Challenges for the future context of animal production

Within the boundaries of planet Earth, agriculture plays an essential role in the production of renewable resources for the desires and needs of the growing human population.

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Agriculture played, and still plays, an important role in the history and evolution of humanity. In a world of hunter-gatherers only about a couple of hundred million people could be fed, but agriculture made it possible to change the ecological equilibrium between the human species and the systems they relied on, allowing the human population to grow to more than 7.5 billion people and increasing daily.

Agriculture did not only influence the total number of people but also changed their way of living, mostly as a consequence of sedentarity following the initiation and development of agriculture.

The still-growing human population leads to increasing demand for food, animal products, energy, raw materials for construction, clothing, chemical industry, etc.

Although awareness about caring for our planet is rising, increasing income and wealth makes it possible to not only fulfill our needs but also encourage consumers to create unnecessary but desired demands. The question then arises, how can this increasing demand on agricultural output match the finite agriculture production input, such as soil, water, and nutrients?

Inevitably this leads to the question of sustainability, its definition, and the consequences for choosing to use agricultural products (including sylviculture). Indeed, although food production was the main goal, and still is the most important one, human society has long since learned that biomass (plants, animals, and forestry) could be used for other purposes than food production.

A good overview of the use of agriculture biomass, including sylviculture, cereals, vegetables, sugar culture, tuberales, and root products, fruits and oil plants was published by Morrison (2016).

Apart from use as an energy source (mainly forestry products, sugar plants, and cereals for biofuel) about two-thirds of the biomass (in millions of tonnes) of all other agricultural products are used for food for direct human consumption, while one-third is for feed use as basic agriculture commodities produced to feed animals.

In 2011, this meant a production of 3.340 million tonnes of biomass for food and 1.510 million tonnes for feed worldwide.

However, taking into account the land that can be used for agriculture, one-third is arable, two-thirds is available for only pasture use, and one-third of total biomass produced on arable land is for animal feed, the impact of animal production in terms of sustainable choices may be even greater than expected.

Therefore, as discussed by Boonen et al. (2012) and Boonen (2015), animal production can and may play an essential role in producing food in so far as it can maximally exploit 'useless' land or convert 'useless' energy or proteins.

Although during the last decades agriculture production strongly increased, still more than 800 million people suffer from hunger. With a global population that will go up to 9 or 10 billion people by 2050, focusing on increasing food production alone will not solve the hunger problem.

One of the important ethical dilemmas of the future will be the competition among the different functions or uses of agricultural biomass production. There is no scientific solution for the question of how these functions or uses have to be balanced since this strongly depends on personal values, desires, and needs influenced by one's sociocultural background and worldview. Therefore, this discussion has to be placed in a broader, philosophical-ethical perspective.

Table 1. Energetic and protein efficiency at population level (Van Es, 1975).

	Energetic efficiency (%)	Protein efficiency (%)
Dairy cows	12	23
Meat cattle	5	6
Sheep	2	3
Pigs	17	12
Broilers	10	20
Laying hens	11	18

Demand and supply of food

When observing the change in human populations as well as the changing consumption pattern of food over a sufficiently long period (40 to 50 years), world meat consumption is increasing faster than the global population increase, indicating a shift in consumption pattern to an increased proportion of animal products in the diet worldwide.

This is reflected in the worldwide per capita consumption of cereals and meat over the period 1960 to 2000. In 1960, the per capita cereal production was 280kg and meat about 20kg, while in 2000 the per capita cereal and meat production was around 340kg and 38 to 40kg, an increase of respectively 20% and 100%.

This shift in consumption pattern towards an increased proportion of animal products, and in spite of word population growth, is mainly triggered by increasing per capita income invariably followed by increasing consumption of animal products.

This phenomenon can be repeatedly observed in different historical periods in different parts of the world. How can this trend - a shift in consumption pattern towards more animal products - be reconciled with the fact that 800 million or close to 1 billion people are chronically underfed?

It indicates at least that the problem is not just production, but efficient production which can and will help, especially where land use for feed/food production is concerned.

There are many opinions regarding the supply of food for the human population. In the scientific-technological realm, it is said that we have to produce more food without a real expansion in order to

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save the natural environments left.

So, solving the hunger problem has to be realised by applying modern technologies. On the other hand, many organisations (many non-governmental organisations (NGOs) to a more or less extent) reject the so-called 'green revolution' and other modern technologies.

According to those who advocate rejection of these technologies, they are not sustainable, they increase the gap between the poor and the rich, and moreover, there is too much animal production.

Although there are conflicting ideas on how to address the problem of world hunger and the increasing demand for food worldwide, most people agree on the following important strategies:

- Limit the extension of agricultural land at the expense of forest, especially in tropical areas.
- Increasing food supply for all by reducing waste and through more equitable distribution.
- Increasing the efficiency of water use and nutrient use for crop production.
- Increasing total production as well as production efficiency of crops via optimisation by using the genetic potential of crops as well as by increasing this genetic potential.

This leads us to the question: What about animal production and its efficiency within this broader framework? The increasing demand (including animal products) but limited production capacity, limited water, fertiliser, soil, and ecosystem of Earth, exacerbates the questions about animal production, its efficiency and legitimacy.

Efficiency of animal production from an energetic point of view

From a fundamental biological-ecological point of view, it is well known that in terrestrial food pyramids about 10% of the energy of one level is incorporated in the next level. This means that from all vegetation used by herbivores about 10% is transformed in their body into energy, and roughly the same is true for carnivores eating the herbivores.

When calculated for the efficiency of different animal husbandry species at population level (including all young and adult, males and females, and replacement breeders, just as in natural populations) the following efficiency ratios for energy and protein were reached (Table 1. Van Es, 1975).

So, it can be argued that if humans behave more like herbivores, five to 10 times greater human population could be fed. However, this is an oversimplification that was elegantly pointed out by Van Es (1975) and contradicted by his calculated efficiency ratios for animal production.

Van Es (1975) stated that digestibility as well as the metabolisability of feedstuffs in the different species of our farm animals is not identical when compared to each other as well as with humans when they eat the feed.

Therefore, it is not the total energy content that has to be taken into account, but the true metabolisable energy (ME) for the different levels in the food pyramid. Only through this can an estimation be made as to if passing the feed through the animal production chains means a loss or gain, and to what amount in the different animal husbandry species.

Of course, this has to be done at the population level, including pregnancy, lactation, youngsters for slaughter or replacement, etc.

The ratio for this estimation is available ME for humans in the animals or animal products (numerator) divided by the available ME for humans if they can and will consume the feedstuffs given to animals (denumerator).

For these calculations some assumptions were made:

- Humans cannot nor will use fodder such as grass, hay, and straw as a source of energy for themselves for the simple reason that it is not digestible for monogastrics.
- Using concentrates for pigs and poultry, it is estimated that about 60% respectively 75% could be used by humans, while in cows this is only 50%, taking into account the less digestible (for monogastrics, including humans) components used for ruminants.

Of course, using milk products for intensive veal production is 100% compatible with direct human use of these products.

- Using the ME ratios to calculate the digestibility coefficients for different feedstuffs in the case of direct human use were those calculated for pigs considering their comparable digestive system, hence also in digestibility.
- What humans can and especially are willing to eat can vary greatly over time and geographical distribution and will depend also or mainly on supply or shortage (for example war, famine).

Van Es (1975) calculated for each of the rations of available ME energy and digestible protein two ratios: one in the event of food shortage and one for full food supply. These calculations were reevaluated by Boonen (2015) taking into account new data about animal productivity and reproduction capacity, new feed sources, and feeding management types.

Also, the influence of what we consider 'edible' was taken into account, but a thorough discussion of this aspect is out of the scope of this chapter.

It may be noticed that in his calculations as presented here compared with the older data from Van Es (1975), the use of soybean meal has not been considered as competitive for direct human food (although it could be in principle).

Based on data on the ecological energetic efficiency as calculated for husbandry species, monogastrics are more efficient than large ruminants.

This is largely to do with reproductive efficiency. Based on these figures, one could agree it is more sustainable to use pig and poultry production for meat instead of cows or sheep, and this is beside the higher greenhouse gas emission for the latter per kg of meat produced.

However, taking into account Van Es's (1975) logic behind the efficiency of ME-use for human food, by directly eating plant production or indirectly after conversion to animal products, it is clear that ruminant meat consumption is far more energetically efficient, and in some cases may even constitute a gain of ME-use for human food consumption.

Sustainability of animal production?

Focusing on sustainable poultry production, two statements can be made for which there is now a universal agreement:

- The livestock sector poses severe pressure on the environment (air, water, soil) and competes for scarce resources (land, water) for the production of feed.
- The production and utilisation of feed are the dominant factors determining environmental impacts of pig and poultry production, for example, crop productivity and animal productivity.

An endless (economic and production) growth on a finite planet with limited resources seems to be therefore a 'contradictio in terminis'. To escape this dilemma, an uncoupling of growth from the use of resources is advocated. A relative uncoupling is realised by increasing the efficiency of production.

However, if the increase in growth is bigger than the increase in efficiency, then there is no absolute uncoupling at all and no sustainability of growth in the long term. The latter is the case for most domains of economic activity, including poultry production (considering the rapid increase in poultry and egg production worldwide).

Many efforts have been and are made in many aspects of livestock production, for example:

- Increased land-use efficiency, which is important to reduce land-use requirements.
- Byproducts from arable production or from the food processing industry are important to reduce the environmental impact of livestock production.

The feed industry should collaborate with the food and biofuel industries to optimise the allocation of biomass streams between sectors. Efficient livestock production must take the whole feed/food chain into account, not only from farm to fork but also from fodder to farm.

- Improvement of livestock production through genetic improvements, through more appropriate nutritional requirements, through elimination of mycotoxins, better sanitary conditions, etc.

Contributions to sustainable poultry production

In view of the competitiveness of poultry production with human food security, its environmental impact, as well as welfare and product quality issues, sustainable poultry production is under increased scrutiny from the value chain, policymakers, and associated stakeholders.

This means that continuing to operate as we have done in the past is not an option.

The challenge we are facing requires new technologies, new business models, and especially new thinking in order to create a more sustainable industry – including poultry production – that protects the planet, and is economically viable and socially responsible.

Many initiatives and actions can be listed based on new approaches to business, greater collaboration through the value chain, and greater use of technologies. Nickell and Saviani (2021) listed six key

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	Van Es (1975)		Boonen (2015)
	Food shortage	Full supply	Full supply
Pig	0.24	0.40	0.11
Broiler	0.22	0.29	0.19
Layer	0.17	0.23	0.29
Dairy cow	1.2	2.4	4.95
Intensive meat cattle	0.21	0.41	0.14
Extensive meat cattle	0,7	1.3	-

Table 2. Available ME for human food as a ratio: ME from animal products /ME directly available to humans from feed but given to animals (Van Es, 1975; Boonen, 2015).

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sustainability platforms in their recent contribution to sustainable animal production. Herein I include some concrete possible examples for each of these platforms for poultry production:

● Improving lifetime performance of farm animals:
Laying hen selection to achieve a longer laying cycle is a good example; often it is said to increase the 'longevity' of laying hens, but since the biological lifetime of chickens can be 6-10 years, we still make suboptimal use of this potential. The fact that laying hens are depreciated after only one year (more or less) of lay due to the current business model requires new thinking.

Even in situations of high feed costs and low egg prices where the choice for a second and eventually third laying cycle is obvious (and can be calculated as beneficial for the farmers if the rejuvenation technique of artificial molting is done correctly), the contracts between farmers, pullet producers, hatcheries, etc., do not allow it.

● Reducing food loss and waste:
In the aftermath of mad cow disease (bovine spongiform encephalopathy or BSE), a disequilibrium between our concept of food/feed safety and food security has invaded the minds of consumers and many policymakers. Blood, feather meal, and slaughter waste could be excellent sources of animal proteins in feed, at least when properly treated.Moreover, these can be used as a substitute for fish meal and soybean meal. The cry, 'No cannibalism' in this context is a false paradigm.

● Reducing livestock emissions:
A wealth of information on reducing nitrogen emissions is available. Techniques for reducing ammonia emission in the ventilation air from poultry houses by washing the air is just an example of a social responsibility of poultry farms.

Considering the shortage of phosphate resources in the world, and the way phosphates are overloading fields and surface waters in production areas densely populated with poultry (and swine), the use of phytase enzymes could greatly reduce the need for additional phosphate in the rations of poultry, especially of laying hens.

● Making efficient use of natural resources:
For example, new and greater use of byproducts of other agricultural speculations (for example byproducts of bioethanol or biofuel production) as well as algae production and/or insect production for high-quality poultry feed supplements.

● Reducing our reliance on marine resources:
This is related to point two (Reducing food loss and waste). Make use of these waste products as a source of high-quality animal protein by substituting fish meal in poultry rations.Also, aquaculture as a source of DHA (docosahexaenoic acid) or EPA (eicosapentaenoic acid) for producing eggs/meat enriched in omega-3 or -6 fatty acids should be replaced by marine algae production of these ingredients.

● Helping tackle antimicrobial resistance:
Smart nutrition leading to eubiotic solutions can possibly minimise or eradicate the subtherapeutic use of antibiotics. A wealth of recent poultry research in Africa, Asia, and Latin America is focusing on new ingredients and natural plant products as alternatives for antibiotics, anticoccidials, anthelminthica (for example, papaya-seeds, moringa oleifera leaves, powder or extracts, etc.).

All these examples, and many more, contribute to a relative uncoupling (and increased efficiency), but not necessarily to the long-term sustainability of production if the overall growth in poultry production overrides the growth in efficiency.

Sustainability from a holistic perspective, including sustainable poultry production worldwide, has to take into account many fundamental aspects listed as the 17 sustainable development goals of the United Nations.

Livestock production is at least included in six or seven of these goals. The relative importance of several of these goals in relation to livestock production is shifting in time and according to the worldview of individual persons or communities.

This could be observed already in the shift in livestock policy objectives in relation to economic development as published by the Food and Agriculture Organization in 2006. In a 4-factor analysis, four aspects were taken into account for their importance in four different societal development conditions.

These factors are, 1) food supply, 2) social/poverty concerns, 3) food safety, and 4) environmental impact. While in low development conditions with a large number of smallholder farms, food supply and social/poverty concerns are by far the most pressing factors, this concern shifts during a beginning or rapid industrialisation phase to food safety and environmental impact.

In a post-industrial society, food supply and social/poverty concerns are becoming of very minor importance while the most important factor for livestock policy is the environment (including animal welfare).

As a conclusion of such a broader perspective, it was estimated that if development in/for the world means the estimated 9 to 10 billion people in 2050 have to reach a way of life and consumption considered normal for the OESO countries, then the economy in 2050 has to be 15 times the level it was in 2010.

Of course, there are increases in efficiency, changes in technology (often unpredictable), and in consumption patterns, perhaps. Awareness of the limited character of ecological resources and the limited character of growth of the world population is urgently needed. The UN's 17 sustainable development goals are clear: our societies or our world society in the future the future world will be sustainable or will not be at all. ■

References are available from the author on request

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