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A balanced perspective on animal production, from environment to human health

Executive Summaries

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Preface

The council of the South African Society for Animal Science (SASAS) decided to dedicate a special issue of the South African Journal of Animal Science to address misconceptions among the public about animal products and livestock production systems, the importance of the livestock sector to the country in terms of food security and its economic contribution, and challenges facing the industry, such as global warming and the contribution of animals in South Africa to greenhouse gas emissions.

The authors were asked to prepare an executive summary of their contributions, to be distributed as an annexure of this special issue.

The content of the issue is presented below, and this is followed by the executive summaries.

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Executive summaries

Should we reject animal source foods to save the planet? A review of the sustainability of global livestock production

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Sustainability is a concern for all global livestock systems. There is no definitively sustainable system, rather, sustainability can be thought of as a process within which systems are more or less sustainable, changing over time and only moving forwards through continuous improvement. No "one-size-fits-all" system exists to achieve livestock sustainability – individual production systems must be tailored to the resources, climate and culture indigenous to that region.

Livestock production makes a contribution to global greenhouse gas emissions, as do all food production systems and human activities. The precise extent of livestock's contribution is under some debate, yet the consumer often believes that reducing meat consumption may reduce their personal environmental impact. This is a fallacy, and leads to a series of impacts, many of which may have negative environmental or health consequences.

Efficiency of feed/food conversion from plants to humans is often used as an argument against livestock production, yet this argument neglects to account for the many grasses, forages and by-product feeds that are fed to livestock and that cannot be used for human food.

Improving productivity (milk yield, meat yield, growth rate) demonstrably reduces the environmental impact of livestock production, while improving economic cost and thus affordability to the consumer. This has been achieved through improvements in nutrition, genetics and management over time, yet future gains may be jeopardized by negative consumer perceptions of technology use in food production.

The challenge to the global livestock industry is to improve outreach and knowledge transfer, to listen to and educate the consumer about the practices used within animal production; and to find innovative ways to communicate that, thereby improving the social acceptability of animal agriculture and ensure that the market for animal-source foods continues to thrive.

A South African perspective on livestock production in relation to greenhouse gases and water usage

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There is a general perception that livestock is a major contributor to global warming. This is based on an FAO publication, *Livestock's Long Shadow*, which indicated that livestock is responsible for 18% of the world's greenhouse gas (GHG) emissions. This figure has since been proved to be an overestimation of the contribution of livestock, since it includes deforestation and other indirect contributions. The net methane (CH_4) contribution of enteric fermentation to GHGs is only 5%. The atmospheric lifetime of CH_4 is 12 years compared with 100–200 years of carbon dioxide (CO_2) and its heating potential is 23 times higher than that of CO_2. More emphasis on the reduction of CH_4 emissions can thus be expected in the immediate future if government reduction targets are to be met, since its impact will be faster owing to the shorter lifetime and greater owing to the higher heating potential than CO_2.

The livestock production supply chain is often accused of using large quantities of water, with claims of 15 500 L/kg beef produced that are based on questionable assumptions. In such a debatable study that claims that the water requirement is 15 500 L/kg beef, it is assumed that it takes three years to produce 200 kg of boneless beef. In the same report, only 1% (155 L) is calculated for drinking, cleaning and post farm gate activities, which is too low. In studies with more realistic and justifiable assumptions, it was calculated that the water requirement for red meat production was 18 to 540 L/kg, the large variation being because of differences in production systems and efficiency. Post farm gate, there is concern about the efficiency of water usage in abattoirs and processing plants as water appears to be used inefficiently and is wasted.

In South Africa agriculture consumes 74.5% of the rainfall, of which 60% is utilized by natural vegetation, 12% by dry land crop production and 2.5% by irrigation. Natural vegetation and dry land crop production use only "green" water. It is called "green" water because only plants growing in the soil can utilize this water stored in the soil. In extensive grazing systems the natural vegetation serving as livestock fodder uses only "green" water that cannot be used for crop production, since crops will not survive or produce economically. Green water can thus be used only for the production of meat or other animal produce on natural rangelands and the quantity of water used is therefore irrelevant. This is different from intensive systems of Europe and North America. In the case of pork, milk and poultry production, much more realistic values are also presented in this paper.

Herbivores are important to humankind since most of the world's vegetation biomass is rich in fibre. Only herbivores can convert this high fibre vegetation into high-quality protein sources (i.e. meat and milk) for human consumption. Livestock is the world's largest user of land resources. In South Africa approximately 70% of the surface area is suitable only for extensive livestock farming Furthermore subsistence farmers keep livestock for multiple purposes and households depend on livestock for the milk, meat, hides, horns, fertilizer and income, making it central to the livelihoods and wellbeing of rural communities.

Production systems have a large effect on the production of GHG. Under natural rangeland conditions (the cow-calf portion of the beef production cycle in South Africa) decomposition of manure is aerobic, leading to production of CO_2 and H_2O as end products. Part of the CO_2 released from the aerobic digestion of manure is absorbed during the regrowth of the surrounding vegetation, rather than released into the atmosphere. The carbon sequestration measurement of this has been neglected and therefore the quantitative effect is not known. This is in sharp contrast to intensive systems in large parts of Europe and North America, where large quantities of manure are stockpiled, often for long periods, and undergo anaerobic decomposition to produce CH_4

In general, ruminants in extensive systems are found to have a lower per-area carbon footprint than grain-fed systems, but a higher footprint if expressed in terms of kg product. Feedlots maximize efficiency of meat production, resulting in a lower carbon footprint, whereas organic production systems consume more energy and have a bigger carbon footprint than conventional production systems. Cows on pastures produce more methane than cows on high concentrate diets.

The argument that livestock should be replaced with fruits, grains and vegetables to feed people implies that all sources of food production require a similar and equal quantity and quality of resources. This is an invalid point of departure. Large regions are completely unsuitable for growing fruits, grains or vegetables, and animal production is the most sustainable way of food production in these areas. Thus, a switch from livestock to fruits, grains and vegetables will have implications for food security in Africa and other developing countries.

An effective way to reduce the carbon and water footprint from livestock is to reduce the livestock numbers and increase the production per animal, thereby improving their productivity. Increased productivity generates less GHG emission per unit of livestock product. Production efficiency can be improved through breeding, feeding management, and alternative production systems.

It is also important to promote the efficient use of green water in extensive grazing areas through good rangeland management systems. This will result in the production of more fodder, increasing animal product per unit of water, promoting increased CO_2 sequestration and reducing the unproductive run-off of water.

This paper gives a balanced view on livestock production in relation to greenhouse gases and water usage to ensure that politicians, decision makers and the public are properly and correctly informed about the impact of livestock on GHG production and water usage, and it is trusted that they note the key issues. Continued efforts are essential to convey a balanced view to the public of the contribution of livestock to global warming and its water usage, while countering the misleading propaganda of activist groups against animal agriculture.

Climate change and livestock production: A review with emphasis on Africa

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The impacts of climate change on agricultural production and livestock are difficult to establish and distinguish from other changes in the natural and human environments. Many non-climatic drivers are interconnected with the effects of climate change, such as migration, overgrazing of natural pastures, alteration in livestock management, and change in human and livestock population. In Africa the agricultural sector supplies up to 50% of household food requirements and of household incomes. Most of the income is generated by beef cattle, dairy cattle, goats, sheep and chickens. Vulnerability to climate change depends on physical, biological and socio-economic characteristics. Low-income populations that depend on subsistence agriculture are particularly at risk of being affected. Climate change will affect animal production in four ways: the impact of changes on livestock feed-grain availability and price; the influence on livestock pastures and forage crop production and quality; changes in livestock diseases and pests; and the direct effects of weather and extreme events on animal health, growth and reproduction. These factors may interact with one another and also with social and anthropogenic changes, including habitat destruction and changes in land use, which occur globally and locally, and increase mobility of people and movement of goods, including livestock.

Livestock production in Africa and southern Africa, especially its developing component, is vulnerable and at high risk of being severely affected by climate change. African farmers are known to keep animals as an insurance policy. For rural communities, the loss of livestock assets could trigger a collapse into chronic poverty and have a lasting effect on their livelihoods. Climate can affect livestock directly and indirectly. Direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance: growth, milk production, wool production and reproduction. One of the most evident and important effects of climate change on livestock production is mediated through changes in feed resources. Although indirect, feed resources can have a significant impact on livestock productivity, the carrying capacity of rangelands, the buffering ability of ecosystems and their sustainability, and the distribution of livestock diseases and parasites.

Climate influences livestock ownership. The probability of owning livestock increases as annual temperature increases, but decreases as annual rainfall increases. Farmers adapt to hot and dry climates by shifting to livestock farming. There is a relationship between the probability of choosing a livestock species and annual temperature and precipitation. The probability of choosing cattle decreases rapidly as temperature rises, while the probability of choosing goats and sheep becomes greater. Generally in Africa, large farms are more dependent on cattle, but as the temperature increases, maintaining production levels will become difficult. In contrast, small farms have the advantage that they can switch more easily from temperate animals to heat-tolerant animals or from crop farming to livestock. Cattle and sheep numbers all decrease as precipitation increases, while goats and chickens are more likely to be chosen as species as rain increases.

The direct and indirect effects of climate change will in all probability be less on small ruminants and monogastric farm animals owing to a degree of tolerance to these conditions and their production environments. However, the same does not apply to extensive beef and dairy production. Mitigation and adaptation measures such as more efficient nutrition; breeding smaller, lighter in colour, reproductively sound, high feed to milk conversion, high feed to meat conversion and disease tolerant animals; environmentally friendly and seasonally adjusted production systems; optimizing output from the developing livestock farming sector; and more drought resisting fodder crops/pastures will be paramount in negating the predicted negative climate change effects.

Livestock breeding for sustainability to mitigate global warming, with the emphasis on developing countries

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Global warming is expected to have more extreme effects on developing countries of the southern hemisphere than on countries of other continents. The anticipated global warming will change southern hemisphere environments and vegetation. Ambient temperature is the factor that has the largest direct effect on livestock production, and nutritional stress has the largest indirect effect on the grazing animal. An improved understanding of the adaptation of livestock to such changing production environments is thus important, but the measurement of adaptation is complex and difficult. Proxy-indicators for adaptation, such as reproductive and production traits, however, can be used.

Livestock industries have a responsibility to reduce the release of greenhouse gases (i.e. the carbon footprint) and water use (i.e. the water footprint). An effective way of decreasing the carbon and water footprints from livestock is to reduce livestock numbers and increase the production per animal. Increased production generates less greenhouse gas emissions per unit of livestock product.

Production recording forms the backbone of any breeding or improvement programme. However, in many developing countries, the infrastructure and systems for conventional animal improvement are lacking and marker-assisted selection does not seem to be the solution. A scientifically based central database has many advantages for developing countries that want to compete globally and at the same time to ensure local capacity in research, development and a knowledgeable industry. Sustained public support is necessary since recording schemes usually benefit users, primary beneficiaries and consumers, as well as a host of other groups, including the government.

Sophisticated statistical models continue to support animal breeding and improvement, especially with production traits. Traits linked to fertility and survival are still problematic and appropriate genetic technology to properly characterize these traits still needs to be developed. Currently most measurements to improve production in developing countries, and many other parts of the world, are per individual (milk production, fibre production, weaning weight, calving interval, growth rate, etc.). Selection for these traits will increase production, but not necessarily productivity or efficiency of production. Proper definition of breeding objectives and trait characterization are therefore essential to implementing efficient breeding systems to cope with climate change and for optimal utilisation of genetic resources. The focus should now shift to improving reproduction, cow/ewe efficiency (e.g. kilogram calf weaned/large stock unit or total weight of lamb weaned) and post-weaning efficiency. For post-weaning efficiency, traits such as residual feed intake and residual daily gain can be considered. An alternative may be to apply economic weights to the breeding values for average daily gain and daily feed intake directly.

Traditional breeding objectives for dairy cattle assume that an increase in individual production will be followed by an increase in the economic margin per animal if maintenance requirements continue to decline as a proportion of the total. This is acceptable only if selection for production maintains or increases feed efficiency and product quality, which may not be true. Any breeding objective for dairy cattle should include all economically relevant traits, as well as traits related to animal welfare.

Strategies that utilize breeding values derived from genomic analyses may speed up the process of breeding animals with higher and more efficient production in dairy cattle. However, in beef cattle and small stock some challenges must still be addressed. Most countries have a large variety of beef or small stock breeds, but most of these breeds do not have the resources to genotype sufficient numbers to render genomic breeding values of sufficient accuracy to accelerate genetic improvement. Another challenge facing these industries is the limited recording of performance traits. Chips that are currently available are adequate for studies on taurine breeds, but contain less information for Zebu or landrace breeds. Overall, strategies that utilize breeding values derived from DNA information, together with conventional mixed-model methodology, may speed up the process of breeding animals that are adapted to the environments that are newly created as a result of global change.

All alterations in DNA function without alterations in DNA sequence are referred to as epigenetics and can be described as the collective heritable changes in phenotype that arise independent of genotype. Epigenetic mechanisms may explain why some breeding programmes, where pedigree populations are developed and selected in ideal environments (different from those in which their progeny are expected to perform), have been unsuccessful. With a better understanding of epigenetic mechanisms and close cooperation between primary breeders and their customers, it may be possible to tailor-make commercial livestock for different environments (specific nutrition, housing types, and climates), resulting in greatly improved production efficiencies.

Developing countries have to enhance the competitiveness of their livestock industries in national and international markets. With beef cattle, it is anticipated that crossbreeding with indigenous breeds as dam lines will be increasingly used. With the impact of climate change, economic crossbreeding will rely heavily on dam breeds with low input costs, but sire breeds that are appropriate for the ultimate use of progeny that optimize the production from the dam line. With regards to crossbreeding, southern African countries have a challenge to develop multi-breed genetic evaluations to better evaluate composite breeds and to accommodate the evaluation of crossbred beef cattle, especially bulls.

The livestock industries in developing countries are highly dualistic with commercial, emerging and communal sectors (subsistence or small-scale farmers) all co-existing, with major discrepancies in production and throughput among the various sectors. Only when these management factors are addressed, will the formulation of breeding objectives and strategies have an impact in the emerging and communal sectors. Furthermore, subsistence farmers in Africa keep livestock for multiple purposes. The formulation of breeding objectives/strategies will somehow have to consider these dynamics.

The ways in which livestock are bred, as well as livestock production systems, have changed drastically in the twentieth century. The human population explosion gave rise to widespread competition with other species and other uses for agricultural land, and influenced the environment in which livestock are raised. This resulted in increased intensification of production, changes in production systems and in the breeds used. In addition, climate change will result in increases in the frequency of heat stress, droughts and floods, which will have adverse effects on livestock production. The last two decades have been marked by the development of advanced technologies and knowledge. To benefit fully from these technologies, developing countries should stay abreast of these developments.

It will become more important to match the genotype to the environment to ensure a sustainable increase in production, to define breeding objectives and to develop appropriate selection criteria to ensure that breeding is effective and aimed at sustainable production in changing environments.

Sustainability of the South African Livestock Sector towards 2050. Part 1: Worth and impact of the Sector.

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Livestock agriculture in South Africa as elsewhere is under scrutiny because of negative perceptions by the general public and anti-livestock activists. In most instances this results from ignorance and wrong information. In this report it is the intention therefore to provide information on the worth and impact of the livestock sector; information and statistics which also will provide a baseline and point of departure in guiding sustainability towards 2050.

Seventy percent of agricultural land in South Africa can only be farmed with livestock and game. Therefore species are found in all provinces with high concentrations in the eastern higher rainfall regions. Statistics in 2010 indicated 13.6 million beef cattle, 1.37 million dairy cattle, 24.6 million sheep, 6.33 million goats, 2.99 million game species (private ownership), 1.13 million pigs, 113 million broilers, 31.8 million layers and 1.6 million ostriches. Forty-one percent of beef cattle, 12% of sheep and 67% of goats are in small scale and communal ownership.

The gross value of livestock products in 2006/2010 compared to 1995/2000 has increased by 185%. During this period, livestock products compared to field crops and horticulture have increased their position from 42% to 47% of agricultural gross value. The main reason is a rise in the value and demand for livestock foods, particularly meat which increased from 33.9 kg/capita/annum in 2000/1 to 56.4 kg/capita/annum in 2008/9. This observation is in line with trends elsewhere in the developing world; increasing affluence being the major reason. Of the consumer food basket livestock foods on a weight basis contribute 27%. Consumption of livestock foods resembles that of developing countries with meat being 50 - 90 g/capita/day, milk and dairy products 120 - 130 g/capita/day and eggs 15 - 20 g/capita/day. Being the average for the country, consumption of livestock foods by the poor which may differ 10-fold from consumption by the rich, is of concern given the many health attributes of livestock foods.

The livestock sector in South Africa is a major role player in the conservation of biodiversity through a variety of environmentally well-adapted indigenous and non-indigenous breeds and rare game species, notably disease-free buffalo, black and white rhinoceros, and sable and roan antelope. It has also shown commitment to rangeland/ecosystem conservation through conservative stocking rates, with several studies and observations reporting improvement in rangeland condition and vegetation species composition since the nineties. With the present rangeland condition as point of departure, a new grazing capacity map was compiled using new technology based on net annual vegetation primary production from the MODIS satellite programme.

Although the sector is a modest contributor to GDP and trade, forward and backward linkages increase the contribution 3-fold. Trade with Africa is increasing, particularly in the SACU region, indicating that the South African livestock sector plays an important role in stabilizing the economies of SADC countries. On the other hand, some imports from the EU, Australasia and Brazil are highly competitive and contribute to the country becoming a net importer of livestock products.

The sector has always been a major employer, but employment rate has declined markedly since 2000 because of increased minimum wages, less commercial farmers and increased property size. Some 245 000 employees are employed on 38 500 commercial farms and intensive units with wages amounting to R6100 million; the number of dependants being 1.45 million. The estimate for communal and small scale livestock farming is 10 - 12 million people depending at least partially on 2 million livestock owners. Livestock farming furthermore is the backbone of the socio-economy and sustenance of most non-metropolitan towns and rural communities; in rural communities providing multiple livelihood objectives and offering ways out of poverty.

Sustainability of the South African Livestock Sector towards 2050. Part 2: Challenges, changes and required implementations

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The intention of this report is to discuss the challenges facing the livestock sector towards 2050 and where changes and alternative management options will be required to maintain sustainability.

A major challenge is the environmental impact of the sector. Climate change is expected to result in a drier and warmer country, the average temperature may rise by 1.5 - 2 ºC. Enteric fermentation by livestock, including farmed game, is estimated at 1330 Gg methane (CH_4)/year and accounts for 95% of total livestock and 60% of total agricultural carbon dioxide (CO_2) equivalent (e) emissions. Agriculture contributes about 8.5% to country CO_2 emissions. For beef and milk South African commercial production estimates are in the upper half of life cycle assessments of 25 - 35 kg CO_2 e/kg beef and 1.3 - 1.5 kg CO_2 e/kg milk for developed countries, suggesting scope for improvement. Grass burning as a common practice in rangeland management will have to be reconsidered in view of its environmental impact. The high variation in abattoir and dairy factory effluent discharge is worrisome, which suggests that bench marks should be set.

Animal welfare in South Africa is supported by the Livestock Welfare Coordinating Committee (LWCC) and adherence codes for production practices. Humane treatment of animals is guided by civilised practices and efficiency of production. Humane treatment is more difficult to maintain in intensive housing systems, which suggest that poultry and pork systems should take special care.

Livestock numbers in communal and small-scale sectors are significant but these sectors need rapid introduction into commercialization to relieve poverty and contribute to gross domestic product (GDP). This requires partnerships, and major inputs and paradigm shifts from government tiers, in terms of land reform too. Input costs are increasing at a faster rate than commodity prices. The increasing labour costs raise concern because of the effect on employment in commercial agriculture and the required rapid commercialization of the small-scale/developing sector.

Efficiency of production should be on par with competitors if the livestock sector is to compete effectively on the domestic and export markets. This is indeed the case in the poultry industry, but rising feed costs, disease and unprotected imports constitute an Achilles heel. Efficiency in the other industries can be measured by off-take percentage. In commercial production percentage off-take is 23 - 33 for beef, 29 - 35 for sheep, 33 for goats and 125 for pigs and in small- scale/communal production 6 - 25 for beef, 2.3 - 36 for sheep, 10 for goats and 51 for pigs. For commercial production the numbers compare well with the most extensive systems in Australia and South America, but fall short when compared with the EU, New Zealand and the USA. An important reason is below average calving and lambing rate, which should be addressed urgently, and high mortality rates through disease and predation. Estimates indicate that the amount of feed and water required per kg beef and the amount of CH_4 produced per kg beef will be reduced by 20%+, if calving rate should increase from 60% (close to national average) to 80%. On the breeding/genetics front more efficient animals should be identified through selection based on Residual Feed Intake (RFI) and by rapid implementation of genome - based techniques.

Although rangeland condition has improved, effective management through conservative stocking rates, adequate resting periods and fodder provision during periods of shortage will continue to be critical, maybe even more so because of climate change. Many farmers do not make provision for extra fodder, thereby putting both the enterprise and the heritage responsibility at risk.

Controlled and notifiable diseases remain a risk, also for participation in world trade. Although recognizing the need for effective control, it is disturbing that certain Office International des Epizooties (OIE) standards are too stringent when trade is commodity-based in which the threat is basically zero. With climate change new and rarely occurring diseases will bring a further dimension. Zoonosis and risk associated with insufficient hygiene measures in informal markets have an infection and food safety component. With certain microbial strains becoming resistant to antibiotics, research and development have to focus on finding alternatives that are effective in maintaining health and efficiency of production.

Stock theft and predation are increasing concerns. Stock theft has a major impact on the commercial sector and is crippling the small-scale/communal sector. It will have to be curbed by the police through greater commitment and resources, supported by farmer and community anti-theft structures. Predation will require joint goodwill-based solutions by farming and wildlife management structures, including activists.

Compared with certain agronomical and horticultural commodities, livestock agriculture is only marginally competitive and is therefore increasingly vulnerable to deregulation and trade liberalization. Tariffication should assist, but needs to be done with circumspection, so does government with free trade agreements. Since export is highly correlated with competitiveness, export opportunities should be sought. Currently export of livestock products is a dismal 5% of total agricultural export earnings.

Farmers should consider the consumer in their production practices, since access of citizens to safe healthy foods and entitlement to being informed are basic human and democratic rights. This will require positive attitudes to bio-security measures and auditing, traceability, control of access to farms, branding and effective communication down the value-adding chain.

Direct greenhouse gas emissions from South African livestock industries: Dairy and beef cattle; Small stock sector; Monogastric livestock and the Game industry

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Globally agriculture and livestock producers have come under increasing pressure over the environmental impact of production systems. The objective of this paper was to re-calculate the direct methane (CH_4) and nitrous oxide (N_2O) emissions of livestock production systems in South Africa, taking into consideration the uniqueness of the South African scenario. It is important to generate accurate greenhouse gas (GHG) baseline figures to develop South Africa's capacity to understand and reduce GHG emissions from the livestock sector.

Livestock produce GHGs in the form of methane from enteric fermentation, and nitrous oxide and methane from manure management and manure deposited on pastures and veld (rangeland) by grazing animals. Agriculture, forestry and land use (corrected for carbon sink values) emitted an estimated 4.9% of South African GHG gases in 2004, which makes it the third largest GHG contributor in South Africa after the energy industry and industrial processes. Livestock produced approximately 27% of national methane emissions and 98% of the agricultural sector's methane emissions in 2004.

Methane is a potent GHG that remains in the atmosphere for 9 to 15 years and is 25 times more effective in trapping heat in the atmosphere than carbon dioxide (CO_2) over a 100-year period. Nitrous oxide has an atmospheric lifetime of 150 years and a global warming potential of 296 times that of CO_2.

South African livestock production is based on a unique combination of commercial (intensive and extensive) and emerging and communal (subsistence) production systems. The levels of productivity and efficiency in these production systems vary greatly in certain areas, and it is important to distinguish between them when calculating GHG emissions. Previous inventories were conducted on a national scale, utilizing IPCC default values (Tier 1 approach) for some or all of their emission calculations. These emission factors do not distinguish effectively between classes of animals, production efficiencies, and production systems. They are often based on assumptions of animals utilizing diets that are not representative of South African production systems.

The IPCC Tier 2 methodology seeks to define animals, animal productivity, diet quality and management circumstances to support a more accurate estimate of feed intake for use in estimating methane production from enteric fermentation. It was also considered important to do separate calculations for provinces, as provinces differ in vegetation or biomes and production systems, which may require different approaches to mitigation recommendations. Owing to the heterogeneity of feed types in South Africa it was considered important to use methodologies that could reflect such differences, and were developed under similar conditions.

The methodology utilized is based on Australian National Greenhouse Accounts' National Inventory Report, which contains Australian country-specific and IPCC default methodologies and emission factors. Emission factors specific to South African conditions and management systems were calculated where possible. A Tier 2 approach was adopted for all major livestock categories, including privately owned game in accordance with the IPCC Good Practice requirements. Recently game farming has become a recognized commercial enterprise in the agricultural sector, and needs to be included as an anthropogenic emissions source.

Methane emissions from South African livestock were estimated at 1328 Giga gram (Gg) in 2010. Dairy and beef cattle contributed an estimated 964 Gg or 72.6% of the total livestock methane emissions in South Africa in 2010. Beef cattle in extensive systems were the largest contributor (83.3%), followed by dairy cattle (13.5%), and feedlot cattle (3.2%). The estimated direct enteric methane emissions factors for dairy and beef cattle were higher than the IPCC default factors for Africa. The Eastern Cape recorded the highest dairy and beef cattle methane emissions, whereas Gauteng showed the highest feedlot methane emissions, primarily because of cattle numbers.

Small stock were responsible for 15.6% of the total livestock emissions, contributing an estimated 207.7 Gg, with sheep producing 167 Gg and goats producing 40.7 Gg. Calculated enteric methane emission factors for both commercial and communal sheep were higher than the IPCC default values for developing countries. A similar tendency was found with goat emission factors. The highest sheep and goat methane emissions were reported for the Eastern Cape.

The pig and ostrich industry both contributed approximately 8 Gg CH_4 in 2010. North West produced the highest commercial pig GHG emissions with the highest communal pig emissions originating from the Eastern Cape. The poultry industry was the largest direct N_2O producer of the non-ruminant livestock industries, contributing 2.3 Gg or 92.8% of the total non-ruminant N_2O emissions.

The privately owned game industry contributed an estimated 131.9 Gg of methane emissions with the provinces of Limpopo, Eastern Cape and Northern Cape being the three largest contributors with 43.4, 37.3 and 21 Gg methane, respectively. The total privately owned game population was estimated at 2 991 370 animals, utilizing 20.5 million hectares.

Beef cattle are the major contributors to livestock GHG emissions in South Africa, followed by sheep, privately owned game, dairy cattle, goats, pigs, ostriches, equines, and poultry. The IPCC default values for Africa underestimate emission factors across all livestock categories. The methane emission factors calculated for commercial livestock production systems are more comparable with emission factors from developed countries and the emerging/communal production systems with those of developing countries. This emphasizes the need to develop country-specific emission factors through quantitative research for livestock in all provinces and on all types of production systems to produce accurate baseline figures, which is critical to future mitigation protocols.

The impact of animal source food products on human nutrition and health

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What we choose to consume (nutrition) influences the health of human beings and therefore also their quality of life. Livestock or animal source foods (such as cattle, sheep, goats, pigs, chickens, and a dozen or so lesser known species) are often the dietary component that evokes the widest array of complex scientific, economic, environmental and political issues. It is viewed as the most expensive component of any diet, yet can make significant contributions to human health through providing high quantities of essential nutrients. In addition to quantity, the high quality of the nutrients found in animal source foods are also of importance as these high quality nutrients are more readily available for absorption into the human body than lower quality nutrients from other food, and non-food sources.

As South Africans increasingly suffer from the consequences of inappropriate diets (both over and under nutrition), the role of animal source foods as part of a healthy diet requires continues investment in research and the extrapolation of the information towards appropriate guidelines and recommendations. Although it is regularly suggested to limit the intake of animal source foods due to possible linkages between animal product consumption and health concerns, scientific evidence increasingly indicates a beneficial role which animal source foods could play in preventing and combating obesity and other non-communicable diseases related to overnutrition.

In appropriate amounts animal source foods are valuable sources of complete, high quality, easily digestible protein and many essential micronutrients such as iron, zinc, calcium, vitamin A and vitamin B_{12}. On the other side of the malnutrition scale, the overconsumption of food, and specifically those high in saturated fat and cholesterol, salt (sodium) and total energy have been linked to overweight, obesity and subsequent diseases of lifestyle. To maintain a healthy balance, it is recommended to consume a balanced diet containing a diversity of foods from all the different food groups, including lean meat, whole grains, vegetables, fruit and dairy products.

In comparison to the significant burden which overweight and obesity has on South Africans, childhood and maternal underweight are ranked as the 12th greatest risk factor for death, with vitamin A deficiency 14th and iron deficiency anaemia 16th. The global fight against hunger is well recognised, and ample policies are in place to increase food availability and access. Yet, the provision of energy, without the adequate intake of critical nutrients such as protein and micronutrients, may promote adipose tissue (fat) gain and obesity, while not contributing to other dietary needs such as protein and micronutrient requirements. An insufficient supply of nutrients to the human body restricts and retards not only physical development, but also cognitive (mental) development, and both manifests as prominent financial and social burdens on a society.

The high nutrient density of animal source food types has an advantage in food-based interventions targeting vulnerable groups such as infants, children and people living with HIV/AIDS, who may have difficulty consuming the large volumes of plant based foods needed to meet their nutritional requirements. A 100 g of cooked beef provides almost an entire day's recommended intake of vitamin B12, half of the recommended intake of protein and zinc and contributes substantially to meeting the vitamin B_1, vitamin B_2, vitamin B_6 and iron recommendations. Similarly, two large eggs would supply more than 20% of the daily protein requirements, nearly 30% of daily vitamin B_2 requirements and two thirds of daily vitamin B_{12} requirements. A serving size (30 g) of cheddar cheese provides almost 20% of the daily calcium requirements, more than 10% of daily zinc requirements and 8% of daily vitamin B_2 and B_{12} requirements.

Furthermore, animal source foods provide multiple micronutrients simultaneously, which may be important in diets that are marginally lacking in more than one nutrient. For example, vitamin A and riboflavin are needed for iron mobilization and haemoglobin synthesis, and iron supplements may not reduce the prevalence of anaemia if intakes of these other nutrients are low. Thus, foods such as liver that contain substantial levels of both iron and preformed vitamin A may be more effective than single nutrient supplements in alleviating poor micronutrient status, emphasising the delivery of nutrients within a specific food matrix.

In addition to the amount (*quantity*) of a nutrient consumed, the *quality* of the nutrients is also important. Animal-based proteins contain greater amounts of protein per portion, and contain all the essential amino acids. Furthermore, animal source foods contain haem iron which is more readily available for absorption in the human body than iron from plant sources.

Originally, dietary fat was mainly considered as a source of energy. Later research has introduced the concept of essential fats which need to be provided by the diet to prevent deficiencies. Two dietary fatty acids are classified as essential, namely, linoleic acid (C18:2) and linolenic acid (C18:3). Meat and meat products contribute consistently not only in terms of the essential fatty acids such as linoleic (C18:2n-6) and α-linolenic (C18:3n-3) acid to the diet, but also C20 and C22 polyunsaturated fatty acids present in meat phospholipids. Ruminant meats and oily fish are the only significant sources of preformed C20 and C22 PUFA in the diet. There has also been considerable interest in the beneficial role of conjugated linoleic acid (CLA) and naturally occurring trans fatty acids found in meat and dairy products, within human nutrition.

Five of the top 10 risk factors for death are directly related to dietary choice, overweight and obesity, namely high blood pressure, excess body weight, high cholesterol, diabetes and physical inactivity. When populations modernize as a result of socio-economic development, urbanization and acculturation, it is often characterized by changes in dietary patterns and nutrient intakes that increase the risk of diet-related non-communicable diseases. While some of the associated dietary changes improve calcium and iron intake as a result of higher dairy and meat intake, it is also associated with an increased consumption of saturated and total fat, sodium and added sugars. Intake of legumes and vegetables commonly decreases while intake of micronutrient-poor snack foods, convenience foods (often high in sodium and fat) and sweetened carbonated beverages as well as added sugar increases.

The rapid increase in overweight and obesity, in the midst of persistent nutritional deficiencies, has increased the focus on dietary-choices. Certain animal-source foods could be considered high in fat, saturated fat and total energy, however these products have the potential to be nutrient-dense (defined as a high ratio of nutrients (in grams) compared to the total energy content (in kilojoules). As an example, due to consumer demand, the fat content of South African red meat has decreased to less than 10g per 90g portion through breeding, farming and butchering techniques. Trimming excess fat and skin of meat, choosing lean or low fat options and minimizing the addition of fat during preparation could ensure that animal source food contribute only small quantities of fat in line with dietary guidelines.

In addition to controlling fat intake, there is ample evidence suggesting that diets restricted in carbohydrates and with a stronger emphasis on protein intake can aid weight loss. Some of the reasons why red meat may help decrease weight include the increased satiating properties of protein which may explain decreased food intake, as well as the effect that increased protein intake has on thermogenesis, body composition and decreased energy efficiency.

A healthy, balanced diet builds upon the foundation of the right amounts of nutrient-dense foods from a variety of food groups, including lean meat, whole grains, vegetables, fruit and dairy products. The more nutrients present and the fewer the kilojoules, the higher the nutrient density.

Animal source foods play a key role in a balanced diet by providing nourishing nutrients. A serving of lean animal source foods can provide more than seven nutrients in significant amounts which are important to human health and development, i.e. the meat from about two lamb chops contribute to nearly half of an adult's Recommended Dietary Allowance (RDA) for protein, more than 30% of the RDA for zinc and it contributes significantly to the intake of other essential vitamins and minerals including iron and magnesium, as well as the B-vitamins.

The effect of production system and management practices on the quality of meat products from ruminant livestock

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The demand for good quality protein from animal origin is increasing worldwide owing to the significant growth in the human population and changes in their health, wealth and life expectancy. Developing countries will play an increasingly important role in terms of supplying the demand for meat and meat products because many developed countries have limited resources with which to increase production. Significant progress has been made in terms of breeding, feeding and managing livestock in different production systems in order to increase both the level and efficiency of meat production, but consumers are concerned about the environmental impact of the intensification of production systems and the use of modern technologies such as feed additives and growth promotants.

Various combinations of pasture-based and intensive systems are employed to raise ruminant livestock for meat production, depending on resources and climate. Environmental and economic conditions influence the feasibility of meat production, and often result in shifts from pasture-based (extensive) to conventional or concentrate-based (intensive) finishing before marketing. Perceptions of consumers of the quality of animal products from these production systems vary, but the real differences in terms of product quality are poorly understood.

In South Africa, cattle and sheep are generally fattened for short periods to ensure efficient production and to meet market requirements. These objectives are more easily achieved by feeding different proportions of concentrate diets, with or without feed additives and growth promotants (steroidal and non-steroidal growth implants, feed additives and beta-adrenergic agonists) that are approved for use in food-producing animals. Although the use of growth promotants is controversial, it is strictly controlled and must comply with health and food safety regulations.

Livestock production systems affect extrinsic and intrinsic aspects of carcass and meat quality. Extrinsic aspects include weight gain, age at slaughter and carcass weight. Concentrate feeding generally yields faster growth and more consistent carcass composition compared with pasture-fed animals, which addresses the necessity for more consistent product quality. Intrinsic aspects of carcass and meat quality include carcass composition and conformation, carcass fat content and colour, meat composition, colour, tenderness and flavour.

One of the most pronounced differences between beef from pasture and concentrate-fed cattle is meat colour. Beef and lamb from pastures are darker, and carcass fat often contains more yellow pigments, which may affect a consumer's choice to purchase. Meat flavour is a complex aspect of meat quality, and perceptions about meat flavour are influenced more by previous experience and cultural background. The typical pasture flavour in meat is due to the presence of branched-chain fatty acids, 3-methylindole and other oxidation products, which may result in off-flavours. In many countries, meat flavour of intensively fed livestock is preferred to pasture-fed animals, although certain consumers prefer meat with the more intense pasture flavour. Pasture feeding has beneficial effects on the n-3 fatty acids, notably eicosapentaenoic acid (EPA, C20:5*n*-3) and docasahexaenoic acid (DHA, C22:6*n*-3). Meat tenderness is regarded as one of the most critical quality parameters of meats. The balance of opinion on the effect on meat tenderness of pasture versus concentrate feeding is in favour of concentrate-fed animals. Although beef and lamb from pasture-fed animals are generally less tender, shelf life is better owing to the presence of antioxidants such as vitamin E. More consistent meat quality is achievable in pasture-based systems, but requires better management and strategic feed supplementation. There is growing demand for meat products from different production systems. This necessitates better labelling to inform consumers about the origin, system and methods of meat production.

The effect of different production systems and practices on the environmental impact, quality and safety of milk and dairy products

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Science has demonstrated the importance of milk and dairy products in childhood development, health maintenance and the prevention of chronic diseases. Recently some milk processors and retailers have begun to make label claims that describe specific production systems and management procedures on dairy farms, thereby confusing consumers by creating the impression that milk produced under certain conditions is healthier or safer than other milk. These claims include the practice of organic farming, the non-use of ionophore antibiotics, and the marketing of recombinant bovine somatotropin (r-bST)-free milk. The purpose of this paper is to clear misconceptions created by uninformed media, environmental activists and irresponsible product labelling, and provide readers with scientific facts about the effects of different dairy production and management systems and the implementation of technology on the safety and quality of milk and dairy products. Recombinant bovine somatotropin was one of the first products of biotechnology, and some still claim that r-bST causes cancer and mad cow disease, increases antibiotics in milk and lowers the quality of milk. However, various health and governmental organisations have concluded that milk from r-bST-supplemented cows is safe for human consumption based on these scientifically established facts: i) bovine somatotropin is a protein hormone, and not a steroid hormone, and, like all other plant and animal proteins, is digested in the human gastrointestinal (GI) tract; ii) it is species specific and does not have biological effects in human beings; and iii) most bST milk is denaturated by pasteurisation. Furthermore, bST is a naturally occurring protein hormone produced by the anterior pituitary gland of the cow, and is present in all milk, whether cows are supplemented with r-bST or not. Fears of higher insulin growth factor 1 (IGF-1) levels in milk from r-bST-supplemented cows are unfounded, since they are insignificant compared with the daily secretion of IGF-1 in human saliva and GI secretions.

Although science does not support most claims that suggest improved health, nutrition and safety from organic foods versus conventional, the “good food, bad food” debates continue. Science has proved that there are few and minor differences in the composition and quality of conventional r-bST-free or milk that is labelled organic, and that all milk is wholesome. Various studies have confirmed that r-bST does not affect milk flavour or manufacturing characteristics that are important during the production of processed dairy foods such as cheese or yoghurt. The important point is that consumers should be able to choose milk and milk products from different production systems and not be confused by “free-from” labels that create the impression that some milk is of higher quality and is more nutritious than other types.

The use of ionophore antibiotics is common practice in the beef and dairy industries in South Africa and many other countries, and significantly improves the efficiency of meat and milk production. Consumers’ increased demand for safe, high-quality nutritious food produced with fewer synthetic inputs, in particular the use of antibiotics, has led to the European Union banning the use of antibiotics, including ionophores. The scientific foundation for these restrictions is based on concerns that the use of animal antibiotics can give rise to transmissible resistance factors that may compromise the therapeutic use of antibiotics in human beings. This scientific basis, however, is not well supported: i) ionophores have never been (or are likely to be) used as an antimicrobial in human beings; ii) ionophores have a distinctly different mode of action from therapeutic antibiotics; and iii) ionophore resistance seems to be an adaptation, rather than a mutation or acquisition of foreign genes. There is no proven pathway of monensin into milk, and therefore no scientific basis for questioning the safety of milk from cows supplemented with ionophores.

Although consumers often have a negative image of technology in agriculture, dairy producers are encouraged to use new and existing technology to adopt management practices that contribute to improved environmental stewardship and conservation, including actions to reduce greenhouse gas emissions through reducing methane production. Ionophores and r-bST can both play a significant role in improving the efficiency of milk production and have great potential to reduce methane production in dairy cows. Organic food production systems usually require more resources, produce less food, and have a higher carbon footprint/kg milk, which makes them questionable solutions to meeting the world's growing food supply needs. Environmental impact, the availability of production system options and the use of new and existing technologies must be evaluated through whole-system approaches based on productivity and efficiency, rather than allowing ideological principles that are founded on naïve incomplete information or lack of understanding future food production.

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