Indian J Anim Health (2022), 61(2)-Special Issue: i-iii
DOI: https://doi.org/10.36062/ijah.2022.spl.overview

Guest Editors' Column

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Overview

The United Nations Organization envisaged ending hunger and malnutrition in all its forms by 2030. Degraded ecosystems, an intensifying climate crisis, and increased biodiversity loss are threatening jobs, economies, the environment and food security around the globe. About 811 million people suffer from hunger and 3 billion cannot afford healthy diets. There is urgent need to transform our agrifood systems to ensure food security, improve nutrition and secure affordable healthy diets for growing population, while safeguarding livelihoods and our natural resources.

The livestock sector is an important contributor in the agricultural gross value added (GVA). India ranks first amongst the world's milk producing Nations and has the largest bovine population in the world. Dairying has become an important secondary source of income for millions of rural families and has assumed important role in providing employment and income opportunities particularly for marginal farmers. The rapid growth in demand for animal protein has resulted in complex interactions among bio-physical resources, economic and social objectives with implications for the natural resource-base and environment. Livestock production has a large impact on the world's natural resources and contributes significantly to environmental problems such as ecosystem pollution and degradation, global warming and climate change by emission of greenhouse gases (GHGs) and biodiversity loss.

Aquatic foods are increasingly recognized for their key role in food security and nutrition, not just as a source of protein but also as a unique and extremely diverse provider of essential omega -3 fatty acids and bioavailable micronutrients. The growing role of fisheries and aquaculture sector in providing food, nutrition and employment is well known. In 2020, global fisheries and aquaculture production reached an all-time record on 214 million tonnes, worth about USD 424 billion. Globally, aquatic foods provide about 17 percent of animal protein, reaching over 50% in several countries in Asia and Africa. Underlying the importance of fisheries and aquaculture sector, UN has declared 2022 as "International Year of Artisanal Fishers and Aquaculture" and the current decade as the decade of "Ocean Science for Sustainable Development". It is high time to transform towards more efficient, more inclusive, more resilient and more sustainable aquatic food systems to help achieve the Sustainable Development Goals (SDGs).

Half of the world's habitable land (51million km^2) is used for agriculture. This leaves only 37% for forests,11% as shrubs and grasslands, 1% as freshwater coverage and remaining 1% (a much smaller share than many suspect) is built-up urban area which includes cities, towns, villages, roads and other human infrastructure. There is also highly unequal distribution of the land use between livestock and crops for human consumption. If we combine pastures used for grazing with land used to grow crops for animal feed, livestock accounts for 77% of global faming land. While livestock takes up most of the world's agricultural land, it only produces 18% of the world's calories and 37% of total protein.

In 2020, global aquaculture production reached a record 122.6 million tonnes, including 87.5 million tonnes of aquatic animals worth USD 264.8 billion and 35.1 million tonnes of algae worth USD 16.5 billion. An estimated 58.5 million people are engaged in the fisheries and aquaculture sector as full-time or part-time workers. Currently, India is the third largest fish producing country in the word and accounts for 7.96% of the global production. The fisheries sector plays an important role in the national economy and has been one of the major contributors of foreign exchange earnings to the tune of around 47,000 crores. Fisheries have emerged as a sunrise sector that is growing at the annual growth rate of over 8% during last five years. The sector also provides livelihood to about 16 million fishers and fish farmers at the primary level and several lakhs along the value chain.

Aquaculture operations can have both positive and negative effects on the environment. Natural habitats and their biota can be negatively affected, so can human health. But aquaculture is also a way to make more efficient use of existing resources. Integrated aquaculture provides a way to use agricultural waste to make marginal lands more productive by converting plant and animal waste into high quality protein and by enriching pond mud as fertilizer and for improving soil quality on crop land. The most common negative environmental impacts that have been associated with aquaculture include eutrophication of waters, water quality deterioration, alteration or destruction of natural habitats, and introduction and transmission of aquatic animal diseases. Normally, eutrophication expresses itself as an overabundance of algae, with the waters turning into agreen soup, but in tropics these is more often a bloom of floating macrophytic vegetation such as *Eichhorina*, *Pistia* and *Salvinia.*

The deposition of organic waste from fish culture ventures enrich benthic ecosystem in the proximity. The diversity of the macrofauna community may be reduced with increase in opportunistic pollution-tolerant species. The anoxic sediments may be formed and accelerated release of carbon dioxide, methane and hydrogen sulphide can happen. Increased oxygen demand may lead to higher BOD. However, in most common aquaculture system i.e. ponds, water exchange is usually low even in fairly intensive systems. Only when the ponds are drained to facilitate harvesting are the effluent discharges large with high levels of solids, BOD and nutrients. Aquaculture needs an enabling policy environment in order to grow in a sustainable manner and to be integrated into the coastal zone. Moreover the interactions between aquaculture and the larger system, in which it occurs, in particular, the influence of the surrounding natural and social environment on aquaculture, must be taken into consideration.

Global food system which encompasses production and post-farm processes such as processing and distribution is also a key contributor to emissions. For this problem we don't yet have viable technological solutions. Food accounts for over a quarter (26%; 13.7 billion tonnes CO_2 eq.) of global greenhouse gas (GHG) emissions. Land used per 100 g protein produced is 184.8 m^2 for lamb & mutton, 27.1 m^2 for milk, 3.7 m^2 for farmed fish and 2.0 m^2 for farmed prawns. Livestock and fisheries accounts for 31% of food emissions. Food waste is responsible for 6% of global greenhouse emissions.

Recent literature highlights different strategies to mitigate GHG emissions in the livestock sector. Any strategy designed to reduce the carbon footprint of livestock production should consider animal welfare amongst other sustainability metrics. The major livestock GHG mitigation strategies are classified according to their mitigation approach as reducing total emissions (inhibiting methane production in rumen), or reducing emissions intensity (Ei; reducing methane per output unit without directly targeting methanogenesis). Strategies classified as antimethanogenic included chemical inhibitors, electron acceptors (i.e. nitrates), ionophores (i.e.Monensin) and dietary lipids. Increasing diet digestibility, intensive housing, improving health & welfare, increasing reproductive efficiency and breeding for higher productivity are categorized as strategies that reduce Ei. Strategies that increase productivity are very promising ways to reduce the livestock carbon footprint, though in intensive systems this is likely to be achieved at the cost of welfare. Other strategies can effectively reduce GHG emissions whilst simultaneously improving animal welfare (e.g. feed supplementation or improving health). These win-win strategies should be strongly supported as they address both environmental and ethical sustainability. In order to identify the most cost-effective measures for improving environmental sustainability of livestock production, the consequences of current and future strategies for animal welfare must be scrutinized and contrasted against their effectiveness in mitigating climate change.

Indian J Anim Health (2022), 61(2)-Special Issue: iv
DOI: https://doi.org/10.36062/ijah.2022.spl.overview

Guest Editors' Column

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Overview

Livestock, dairy and fisheries are an important sub-sector of Indian agriculture and are gradually but steadily emerging to play a significant role in the food scenario to the livelihood security of millions of rural poor. Changing food consumption patterns among the population in favour of quality dairy, fish, poultry and other meat products coupled with growing exports of animal products on the one hand and the uncertain potential of traditional agriculture by itself to ensure food security to the masses have made the livestock, dairy and fisheries sector an increasingly important factor on the agricultural scene. Before initiation of the world's largest dairy development programmes "Operation Flood", the milk production in India was around 20 million tonnes. But now India is the largest producer of milk in the world, with an annual production of about 160 million tonnes. Though the milk production has shown an impressive growth during the last four decades, the productivity is comparatively lower in our country, which is a matter of concern and deserves attention. In these sectors food processing is also an important sector of the Indian agricultural economy. Though India has strong raw material base for food processing industry but only 37% of milk and 26% of marine products and 5% of meat are further processed in India.

Aquaculture being the fastest growing sector of animal protein production needs to be strengthened equally in terms of safe public food chain and also avoid significant problems due to high stocking densities used in aquaculture practices. Training, educations are pre-requisites to enable the personnel involved in various stages, from field to labs personnel, to detect zoonoses. However, there is a need for the fisheries sector to focus on domestic market consumption along with experts deploying more scientific methods of production, collection and processing.

The new technologies in livestock sector must be integrated with the indigenous knowledge and practices of our livestock owners and farmers. There is an implicit need to change the attitude of the field veterinarian from a clinic centered activity to more pro-active disease prevention and production promotion activities, so that the sporadic incidences of various diseases do not assume epidemic proportions. Training in various extension tools and techniques besides problem analysis and problem-solving methods.

There is also a need for policies and strategies to adjust to the new types of technologies, changing demand patterns, upcoming value chains and supermarkets, revolution in communication technology, institutional innovations and globalization and other evolving changes in the system surrounding livestock, dairy and fisheries sectors. Elimination of poverty, improvement in nutrition and supply of safe food are of prime importance in India. Often policies are focused on farming without looking at their implications for the farmers. Unless growth and development of these sectors leads to improvement in welfare of farmers, it cannot be sustained. There is a need to reconsider and reshape the good dairy farming practices including animal health, clean milk procurement, animal welfare, animal quality feed, environment and social issues etc., suitable for Indian dairy and farming scenario with sustainable fishery production.

Indian J Anim Health (2022), 61(2)-Special Issue: v-vi
DOI: https://doi.org/10.36062/ijah.2022.spl.overview

Guest Editors' Column

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Overview

Over the last few decades, the livestock sector has successfully evolved to support the global economy in addition to being able to meet up with the substantially rising human demands. Along with terrestrial crop and livestock production, aquaculture is also emerging as the fastest growing food sector. Being an excellent source of animal protein, there have been rising customer preferences for livestock products. This has added up to the production pressure from livestock especially with the prevailing global climate change scenario. In addition to this, the rapidly growing livestock sector has also resulted in complex interactions among bio-physical resources having a significant impact on the world's natural resources. The livestock sector holds its uniqueness for being severely influenced by climate change while at the same time being a potential contributor to global warming.

As the ecosystems are sensitive to changes in climate, it is necessary to examine the likely impact of climate change on various sectors within the ecosystems to be able to comprehensively understand the effects of climate change. The agricultural sector has generated considerable interest in this regard and most international studies that examine the impact of climate change on this sector due to global warming conclude that in many instances agriculture will be disadvantaged. The erratically changing climatic conditions would pose a challenge to the livestock and aquaculture due to its a drastic impact fodder and feed production, water scarcity, disease outbreaks, impaired performance and reduced reproductive efficiency. The predicted rise in temperatures along with the rising global population would increase the challenges of land and water scarcity. Severe productive losses have been reported in livestock and fishery across the world, because of climate change leaving a significant economic loss.

As per the IPCC (2018), if the global warming is not controlled to a maximum of 1.5°C within the next 10-12 years, even half a degree rise in global environmental temperature can result in devastating droughts, floods and extreme heat waves. A considerable role of human activities towards the accelerated greenhouse gas (GHG) emission has been established by the IPCC (2015). Among these activities, electricity and heat production sectors are the major contributors towards the global GHG emissions (24%), followed by industry (21%), transportation (14%), agriculture (14%), forestry and other land uses and buildings.

Farming and its allied practices serve as a potential source of GHG emission thereby leaving significant environmental consequences. Apart from agricultural farming, the livestock sector holds a substantial share towards GHG emissions (18%; FAO, 2006). Methane, nitrous oxide and carbon dioxide, are the major livestock originated GHGs with a global emission of 44%, 29% and 27%, respectively. The livestock sector is one of the significant sources of anthropogenic GHGs having a global GHG emission of 7.1 gigatonnes CO_2 year^{-1}. On the global from, India, China, Brazil, and the

USA are major regional contributors of livestock associated GHG emission. Along with these sectors, aquaculture is also gaining the spotlight for its important contribution towards food security. Global aquaculture was stated to account for nearly 0.49% of anthropogenic GHG in 2017, which was of a similar emission magnitude as that of sheep production.

Though these sectors hold an alarming contribution towards global GHG emission, their significance towards ensuring food security and global gross domestic product (GDP) make it of prime importance to implement efficient mitigation measures. This however requires an interdisciplinary and multi-institutional approach involving active global participation.

Indian J Anim Health (2022), 61(2)-Special Issue: vii-viii
DOI: https://doi.org/10.36062/ijah.2022.spl.overview

Guest Editors' Column

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Overview

A. Dairy

The environmental impacts of dairy production can vary immensely, depending on the farm management practices undertaken. The usually studied environmental impacts of dairy systems involves emission of greenhouse gases (GHGs), soil and water pollution, biodiversity loss and wildlife health, nutrient cycles (namely N, P) and land use change. For many impacts, raw milk production was implicated to be the primary contributor, regardless of the product type. Dairy products are associated with large quantum of GHG emissions as compared to food of similar nutritive content. A typical bifurcation of emissions from a dairy farm is as follows: (a) 60-70% from methane produced by rumination of cows, (b) 10% each from nitrous oxide arising from dung and urine, energy and indirect losses from wet soil and production of electricity used on-farm.

Usage of fertilizer, agricultural material production and use and on-site emissions were the salient drivers associated with raw milk production stage, leading to impact on global warming, acidification and eutrophication. Concerning production processes, energy use emerged as the primary cause of environmental footprint. Amongst dairy products, butter seemed to have highest environmental footprint, followed by cheese. Typical environmental performance indicators in dairy sector (calculated per kg of final product or per liter of raw milk) include product yield, water consumption, water-to-milk ration, water reuse, energy consumption, energy to milk ratio, waste water discharge, solid waste performance and usage of chemicals.

The caution to be exercised in reducing the environmental footprint of dairy products are as under- using energy-efficient devices for production, optimizing transportation routes and harnessing environmentally friendly vehicles, modify the feed content for farm animals, and resorting to use of renewable energy sources. Even milk transport is required to be addressed.

In one case study, most of CF estimates of dairy products ranged between 1 and 3 kg of CO_2e/kg product; cheese, butter and milk powder assumed higher values (5.3-10.1 kg CO_2e/kg product). The GHG emissions per kg of protein ranged from 13-40 kg CO_2e. Emissions can be offset by 'locking' carbon up in various forms viz., tree plantings.

Best management practices such as (a) better targeted and timing of fertilizer applications to reduce nitrogen losses, (b) balancing feed rations for cows to ensure correct energy, protein and fibre ratios, influencing well-functioning rumen, and (c) ensuring that stock is adequately fed to achieve genetic merit and optimum milk production can help reduce emissions from major sources of on-farm GHGs.

In dairy plants, mitigation options for optimizing environmental indicators would rely on the choice of production/packaging portfolios, energy fuel profile and water optimization.

B. Livestock

GHG emission per kg of food product is as follows: Milk – 3.15 kg, Beef – 99.48 kg, Lamb and mutton – 39.72 kg. Livestock viz., animals raised for meat, dairy, eggs and seafood production contribute to emissions in several ways. Ruminant livestock, mainly cattle, produce methane through their digestive processes (i.e. 'enteric fermentation'). A bovine animal, on an average, weigh 400 kg and discharges 15-20 kg/day of dung and 15-20 L/day of urine.

Air emission concerns include odor, nitrogen and sulfur emissions. Livestock farming contributes about 18% GHG emissions globally. Primary sources of GHG emissions in dairy farming are feeds, animals and manures. Livestock originating methane, nitrous oxide and carbon dioxide accounts for 44, 29 and 27% in global GHG emission respectively. Methane is produced from enteric fermentation of ruminant animals while denitrification and nitrification processes in soils are the major sources of N_2O. The dung produces many gases/compounds such as carbon dioxide, ammonia, hydrogen sulphide, methane, etc. which emitted into the atmosphere and responsible for odour issue.

Reducing fertilizer N input, utilizing optimum fertilizer form, nitrification inhibitors and land drainage management are the tools to retard N_2O emission. Livestock management through changing of animals' diet, optimal use of gas produced from manures, frequent and complete manure removal from animal housing are the mantras to mitigate problems on environment. Animal genetics and breeding and Rumen modification can also help in curbing GHG emissions. Strategies such as anti-methanogenic chemicals, increasing diet digestibility, intensive housing, improving health and welfare, increasing reproductive efficiency and breeding for higher productivity will pave way to curb GHG emissions and increase soil carbon storage. The solid waste (i.e. cow dung) can be managed through (a) Composting/Vermicomposting, (b) biogas or compressed biogas production, (c) manufacture of dung wood to be used as fuel.

C. Aquaculture

Livestock and fisheries account for 31% of food emissions. Manure management, pasture management and fuel consumption from fishing vessels also fall into this category. This 31% of emissions relates to on-farm 'production' emissions only, excluding use change or supply chain emissions from production of crops for animal feed.

The fuel use and feed are the dominant factors in GHG emissions in aquaculture. Protein metabolism is the major source of N_2O emission. Production of raw materials and successive processing and transportation steers GHG emission; feed production accounts for 57% of total emissions. Improving fish health can aid in retarding GHG emission. Water quality inside the enclosures affects GHG emission footprints. Aquaculture management practices to improve fish health and improving feed conversion efficiency can help in reducing the GHG emission footprints. Production, processing, transportation of feed for the fish, land-use changes for aquaculture and water quality can affect fish performance and impact GHG emission. Well managed aquaculture ponds may act as carbon traps and help to mitigate such adverse impact.

Facing climate irregularities has increased the incidence of accelerated GHG emission related to several sectors of economy applying the GWP100 standard. It is advisable to control climate change well below 2°C.