions, each consisting of a broad range of different aspects that may contradict or reinforce each other. Literature published between January 2000 and March 2020 with a geographical focus on Europe, North America, Australia, and New Zealand was included. We found that papers analysing environmental sustainability were more frequent than papers analysing economic or social sustainability. However, there are many different aspects within each dimension of sustainability, hampering comparisons between studies.

These interrelations are not well understood and that possible trade-offs or synergies between different aspects of sustainability dimensions remain unidentified. This systematic mapping of the current literature on farm-level sustainability in pig production can support a more informed discussion on knowledge gaps and help prioritise future research at farm-level to enhance sustainability in pig production.

pork swine environment social economic animal welfare ecology

## 1. Results

The literature searches resulted in a total of 589 hits, of which 362 hits (61%) originated from CABI: Cab Abstracts, 106 hits (18%) originated from Scopus, and 121 (21%) hits originated from Web of Science Core Collection. Review papers, papers not written in English, and papers not referring to countries within the scope of this study were removed, leaving 36 papers that were included in the analysis. No reported studies conducted in Australia or New Zealand were found. The 36 selected papers were screened to ensure that they covered all three sustainability areas and belonged to the target geographical area.

On assessing the abstracts of the 36 papers, we found that only seven included key words that were associated with all three dimensions of sustainability (environmental, economic, and social). Seven abstracts included two dimensions (economic and social, environmental and social, and economic and environmental in one, three, and three papers, respectively) and one paper involved one of the dimensions (environmental). This left us with a total of 15 relevant papers (Figure 1), of which nine papers described empirical experiments. Table 2 summarises characteristics of the selected 15 papers with respect to (i) what indicators of each sustainability dimension have been used, (ii) under what wider label indicators under each sustainability dimension can be grouped to facilitate comparison, and (iii) number of papers that have investigated sustainability under each label.

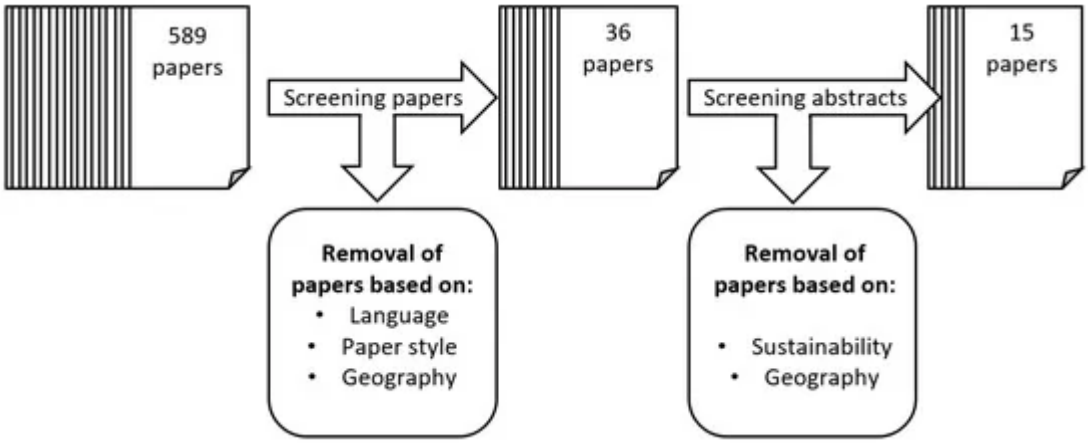


**Figure 1.** A schematic picture of the selection process of papers included in the systematic mapping.

**Table 2.** Indicators of environmental, economic, and social sustainability and research methods used in the selected papers (*n* = 15), and number of times each summarised category was used in these papers.

| Economic Dimension | Summarised Economic | Number of Papers | Environmental Dimension | Summarised Environmental | Number of Papers [1] | Social Dimension | Summarised Social | Number of Papers |
|---|---|---|---|---|---|---|---|---|
| Economic viability | | | Climate change | | | Animal welfare | | |
| Net farm income | Firm economic viability | 4 | Acidification | LCA based | 5 | Animal health | | |
| Income generation | | | Land occupation | | | Use of antibiotics | Animal health and welfare | 8 |
| Producer surplus | | | Eutrophication | | | Pig mortality rate | | |
| Financial stability | | | Soil quality, erosion, and C accumulation | | | Breeding programs | | |
| Net present value | Financial situation and returns to capital | 3 | Soil quality, nutrients | Local ecosystem services | 4 | Working conditions | Employment and working conditions | 6 |
| Internal rate of return | | | Biodiversity | | | Occupational health | | |
| | | | Maintenance of ground water | | | | | |
| Transferability | Market adaptation and | 4 | Ammonia emissions | Local emissions | 5 | Job creation | | |

| Economic Dimension | Summarised Economic | Number of Papers | Environmental Dimension | Summarised Environmental | Number of Papers [1] | Social Dimension | Summarised Social | Number of Papers |
|---|---|---|---|---|---|---|---|---|
| Generating capacity | consumer perspectives | | Nitrogen losses from soil and manure | | | Local income | | |
| Market conformity | | | Odour control and emissions reductions | | | Employment | | |
| Consumer surplus | | | | | | Meat safety | | |
| Costs | Costs | 3 | Nitrogen Phosphorus Energy | Global resources | 6 | Food security | Food security | 4 |
| | | | Transport | | | | | |
| Efficiency | | | | | | Changes in agricultural structure | | |
| Labour productivity | | | | | | | Legislation and regulation | 2 |
| Productivity | Efficiency and productivity | 4 | | | | Political and social possibilities to control production | | |
| | | | | | | Stakeholder perceptions | | |
| Dependence on subsidies | Subsidies | 3 | | | | Social acceptability | | |
| Governmental payments | | | | | | Cultural acceptability | Societal acceptance | 8 |
| Production management | Management | 1 | | | | Landscape aesthetics | | |
| | | | | | | Appreciation of the region | | |
| | | | | | | Odour | | |

stematic as for a full systematic review, but the process does not extend to critical appraisal or data synthesis [2][3][4]. The results obtained through systematic mapping enable identification of relevant knowledge gaps in the context of stakeholder knowledge and opinions. This information can then be used to establish a tentative agenda for high-priority areas for future research involving stakeholders—in the present case with the primary focus on pig production in high-income countries. The data extracted from the dataset included in the present analysis described important aspects of the different dimensions of sustainability dealt with in the studies. A major benefit of systematic mapping is that vast and potentially diverse research areas can be investigated (mapped) in a comprehensive way, providing a useful overview of the area and priorities and the main focus applied in earlier

| Economic Dimension | Summarised Economic | Number of Papers | Environmental Dimension | Summarised Environmental | Number of Papers [1] | Social Dimension | Summarised Social | Number of Papers |
|---|---|---|---|---|---|---|---|---|
| | | [5] | | | | sLCA | sLCA | 1 |

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With our search method, we identified papers where the words in the search string were included in the title, abstract, or keywords. However, the papers produced by the searches did not necessarily have sustainability as part of the aim. Furthermore, the aims stated were often not those we were initially interested in, or were outside the scope of the analysis. We excluded studies without clearly stated aims about investigating sustainability, but these may well have covered aspects of sustainability that were relevant to our study.

Most papers identified were not in areas that were relevant to our topic, i.e., farm-level sustainability in pig production. Although our searches contained search terms for all three dimensions of sustainability, only a limited proportion of papers (15 out of 36) were initially identified as actually dealing with all dimensions (environmental, economic, and social). Further investigation of the 15 papers revealed that only five of them actually fell within the defined scope, leaving us with an even smaller proportion (five out of the 36 relevant papers). In the rejected papers, sustainability was not part of the aim or the content of the paper did not meet our set criteria, including all three pillars of sustainability. Further investigation revealed that only five papers fully fit the set criteria. Of the five final remaining papers that met our inclusion criteria, two were methodology papers describing methods and procedures for evaluating sustainability [6] and were part of a larger project where the actual results were published in other papers. The outcomes of our search method were therefore rather limited, and it was rare for all three dimensions of sustainability to be actually investigated within the same study.

Of the few papers that covered all dimensions of sustainability, some described a single scientific study and reported the results on the different sustainability dimensions in separate papers, e.g., works performed by Bonneau and co-workers [6]. This indicated that we might have retrieved an incomplete set and missed relevant papers by only including papers concerning all three dimensions. Therefore, we performed a further analysis of papers covering one or two of the three sustainability dimensions regarding the scope in order to analyse the relevance. However, the lack of papers discussing and evaluating all three sustainability dimensions in relation to each other might lead to loss of significant information of importance for the development of sustainable pig production. There may also be other papers that covered all three dimensions of sustainability, but which did not appear among the hits because they did not include the exact words used in our search strings. However, to ensure achieving full coverage of the dimensions, the search string was developed through an iterative discussion within the project group and with a qualified university librarian. This made the search strings rather comprehensive, so we believe that we included a majority of studies dealing with sustainability within pig production at farm-level.

Another consideration is that using our search strings resulted mainly in papers that were considered to be outside the scope of our analysis. The comprehensive search strings included all papers containing one or more words

from each group of words connected to each sustainability dimension in our search string according to the string set-up. The identification of ‘false’ papers (i.e., containing key words, but not covering the topics of interest) could have been minimised with a more specific search string, either containing fewer words or more specific searches, for instance for matches only within the title, instead of in title, abstract, and key words. However, such an approach would have increased the risk of missing relevant papers. The wide range of hits due to the comprehensive search string was instead manually assessed to identify relevant papers from the abstract, so the risk of deleting relevant papers was low.

Initially, we did not include animal welfare as a criterion in social sustainability, but we added it to this dimension during the reading process, as it is closely linked to society’s view of animal production. However, it is not straightforward to decide which dimension of sustainable development animal welfare fits best into, or if it should be considered a dimension on its own. In particular, animal welfare can be considered related to all parts of sustainable development. This can be clarified through some examples: (i) Grazing animals are allowed to express their natural behaviour and should thus experience higher levels of animal welfare. At the same time, grazing animals often help to improve biodiversity, which is part of the environmental dimension of sustainable development. (ii) Animal health is part of animal welfare and having healthier animals reduces spending on veterinary treatments, discarded agricultural products, and labour requirements, which is part of both the economic and environmental dimensions of sustainable development. (iii) Improved animal welfare is likely to improve society’s acceptance of animal production, which is part of the social dimension of sustainable development. Animal welfare, although it may be defined in different ways [7], was then included as part of social sustainability. It should be noted that other aspects of sustainable development perspectives may be interrelated in similar ways. However, it is clear from our systematic mapping of the current literature that those interrelations are not well-understood and that possible trade-offs or synergies between different aspects have not yet been identified. This is an important area for future research and highlights the importance of all aspects of sustainability being discussed and evaluated within the same paper.

However, improving pig health and immunity is not only an animal welfare issue, but also affects the efficiency of the process by which production inputs are converted into production outputs, and thus the economic return of the process. This also applies to environmental sustainability, as reduced production efficiency often leads to inefficient resource use, and hence higher impacts per unit of meat produced. However, concerns about potentially large economic costs associated with improving animal welfare have been voiced by stakeholders, for instance in a recent government inquiry in Sweden [8].

Few papers in the dataset covered all three dimensions of sustainability together and none of the papers assessed whether or how different sustainability dimensions can counteract or reinforce each other. It is difficult to estimate and take full advantage of the aspects of environmental, economic, and social sustainability within a particular production system at the same time. The various sustainability aspects therefore need to be weighed against each other in order to maximise the overall sustainability at farm-level, or even in a broader societal context. According to Hansen (1996), sustainability can be defined at different systems levels—farm, region, and global. At the base level, the farm, production must be sustained environmentally and economically over a long time. The higher

levels, regional and global, add more requirements that need to be met, but they build on sustainable farms. Hence, farm-level sustainability is crucial for larger-scale sustainability [9]. This emphasises the need for studies investigating several aspects at the same time, and their relations to each other. Furthermore, it is probably difficult to maximise environmental, economic, and social sustainability within the same production system. Therefore, various aspects of sustainability need to be balanced in order to maximise the overall sustainability within a farm, or even in a broader societal context.

Initially, we aimed to identify papers presenting research conducted in Europe, North America, Australia, and New Zealand. These geographical areas were included due to expected similarities between production systems, enabling comparisons between studies. However, we did not identify any papers from Australia and New Zealand, probably due to the minor importance of pig production in these countries.

Regarding the definitions of the sustainability criteria, a clear challenge was the very wide definitions of the three dimensions of sustainability that are used in the scientific literature. For example, the term environmental sustainability was used to describe studies ranging from energy use in a single process line to full-scale cradle-to-gate LCA studies. There was similar, or even larger, variety in the definitions of social and economic sustainability. In addition, there are many different aspects within each dimension, which complicated comparisons between studies since there may have been differences in the approach used to investigate, e.g., environmental sustainability may differ radically between studies. Future research should focus on developing a taxonomy for conceptualising various aspects of the three dimensions of sustainability, which could enable comparison between studies.

In most of the papers in the dataset there was a clear focus on one dimension of sustainability, which was quantified, while the other dimensions were discussed more briefly, mainly to put the main results in context. As concluded by authors such as Bonneau and co-workers [10], regarding sustainability, we found that few previous studies have investigated all three dimensions of sustainability in pig production, with more papers covering just one dimension. We found more papers dealing with environmental or social sustainability than economic sustainability. These findings can be used for prioritising future research related to the sustainability of pig production, by comparing current knowledge against identified needs for future knowledge. In the future, an interdisciplinary study probably should be performed in order to develop a conceptual framework for a sustainability performance assessment of pig production at farm and territorial level, where all three dimensions of sustainability are assessed, including potential synergies and conflicts between sustainability goals and targets.

## 3. Conclusions

We identified the scientific papers on sustainability in pig production, including all dimensions of sustainable development. In the retrieved literature, we found few studies that included all three dimensions of sustainability simultaneously, but papers covering one of the three dimension of sustainability were more common. Papers that were dealing with environmental sustainability were more frequent than papers analysing economic or social

sustainability. Our findings can be used for prioritizing future research to understand the interplay between different aspects and how this can affect the development of sustainable pig production.

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