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Reviews

Sustainable development perspectives of poultry production

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The concept of 'sustainability' or 'sustainable development' is multi-dimensional, encompassing economic, environmental, social, and institutional governance aspects. The theoretical framework for this article on sustainability in poultry production is built on this multi-dimensional understanding of the concept, acknowledging that it is complex and contested. It is challenging to analyse or discuss the sustainability of one single sector within agriculture, because this sector is part of a global food system, and a systems approach is necessary. This article gives examples of elements which link to one or more of the four aspects, *e.g.*, pollution and antibiotic use, biodiversity (environmental aspects), conditions for farm workers and animal welfare (social aspects), governance of the food chain (institutional aspects), and the development of poultry from a valuable food to a cheap staple food throughout major parts of the world (economic aspects). There are numerous potential pathways for sustainable development of poultry production. Poultry are living, sentient animals that can be well integrated into many different types of urban and rural farming systems, where they benefit from and contribute to such systems and to the livelihood of households around the globe, with special emphasis on women. Furthermore, local production provides potential for production with minimum transport and, concomitantly, minimum usage of fossil fuels. Among the terrestrial animals, poultry has the best conversion rate of feed to human food and the smallest environmental footprint in terms of energy and water use per kg meat or eggs produced.

Keywords: sustainability; environment; social aspects; economic; governance; global responsibility; food system

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Introduction

Poultry, defined as domesticated birds kept either because of their meat, feathers or eggs, constitute a fascinating and diverse group of animals, which can be integrated into many farming systems throughout the world for the mutual benefit of animals and the humans involved. Their ability to convert many types of feed, such as residuals from agricultural activities, households and food processing industries, into animal products and protein sources is more efficient than most other animal species. Their contribution to food security, protein supply, and peoples' livelihood makes them valuable animals on a global level. They can fit into urban and peri-urban production, and in many parts of the world they generate income over which women have control, thus contributing to the millennium goals regarding gender issues. In many parts of the world, they are involved in industrial livestock production. Poultry meat consumption worldwide is about 13.6 kg per head, varying from 1.77 kg in India to 43.81 kg in USA in 2014 (International Poultry Council; http://www.internationalpoultrycouncil.org/industry/industry.cfm). The increases in poultry meat production by a factor of seven (3206%) and eggs by a factor three and a half in the period 1967-2007 (FAO, 2011) present a huge challenge to sustainable development. At the same time, the poultry sector encompasses a contrast between dominant global large corporations and small-scale producers especially in the Global South (2011). This can be viewed as a great potential, because a variety of different trends and spurs to development can be explored and exploited.

In this article, poultry production is understood as all types of production in which domesticated birds are involved, either for meat, feathers or eggs from small scale producers to large-scale industrial poultry production units. Specific examples will be picked from different categories of production, but many of the sustainability perspectives can be broadly discussed across all types and purposes of poultry production.

The notion of 'sustainability' and 'sustainable development' is, in many ways, contested. It is challenging to deal with all aspects of it in connection with a single sector within agriculture, because it is interlinked with so many other sectors and developments, including the global food system. One major starting point for the concept of sustainability came in 1987, when 'Our Common Future' (World Commission on Environment and Development, 1987) stated that a sustainable development was attained when current generations could meet the needs without undermining or destroying the future generations' chances of having their needs met. This core principle of sustainable development aims at balancing economic, social and environmental interests. Valentin and Spangenberg (2000) argued for a fourth imperative for the concept of sustainability, namely 'institutional sustainability'. At the same time, Thompson (2007) raised the philosophical point that we should take care not to equate 'what is sustainable' with 'what is good *per se'* (referred to as 'non-substantive uses of sustainability'). He raised the point that '*once we have deemed a practice worthwhile on other grounds, it becomes meaningful to ask whether it is sustainable, and to seek relatively more sustainable ways of securing the values or achieving the goals that make a practice worthwhile in the first place'*. In this way, 'sustainability' becomes an 'add-on value' to a practice which is judged ethically 'good' and an agreed goal in the community.

The aim of this article is to unfold the concept of sustainability and discuss a range of aspects of this in the context of the current poultry sector in its many forms throughout the globe. An initial definition of the concept of sustainability will give the theoretical framework for this discussion.

The concept of sustainability

The theoretical framework for this article on sustainability in poultry production is the multi-dimensional understanding of the concept as discussed by Spangenberg (2004) and Valentin and Spangenberg (2000). Their work in four dimensions (*Figure 1*) supported Agenda 21, or the Rio Declaration, which included social, environmental, economic, and institutional objectives. Spangenberg (2004) and Valentin and Spangenberg (2000) stressed the context-specific approach as well as the importance of not only assessing and considering the dimensions, but also the inter-linkages between them. So, when they stated that 'democracy' is a key for the interlinkage between the institutional and social dimensions, this was seen as increasing tolerance and social cohesion developed in a society, which can only be fostered through the creation of institutional structures that can ensure participatory democratic processes. In Valentin and Spangenberg's model, the social imperative included 'human capital', that is, the skills and capabilities of people, where the institutional imperative comprises governance, and, to some extent, certain social capital perspectives.

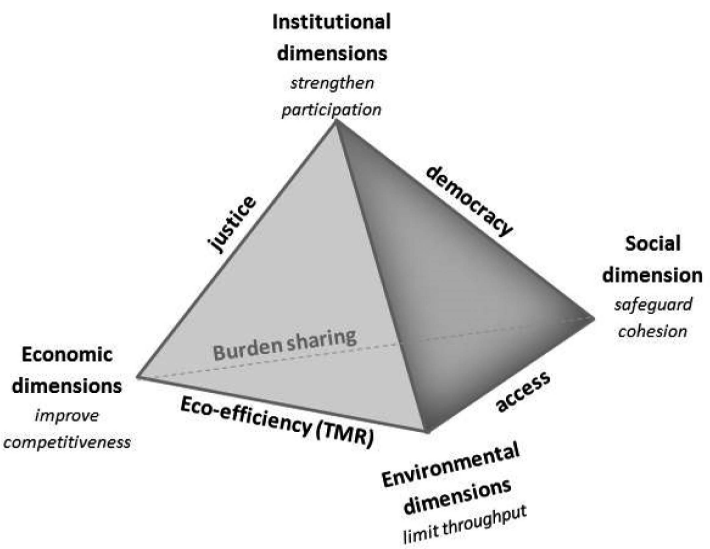

Figure 1 The sustainability prism, slightly modified from Valentin and Spangenberg (2000) and Spangenberg (2004).

There is a wealth of literature dealing with 'sustainability,' meaning many different things. In some cases, only one aspect of sustainability is considered, *e.g.* carbon footprint or economic short-term survival of the production. Castellini *et al.* (2012) described a multi-criteria approach for measuring sustainability of different poultry production systems. In their assessment addressed human food needs (the social dimension), environmental preservation, economic feasibility, and quality of life. The FAO (2012) developed a system of sustainability assessment, SAFA, in which four dimensions are taken into account and measured, using multiple indicators, namely 'environmental integrity', 'economic resilience', 'social wellbeing' and 'good governance'.

Aspects of sustainability of poultry production

ENVIRONMENTAL ASPECTS

On a global scale, livestock takes up about 70% of all agricultural land, and 26% of the ice-free terrestrial surface is used for livestock grazing (Steinfeld *et al.*, 2006). The current global growth of the livestock sector is, however, achieved at substantial environmental cost (Gerber and Steinfeld, 2008). Biodiversity loss - one of the most critical environmental losses of our time, among others because 65-70% of global food production relies on pollinators which are heavily reduced - is to a large extent a result of changes in land, use such as increased cropland (Röckström *et al.*, 2009). Livestock activities have been estimated to contribute about 18% of total anthropogenic greenhouse gas emissions (Steinfeld *et al.,* 2006). Considering the agricultural and forestry sector as a whole, the livestock share alone is over half. These activities are linked to multiple factors related to production of feed, and include deforestation, N fertiliser use, processing and transport. However, poultry is the livestock species with generally the least impact in terms of land size, water use, environmental stress and footprints both for poultry meat and eggs (De Vries and De Boer, 2010). Transport must be considered as an environmentally burdening activity, although it is at the moment 'cheap' in terms of price. The trade with poultry meat is huge, *e.g.* between Asia, South America and EU-28 (Anonymous, 2013b).

A Life Cycle Assessment (LCA) is a method to examine the complete production or value chain, while tracing the inputs back to natural resources and emissions produced along the way. Williams *et al.* (2009) conducted an LCA specifically for broiler production and concluded that it is the most resource-efficient meat production in agriculture, mostly due to genetic development and nutritional efficiency. They pointed to the potential for such improvements as increasing overall lifetime feed conversion efficiency and energy use to explore opportunities for reducing reliance on fossil fuel.

RESOURCE MANAGEMENT

Gerbens-Leenes *et al.* (2013) conducted a study on modelling the water footprint in poultry and other meat production in Brazil, China, Netherlands and the United States, and concluded that this was mainly determined by FCR, feed composition and ingredient origin. Concentrated feed has a larger water footprint than roughage, but a higher FCR. Industrial systems generally had a considerably smaller water footprint than other systems, mainly because the animals are bred to grow faster, move less and have better FCR. This term distinguished between rainwater and ground or surface water, where rainwater was regarded as having less environmental impact than other freshwater sources. The authors emphasised that the impact of poultry production had to be viewed in context with local water scarcity, among other factors. Obviously, production which requires much water is not sustainable in an area with water scarcity.

A relevant aspect of resource management related to feed and food is the potential risk of poultry competing with humans for protein sources, *e.g*. if more of a protein-rich feedstuff is fed to animals. Feeding of organic poultry, as discussed by Magdelaine *et al.* (2010) and Sundrum (2005), provides a very interesting case, in which different aspects of 'environmental sustainability' are challenged especially with respect to the EU requirement for 100% organic feed in a few years. The final date for transition to 100% organic feeding in EU has been postponed until January, 2018, allowing 5% non-organic ingredients until then (EU, 2012; 2014), indicating a concern with regard to the availability of sufficient protein sources of suitable quality. The 100% organic feeding can be based on increased amounts of locally-sourced feed stuffs, which do not

compete with human food or needs transport, and therefore can be regarded as more sustainable. This can lead to increased difficulty meeting the birds need for methionine, leading to protein overfeeding and increasing N-excretion to the environment with the risk of disease and impaired production. This calls for a broader understanding of 'adequate feeding' seen from a systems approach, where animals are more robust and there is more emphasis on resilience related to feeding and keeping poultry (Horsted and Hermansen, 2007; Steenfeldt *et al.*, 2013).

POLLUTION

In a well-integrated farming system, animals are part of a nutrient cycle. Ideally, the animals are sustained from products on the farm, which in the current situation are made 'best use of', with minimum use of labour and resources, in particular non-renewable resources. The manure of the animals contributes to soil fertility. This cycle does not exist in industrial animal production, which relies on the transport of all resources. Manure becomes 'waste' which needs to be handled, like medicine residuals or byproducts, odours or dead animals.

The use of fossil fuels is a part of food and trade-related pollution, needed for growing and transporting feed, live animals and poultry products and to heat or cool poultry barns. Given the fact that poultry can be raised under many different local circumstances, it may be unnecessary to involve so much transport when meeting the need for human protein supplies.

ANTIBIOTICS

Two specific types of growth promotors in feed for poultry were prohibited from 1999 (Engberg and Petersen, 2001), however, in 25 EU-countries, a total of 8.420 tonnes of antibiotics (not including coccidiostats) were sold for farm animal use in 2011 (Third ESVAC report). Poultry account for 13% of antibiotics in the EU, given in the forms of premix or oral solutions (about 84% of all antibiotics, primarily for mass medication of pigs and poultry). Any type of production which relies on the use of medicine, where there is a risk for developing resistant bacteria over time, or whose residuals pollute the surrounding environment, can obviously not be classified as 'sustainable', especially if medication is used for preventive purposes and/or as mass medication.

BREED DIVERSITY

Humankind has domesticated 30 species of animals, which accounts for about 8,000 registered breeds, including hundreds of poultry breeds. Most of these breeds are kept by smallholder farmers throughout the world, who produce a large part of the world's poultry meat and eggs, and at the same time conserve some of the world's livestock breeds. Many of these breeds are locally adapted, multi-purpose, and indigenous, and suited to various farming enterprises. The current breeds in industrial systems are almost exclusively single purpose breeds, either broilers or layers. Very few genotypes exist in today's broiler production, which are selected for growth and FCR, but are more vulnerable in terms of immune competences (Rauw *et al.*, 1998). Eradicating breeds means not only losing natural capital or genetic 'wealth' but also eradicates the possibilities for adapting to different environments and situations, *e.g.,* climate changes (FAO, 2015). Furthermore, killing millions of male chickens immediately after hatching raises ethical concerns, and the sustainability of this can be questioned.

Social aspects

INDUSTRIAL FARMING, FARM WORKERS AND CONTRACT FARMERS

Several studies have been carried out regarding working conditions of farm workers in industrial farms in general, specifically on poultry farms. These studies deal with two different categories of social aspects for humans: 1) working conditions and health of the humans (owners or workers), and 2) the fairness of employment contracts, *e.g.* health insurance, decent salaries, and collective bargaining rights. Poultry farmers and their family members are at higher risk of being infected with antibiotic-resistant bacteria as well as of developing allergies to antibiotics. Since 2012, poultry farmers in The Netherlands have been categorised as people who need quarantine and special attention if hospitalised because of this risk. Other risks include health problems due to dust exposure from litter and feathers (Le Bouquin, 2014). Quandt *et al.* (2013) conducted qualitative interviews of Latino chicken catchers in the U.S. about their working conditions and concluded in short: '*Chicken catching is characterised by a work environment and organization of work that promotes injuries and illness'.* Studies like this shows the close connections between disease risks, human rights issues and general working conditions. Many workers in the food producing industry are exploited unfairly and employed under poor conditions to keep the direct costs of production low. Furthermore, many poultry farmers today are contract farmers, meaning that they are 'out-growers' delivering to a bigger producer or a processor. The arrangements and conditions under which these arrangements are taking place vary widely, and are in some cases highly unfair (FAO, 2011; Anonymous, 2015).

GENDER BALANCE

The third Millennium Development Goal is to promote gender equality and empower women. Poultry production has been and still is a type of production in which women are heavily involved throughout the world especially on individual, family and/or small-scale farms (Dolberg, 2007), for the benefit of the whole family.

ANIMAL WELFARE

Animal husbandry systems which cause suffering to the animals are unacceptable, seen from an ethical point of view. Thompson (2007) argued that we, as human society, want to secure practices for the future that we find worthwhile for ethical reasons, and giving animals a life without suffering can be seen in a sustainability perspective, either in relation to social aspects, or as in SAFA (FAO, 2012), as an environmental aspect of sustainability. The EU sponsored WelfareQuality research project established a list of 12 criteria for animal welfare (*i.e.* that poultry should not suffer from prolonged hunger and thirst, have space to move around freely, and be able to express normal non-harmful behaviour). The 12th criterion stated that 'Positive emotions should be promoted and negative emotions, such as fear, distress, frustration and apathy should be avoided'. Many systems today do not give animals' sufficient opportunities to fulfil these criteria, and some systems and methods of rearing poultry cause suffering, *e.g.* foot pad dermatitis, which may be associated with fast growth. This may compromise animal welfare, and cause abnormal behaviour, such as spending more time resting than slower growing genotypes (Nielsen *et al.*, 2003). Some studies discuss the strategy of providing growing female broiler breeders with low density diets as an alternative to feed restriction (De Jong *et al.*, 2005), and reported reduced hunger and frustration, observed as reduced stereotypic and tail pecking and increased dust bathing and other comfort behaviours compared with those fed standard restriction diets (Nielsen *et al.*, 2011). Further research is needed, however, to study if high fibre diets can increase

the birds feeling of satiety. Irrespective of the applied animal welfare definition used, it is a fact that farm animals, including poultry, are living, sentient individuals which need to be protected and offered opportunities for living a life worth living.

Institutional aspects

Institutional aspects of sustainability include the control and governance of global systems and ensuring that the institutions are accountable, transparent and open to its members and representatives ('The Rio Declaration'; UN, 1992). This is challenged in our current food regime, where a few breeding companies le control a large part of the market, making it difficult for smaller companies to establish. Secondly, the different interests embedded in the sustainability concept should be balanced in the governance of the systems. In 2001, the European Commission (2001) wrote in a rather severe self-reflection on the so-called 'Cardiff Integration Process' launched in 1998: '*Although the Union has a wide range of policies to address the economic, environmental and social dimensions of sustainability, these have developed without enough coordination. Too often, action to achieve objectives in one policy area hinders progress in another . . . , while solutions to problems often lie in the hands of policy makers in other sectors or at other levels of government. This is a major cause of many long-term unsustainable trends…*'. In other words, policies which are implemented to support *e.g.* economic development can undermine initiatives to support social development. Such governance can include the responsibility to protect the environment in other parts of the world, such as in South America, or support a more sustainable local production and market, *e.g.* in Africa or Asia, or production which contributes to gender balance.

The 'concentration ratio' (CR) is a term which describes an industry's control over a certain enterprise. For example, the CR4 gives an estimate of the market share of the four biggest firms in control of this particular product. When it is over 40% such as the poultry production, where CR4 for broilers was 58.5% in USA in 2010 (FAO, 2013), there are reasons for concern for the competiveness of the market (FAO; http://www.fao.org/docrep/005/y4671e/y4671e0e.htm).

Economic aspects

POULTRY FROM VALUABLE FOOD TO CHEAP STAPLE FOOD

Chicken has been domesticated, raised and eaten throughout the world for many centuries, but its role as food has changed during last century. In the U.S., chicken meat was reported as a luxury food in the 1920s. Since the US broiler industry developed into the first real 'agribusiness' in the 1960s, over the decades chicken meat has turned into an increasingly cheaper 'staple food' (Godley, 2007). Now, broilers are considered to be '*the cheapest source of protein*' (Anonymous, 2013b). In UK, the chickens which were eaten in the 1940s were basically by-products in the form of cockerel chicks from a growing egg industry. The growing demand and the relatively high price for chicken became a huge driver for mass production, leading to specialisation within production, and an emergent industry of significant efficiency (Godley, 2007). Africa currently is experiencing a growth in intensive poultry production near cities (FAO, 2011), while frozen poultry is exported in large quantities from subsidised EU industrial farms to African and Asian countries (Anonymous, 2013a), *e.g.* the Netherlands exported approx. 119.000 tonnes of poultry meat to African countries in 2012 (Anonymous, 2013b). Titze *et al.* (2007) discussed the consequences of such trade in undermining the local viable

poultry production, which has the potential to improve the livelihood of many local farmers. The livelihood concept gained widespread prominence following the report entitled 'Our common future' (WCED, 1987). In its simplest form it can be understood as 'getting a living', and comprising 'the capabilities, assets and activities required for a means of living' (Chambers and Convey, 1991). Village poultry makes a significant contribution to poverty alleviation and household food security in many developing countries (Alders and Pym, 2009).

Poultry production as part of the current agricultural and food system

CONSUMPTION PATTERNS AND DEMAND FOR POULTRY PRODUCTS

Despite the huge rise in the consumption of poultry products over the past decades, projections suggest that demand will double by 2050, compared to 2010 (FAO, 2011). We have never before in the world's history produced more calories *per capita*. Today's challenges in food insecurity are not due to lack of food, but rather to the lack of ability among poor people to buy it. Today there are estimated to be about 1 billion hungry people, and close to 1.5 billion people who suffer from obesity and/or life style diseases. Different consumption patterns can develop in various directions, whereby demand for animal products increases on some countries, while others foresee an increasingly 'green' healthier diet, as people grow wealthier. The FAO (2011) stated that '*Livestock source food is not essential to human nutrition, but it is highly beneficial'* (p.94). McMichael *et al.* (2007) suggested an average global meat consumption of about 100 g per consumer per day. If poultry is integrated into self-sustaining agricultural systems, *e.g.* on marginal land, forest areas or fruit production areas, there can be a synergy between the different components of the farm. If not, then the need to import feed and dispose of manure adds to the environmental costs of livestock production, even though poultry has good efficiency in transforming feed to animal products. This raises the issue of the 'true costs of low prices', in combination with the consequences of industrial poultry production. The long-term external costs of poultry systems (loss of biodiversity, pollution, use of fossil fuels and water shortage) can be discussed in relation to sustainability. The poultry sector has developed into one of high animal concentrations, with risks for animal and human health as reported and discussed in connection with Avian Influenza, by Leiblein *et al.* (2009), which can increase costs of the production.

Current food waste, due to cheapness and availability, is estimated to be between 30% and 40% of all produced food, taking place on every level from production to the consumers' home. The systematic killing of male chicks from egg production in both organic and conventional production is also a waste. It seems relevant to address this dimension of the food system as part of the effort for a more sustainable production on the farm and processing levels.

Consumers' choice?

With a CR4 over 40%, the true decision power of consumers is clearly questionable. If there is a real choice for consumers to choose poultry products in accordance with their preferences, they need to be aware and well informed about the background for and potential consequences of productions methods. This means that a certain transparency throughout the chain is necessary. Sæbjørnsen (2013) investigated Oslo's egg market and

described it as complex and non-transparent. A Dutch report on chicken meat (Hin *et al.*, 2013) concluded that chicken products were based on very non-transparent procedures, trade and chain relations and called for new business models. However, it is a fact that animal welfare is on the agenda in many countries in EU, in USA, and Australia, among others. Influenced by consumer groups and NGOs, some supermarket chains have chosen to sell 'alternative poultry products'.

Conclusions

Many sustainability aspects need to be addressed in the current poultry sector. One major challenge for the sustainability of a complex system is that it cannot be classified as 'sustainable' if one or more of its subsystem presents unsustainable challenges, *e.g*. feed production in environmentally and socially critical conditions. Nor can a system be considered sustainable in itself if it forms part of a larger system that involves unsustainable practices or structures, such as resulting in a lot of food waste. In search of solutions, there will be many cases, where potential conflicts between different priorities arise, *e.g*. between long term consequences versus short term costs or benefits of the production. This is illustrated in Williams *et al.* (2009), who compared different poultry production systems and concluded that organic and non-organic systems had different aims and therefore were difficult to compare. However, the nutrient output per hectare was generally lower in organic systems, due to slower growth rates and lower livestock density. This can be seen as unsustainable, because it produces less human food using more resources. However, Leinonen *et al.* (2012a; 2012b) reported that feed seems to be the factor in poultry production that caused the largest environmental impact, being highest in organic egg and meat production compared to other systems (cage, barn or free range), due to higher feed intake, less output efficient production and poorer FCR. Some ingredients in conventional feed, however, have a high environmental impact, such as the use of non-organic soya, palm oil and pure amino acids (Leinonen *et al.*, 2013). If a production system did not rely on imported feed, poultry fitted well into a diverse farming system, with locally sourced feed, and then the slower growth of chickens and access to outdoor areas could lead to higher animal welfare, and better use of marginal areas. There may even be synergistic effects between chicken production and fruit production, for example, in terms of pest and weed management and manure to the trees on one side and better animal welfare on the other side (Pedersen *et al.*, 2004).

Poultry has potential to be part of many systems, creating a more resilient poultry sector. The FAO (2011) pointed to the necessity to ensure resilience in food production. Darnhofer *et al.* (2010) explored possibilities to assess farm sustainability, using a resilience theoretical approach and concluded that this can only be achieved through adaptability and change, where farmers retain diversity and redundancy to ensure the adaptability of their production. As discussed in this article, there is potential for producing poultry in diverse rural and urban settings, where smallholders, as well as large scale animal systems can be integrated into the household and local food chains, and poultry can utilise food and plant byproducts and produce manure and protein rich food to the family and local community in return. In France, for example, the Label Rouge concept has been known for many years, and formed the original basis for the EU-regulation for organic broiler production systems (Hermansen *et al.*, 2014). This free-range production system has a high market share in France, especially for whole chickens. In addition to the Label Rouge system, other regional broilers are extensively produced several places in France such as the Bresse and Geline de

Touraine chickens (Verrier *et al.*, 2005; Baéza *et al.*, 2010). This means that changes from the current poultry production systems must be introduced, such as locally adapted breeds, *e.g.* dual purpose breeds, and local markets.

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