Journal of Population Therapeutics & Clinical Pharmacology

REVIEW ARTICLE
DOI:10.53555/jptcp.v31i7.4394

SUSTAINABLE STRATEGIES FOR THE DEVELOPMENT OF LIVESTOCK PRODUCTION SECTOR: MOVING TOWARDS ZERO HUNGER AND FOOD SECURITY

Habib Ur Rehman[1*], Niamatullah kakar[2], Inayatullah Kakar[3], Muhammad Bakhsh Bugti[1], Kaleemullah Mandokhail[4], Fazalur Rehman[4], Muhammad Musawir Khan[4], Bakht Muhammad Kakar[5], Asmatullah Khan[6], Jameel ur Rehman[7], Mujeeb ur Rehman[8], Qudratullah[9], Muhammad Farooq Tareen[1], Abdul Rehman Tareen[1], Ashraf Khan Barech[1], Altaf Hussain Baloch[1] and Najeebullah Dummar[1]

[1]Livestock & Dairy Development Department Quetta.
[2]Department of Natural & Basic Sciences, University of Turbat (UoT-Kech), Balochistan.
[3]Additional Secretary, Livestock & Agriculture Section, Civil Secretariat Balochistan, Quetta.
[4]Department of Microbiology, University of Balochistan, Quetta.
[5]Ministry, Livestock & Dairy Development Department, Quetta
[6]Helper's Eye Hospital, Quetta
[7]Bolan Medical College, BUMHS, Quetta
[8]DIKIOHS, Dow University of Health Sciences (DUHS), Karachi
[9]Cholistan University of Veterinary & Animal Sciences (CUVAS), Bahawalpur, Pakistan.

Corresponding Author: Habib Ur Rehman
*Livestock & Dairy Development Department Quetta. habiburrehman.2085@gmail.com

Abstract

Animal production has been a vital part of human civilization for millennia, providing food, clothing and livelihoods. Livestock sector is crucial to the national economy of many developing countries since it is a source of food, income, and employment. The livestock sector in developing nations is experiencing difficulties with low productivity due to changes in demographics, socioeconomic circumstances, and climatic variables globally. Sustainable livestock management is the linchpin that harmonizes the need for animal-based products with ecological well-being. Sustainable livestock development is a broad and dynamic term, describes as a system of sufficient and profitable food production (animal products rich in important nutrients include foods such as milk, meat and eggs), to promote a certain scale or pattern of farming, to maximize production and to minimize release of environmentally harmful byproducts of livestock. As in many other developing countries, livestock sector in Pakistan is seen as crucial to reducing poverty and enhancing the nutritional status of the population. However, there is a need for significant improvements in feeding practices and animal productivity to exploit the genetic potential of livestock. Hence to improve nutritional value and utilization of existing feedstuffs, like the utilization of urea, molasses, and enzymes is very crucial to improve feed digestibility and consequently the strategic implementation of technologies for efficient maintenance of biomass from forages is crucial for livestock that are only seasonal in nature. However, new findings and utilization of novel anti-methanogenic feed additives is crucial to develop a viable, productive and environmentally sustainable livestock sector. Future feeding strategies for monogastric animals should incorporate the development and utilisation of novel protein feed ingredients, such as insects raised on indigestible plant residues, to support a circular bioeconomy and enhance productivity,

particularly in small-scale poultry production. It is recommended that future policies prioritise the establishment of a productive and sustainable livestock sector in Pakistan by encouraging collaborative efforts between research and industry sectors, as well as by strengthening capacity building and developing research infrastructure.

Key words: Livestock, Sustainable Development Goal, Food security, Livelihood, Environment.

Introduction: Livestock sector is a major source of nutrition and employment worldwide. Approximately 1.3 billion people make their living from it, and it is one of the fastest-growing agricultural subsectors, contributing approximately 40% of the world's agricultural gross domestic product (AGDP) (1). Sustainability for animal production describes an outline of independent and complex interactions scale between agriculture and society, to lower inputs (chemicals, fossil fuel energy), to efficiently convert the nutrients into products for human consumption, preserving food security, poverty alleviation, financially secure and profitable for owners, within its local community. Furthermore, animal agriculture provides organic fertilizer, labor, hides and hair to clothe, horns and bones for tools, and energy, and serves for education, entertainment and spirituality (2). Sustainable development in the livestock industry mean, to meet the demands of the world’s growing population for safe and secure food derived from animals reared under increasingly stringent conditions while protecting the environment, via using advanced and adopting nuclear based techniques to optimize sustainable animal production, reproduction and breeding practices platforms and systems that maximize the production via optimally utilize the world’s natural resources and minimize the release of environmentally harmful byproducts (3). The livestock industry is predicted to grow even more significant in the future with a projected 9.7 billion human population on the planet by 2050, (4). Safe and secure food demand in future only be met via increased output that come mainly from an intensified and more efficient use of the land, water and plant and animal genetic potential, as well as the fisheries and forestry resources that smallholder farmers, particularly in developing countries, have at their disposal. The livestock industry has the challenge of producing sufficient food to satisfy the increasing consumption demands of the growing human population while at the same time reducing total greenhouse gas emissions to protect the environment (5). In this regard, livestock sector will be crucial in fulfilling the rising need for food derived from animals, while ensuring future global food security.

Livestock is an essential part of small-scale crop–livestock mixed agricultural systems and the main source of major nutritional elements in the developing world, which includes Pakistan and other Asian regions. Rising levels of affluence and urbanization are expected to drive up demand for animal products in developing regions (6). Furthermore, it is estimated that developing nations will account for as much as 97% of the increase in global population, with the population of the developing world alone expected to reach 7.9 billion by 2050 (7). There are currently two main issues that developing country livestock industries must deal with. Firstly, while there are indications of increasing production levels, mainly for monogastrics, poor animal productivity is still a major issue (8). Second, 50–65% of the world's greenhouse gas emissions from the livestock industry come from cattle in developing countries (6), which adds to global warming and climate change.

Nonetheless, the production of products derived from animals and the livestock industry both significantly contribute to climate change. About ~18% of the world's total anthropogenic greenhouse gas (GHG) emissions come from the livestock industry alone, including enteric fermentation, manure management & feed production (9). Methane from enteric fermentation is the highest contributor (44.1%), N2O emissions from manure is the second largest contributor (13.4%) followed by CO2 emissions related to feed production (12.9%)Although, Pakistan contributes only 0.8% of the global carbon footprint, but is among the ten , most climate-stressed countries on the

planet (10). Growing concerns on the impacts of the livestock sector on environmental health have posed severe challenges to this sector, and there is increasing pressure for GHG mitigation from environmentalists, consumers, and policymakers, both locally and globally. Thus, it is a primary issue for the livestock sector today to develop sustainable production systems, where animal-derived food can be produced with increased efficiency to accommodate growing demands from an increased human population, at the same time as impacts on the environment need to be decreased (11).

Unfortunately, the limited number of studies assessing the state of animal production in developing nations, especially in very low-income nations. This restricts our understanding of the action steps that need to be taken in the future to increase productivity at a reduced cost to the environment. In light of this, the objective of this article is to assess the current status of livestock production in Pakistan and to recommend future approaches for establishing a more sustainable development for the livestock production systems, while considering the current socioeconomic circumstances. Furthermore, the strategies raised here would also be expended to other low-income countries with comparable agro-climatic circumstances, as they also experience with similar constraint in pursuing goals for the long-term sustainable development of livestock production.

Development of livestock sector and Current livestock production system in Pakistan:

Pakistan is an agricultural land-locked country situated in South Asia with neighbors' India, China. Iran and Afghanistan (12), where the agricultural sector is the prime source of national income, and it contributes about 23% to national gross domestic production (GDP), involving 37.4% of the national labour force. Livestock is an important sub-sector within the Pakistani agricultural sector. Livestock contributed approximately 62.68% of agriculture GDP and 14.36% to the national GDP. More than 8 million rural families derive around 35-40% of their income from livestock production, while Poultry sector have 1.3% significant contribution into national GDP. Currently, with 220 million ruminants & 1.9 billion poultry birds, livestock sector is annually providing 55 billion liters milk, 5.5 billion kg meat & 24 billion eggs to the national population of nearly 240 million human beings, according to the Economic Survey of Pakistan, (2021-2022) (13).

Livestock production is the primary source of income for the majority of rural households in Pakistan. Livestock has dominant effect on domestic needs fulfillment and food for table. Livestock in Pakistan has not only socioeconomic aspects but also has contribution towards transportation, draught power and as source of renewable energy and fertilizer. Because of this, livestock is very essential to accomplishing the vital SDG via combating food insecurity and hunger by supplying quality food. The existing livestock production systems comprise; "Traditional Livestock Production System", which is more prevalent in rural areas, concerning with small-scale livestock farmers for their survival, while the animals of indigenous breeds are kept in open fields with grazing feeding pattern. The "Intensive Livestock Production System" is actually a commercially practiced on large scale in urban areas, maintaining exotic breeds, basically based on high-input high-output system. The "Semi-Intensive Livestock Production System" is generally practices in both rural and urban areas, and the farmers maintain a mix of indigenous and exotic breeds on grazing and supplementary feeding. "Feedlot Fattening System" is mainly used for fattening of beef cattle, fed high-energy diets for meat. In "Rangelands Livestock Production system" the livestock is reared on pastures and rangeland. It is mainly practiced in Balochistan and Gilgit Baltistan provinces (14; 15).

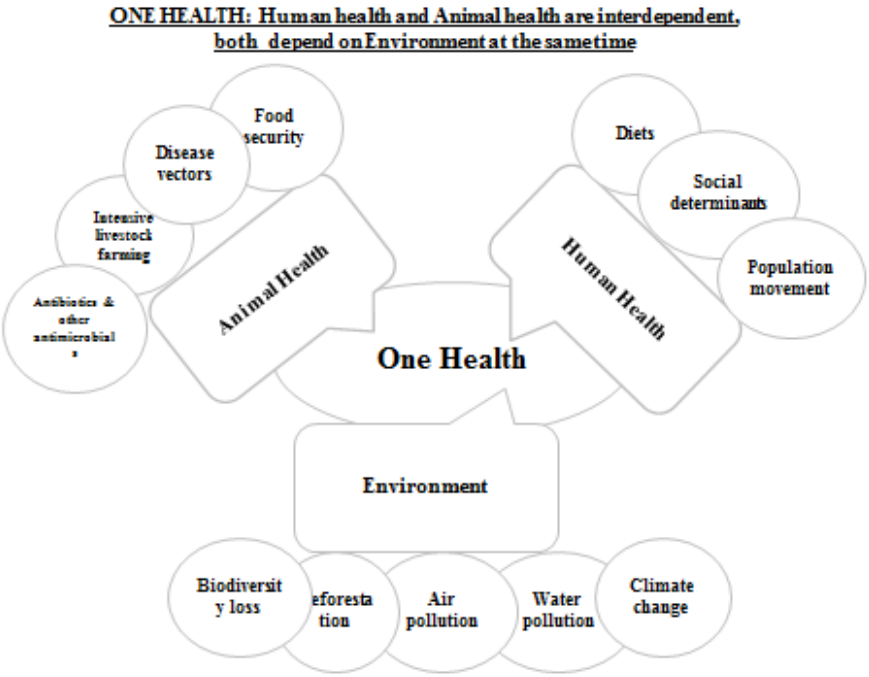

Figure 1. One Health Formulation: collaborative & interdependent networks recognized as a central player to sustain & improve food security for the existing and future human population.

Strategies for sustainable livestock production systems:

1. Breed improvement: Breed improvement is the fundamental step for the productivity of milk to be increased from current 7-10 liters per day animal up to 30liters and development of beef breed to be improved the carcass yield and quality of animal products to realize high standard through local and exports marketing. Development of Sex Semen technology, strengthening of Semen Production Units at public and private sector, Training of AI Technicians and a national database of all livestock species and breeds are the main components of the developed and sustainable livestock production (16). Breeding practices in Pakistan depends on the specific region and species. Improvement programmes of breeding are necessary to increase and sustain the productivity of livestock to meet consumer demands. Commonly there are two main breeding practices in Pakistan comprises of Natural breeding (also known as bull service) and Artificial insemination (AI). AI is most common practice on commercial dairy farms. Embryo-transfer is a relatively new breeding practice in Pakistan (17). The government implemented various policies and programs including National AI Program, Livestock Breeding and Development Project, National Animal Genetic Resources Management and Conservation Programme to improve the genetic potential and productivity of livestock through adoption of modern breeding technologies (18).

2. Animal disease surveillance, locally vaccine production and animal disease diagnostic & reporting system (ADRS): The disease surveillance is essential to identify and monitor the occurrence of infectious and non-infectious diseases in animals. Monitoring of animal health regarding the signs of disease and certain injuries through the use of sensors technologies, allowing farmers to intervene quickly by adopting adequate management practices to prevent the spread of disease and specify the need of medical treatments. Locally vaccine production of Transboundary diseases (FMD and PPR) is the crucial domain to reduce the losses of livestock and also sustain the growth of livestock to enhance farmer's profitability. Some of the major challenges to healthcare include: lack of adequate resources, outdated infrastructure, limited awareness and inadequate disease surveillance (19). Import of virus seed kits, capacity building of the provincial veterinary research institutes (VRIs) for vaccine production, digitalized Animal disease diagnostic and reporting system (ADRS), development of disease-Free Zones and endorsement of control programs

for FMD and PPR to move Pakistan from level 2 to level 3 in supporting the meat industry to access new international markets i.e., China and other potential markets of the region with the diversified range of products (20). As far as the livestock healthcare system is concern in Pakistan, it is primarily based on public and private veterinary services, emphasis by federal and provincial governments through the Livestock and Dairy Development Department & private veterinarians and pharmaceutical companies, respectively (21). Livestock identification and traceability system in Pakistan have several benefits in order to reduce stress, improve animal welfare, health and overall productivity. A livestock traceability system can help in controlling the spread of diseases by enabling quick tracking of infected animals, monitoring specific farming environment suitable for animals, providing information on the origin and movement of the animals and ensuring the food safety by rapid identification and removal of contaminated products (22).

3. Development of the climate resilient fodder seed and Management of rangelands: It is another significant domain for progressive advancement through public private collaboration. Nutrition is critical in the fight to save emissions produced by livestock. Good overall nutrition on the farm boosts the animal's natural immune systems, helping to keep them at their optimum health and production. Rangeland management is rationale to fulfill the shortage of feeding resources for livestock and to cope with the future challenges. Furthermore, Climate smart practices in feed and fodder production along with Good manufacturing practices (GMP) at all levels of the livestock value chain are very crucial to reduce GHG emissions as Pakistan is committed with global community to reduce GHG emissions up to 30 % by 2030. Apart from Climate Smart measures in all other relevant sectors, it has positive impact to make our livestock industry of Pakistan more efficient, productive and climate resilient and contribute more in our national food security & trade with continued growth & development (23). The availability of quality feeds all year round is important to sustain animal production and exploit the genetic potential of livestock. Improving livestock production efficiency through better breeding techniques and feed utilization strategies is essential to reduce methane emission from the ruminant livestock sector. Innovation within supplements and vaccines is helping to cut emissions by targeting the production of methane within the digestion process, via blocking an enzyme which triggers microbes in the gut to create the methane.

Supplement was found to reduce methane production in dairy cows by up to 30%. Sustainable livestock raising is dependent on the production of sufficient quantities and quality of forages and fodder, and natural biomass in grazing-land of Pakistan, with specific strategies such as removal of undesirable plant species (e.g. mechanical, chemical, biological control methods), seeding desirable and climate resilient plants that compete with undesirable species, and using tools such as grazing or prescribed fire as means for restoration. Preservation/conservation of plant biomass during the season, when it is available, is an important strategy to ensure more consistent availability of feed for animals throughout their production cycle.

The substantial amount of biomass available during the rainy season could be stored as hay or silage, thus preserving the available nutrients for use during the dry season, with a positive impact on overall annual animal productivity (24). Furthermore, the silvopastoral system is a crucial practice, which combines forestry and grazing of domesticated animals in a mutually beneficial way. Such systems provide advantages over grass-only pasture-livestock production systems by minimizing greenhouse gas emissions and the chemical contamination of soil and waterways, while preserving biodiversity by avoiding the use of vehicles, fertilizers and herbicides (25).

4. Cluster-based value chain development: Cluster based development strategy is more appropriate for the value chain development of milk and meat in the country. It may include farmer's enterprise groups, development of Farm Services, capacity building of farmers, Field

practices and development of Mini milk pasteurization and value addition Units in milk and small-scale abattoirs and meat value added in meat value chain in order to develop farm to folk model at a single cluster. It is a successful model for the small farmers to get input supplies, better extension services, adopt new technologies and the most important is to access market for their produce, resulting an improvement in the quality of products for the retail and international markets (26).

5. Entrepreneurship and technology transfer: Entrepreneurship development within the identified cluster for young graduates, women and new investors is the best strategy for the value chain development. Government has need to initiate Youth and Women Entrepreneurship to help the youth and women to start their own business initially on small scale and then to become self-sufficient economically and contribute positively in the national economy. Livestock and poultry are very potential sectors for entrepreneurship at small scale models like dairy farming, heifer production, cattle breeding, calf rearing, feedlot fattening, silage and hay production, feed & TMR delivery, Semen distribution, backyard poultry, broiler and layer production, small scale hatcheries, milk and meat value added shops, quality testing labs and many others domain.

Furthermore, livestock sector have the capacity to provide ample opportunities for the integration of digital technologies. Concepts such as e-commerce may be effectively applied to livestock trade and input supplies marketing, potentially transforming the currently challenging environment of animals and feed markets. The incorporation of feed formulation software and farm management programs can transfer the industry from conventional practices to modern and digital ones. The young researchers and veterinarian with thorough learning and implementing the modern technologies, may capable to serve the farming community as a service providers and become pioneers in revolutionizing livestock industry. Commerce sector with financial and technical support to the relevant public sector institutes including academia, research and extension organizations and private sector stakeholders on the identified innovative development models, may have the capability to translate into best practices and profitable businesses for farmers and the industry people involved in the milk, meat and poultry sector, to explore the full potential of livestock field and its enhanced role in the sustainable development goals concept (27).

6. Integrated approaches support sustainability: Integrated, exclusively and community-based approaches have been found to support a sustainable increase in animal production. Crop–animal interaction is an integral component of mixed farming systems in Asia, including Pakistan, where both crop and livestock complement resources to establish and sustain such farming systems (28). The synergies produced by integrating crop and livestock production systems offer many opportunities for farmers to participate in the sustainable increase in productivity and resource use efficiency. Mixed crop-livestock systems produce about half of the world's food. In such systems, the output of one process becomes the input of another, and there is minimum nutrient leakage to the environment, for example, in the form of greenhouse gas emissions. Integrated approach explains how improving of feed quality and feed balancing not only lowers enteric and manure greenhouse gas emissions, but also helps farmers become more productive and profitable. An additional way that better breeding and animal health practices contribute to lower emissions via lowering the overhead of animals that are designated for breeding but are not yet giving good results, even they are consuming feed resources (6).

7. Nuclear and isotopic techniques contribution in livestock sustainability: Radioimmunoassay of hormones has the capability to identify pregnant animals in dairy herds, a technique which may then be applied to identify and reduce the proportion of non-productive animals involved in breeding. These advanced techniques may be used to construct whole-genome radiation hybrids (RH) panels and RH mapping of livestock species and breeds, and thereby improve animal breeding. The analysis of "carbon-13" in plants eaten by animals and in animals' faecal samples

provides accurate estimates of feed intake by grazing and browsing animals. Stable isotope ratios in metabolically inert tissues from infected birds and animals provide a way of back-tracking their movements, which helps assess the risk of disease dissemination. Gamma irradiation of pathogens makes it possible to develop attenuated vaccines for controlling animal diseases. Finally, the incorporation of tritiated thymidine (3H-TdR) into cellular DNA is used to measure cell proliferation and chromium-51 (^{51}Cr) – an assay that helps monitor vaccine responses.

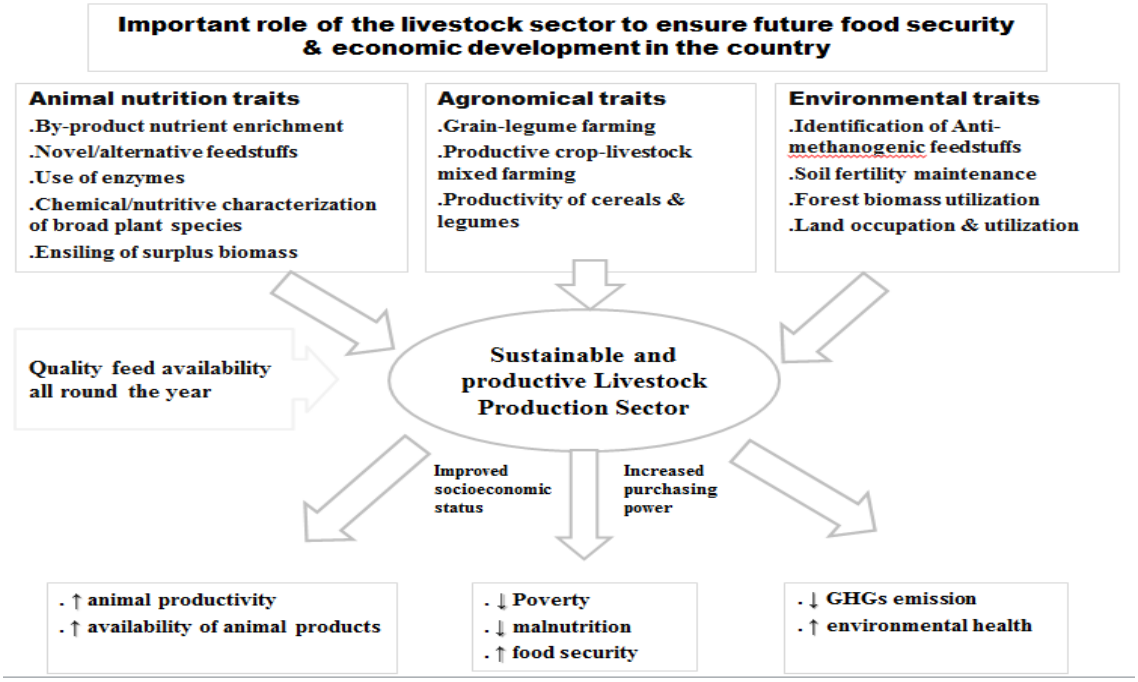

Figure 2. Future considerations to develop a sustainable & productive livestock production sector in developing countries, mentioning the important & associated aspects of animal nutrition, agronomy, and the environment in the development of a productive livestock sector, which could lead to fulfill the increasing demands of livestock production in changing demographic and socio-economic situations.

Conclusion

Livestock sector is a pillar of the global food system and a contributor to poverty reduction, zero hunger, food security and agricultural development. Conclusively, adopting and putting into practice these strategies would aid in addressing the challenges the livestock industry is currently facing and would encourage its sustainable expansion and fulfill the demand of largely driven human population growth alongwith the development for the benefit of the national economy.

Hence, rather than increasing the livestock population rapidly each year in both commercial and rural sectors, more attention needs to be driven typically on enhancing livestock productivity per animal through advanced sciences and technology, and scientific and technological developments in breeding & genetics, adequate and affordable nutrition & feed resources, feeding patterns, efficient livestock management, housing, creation of an effective organized marketing system, preventative measures, disease surveillance and potential animal health measurements, food wastage, deforestation, soil degradation, loss of biodiversity, control environment impacts and water pollution, to meet the ambitious and high demand of sustainable livestock production globally, keeping heavily moderated socio-economic factors such as human health concerns and changing socio-cultural values.

Suggestions and way forward:

Future livestock policies should be directed towards developing better research environments to address upcoming vital issues associated with livestock production and management, particularly efficient utilization of existing and alternative feedstuffs and the development of new feed resources. Proper capacity and infrastructure building of research institutions are crucial to identify and evaluate the suitability of existing and novel feed resources. Future livestock education policies should aim to transform the existing universities into more research-based institutions, thus prioritizing both research and teaching as their major activities.

Food production is more difficult and unpredictable in many regions of the world and destroying via many environmental consequences. Current consumption habits have the potential to exacerbate obesity/malnutrition problems and chronic diseases and many other complications. It is necessary to adopt measures focused on both production and consumption and establish objectives based on the three pillars of sustainability: environment, economy, and society, which guarantee biodiversity, ecosystems, food and nutritional security, and healthy life for current and future generations. This will undoubtedly be one of the great challenges.

The utilization of natural pastures and meadows in hilly areas can also improve the potential of organic livestock products. The long-term policy strategy should focus on the potential for producing novel protein sources that can be less competitive with humans for food, and insects. Facilities to assess potential anti-methanogenic properties of existing or novel feedstuffs are also highly relevant in this context, so as to be able to design the most productive, as well as climate-friendly, strategies for livestock sector development. Thus, integrated future livestock policies should include instruments (e.g., National research funding) to promote research–academia–industry (RAI) collaborations to develop a sustainable livestock industry sector, maintaining good animal health, more production and live better lives with better disease management to create emission savings of 4.5% of GHG by adopting existing best practices in health and husbandry, making the production process much more efficient and profitable for the farmer.

Acknowledgement: The authors would like to thank all the staff of Livestock & Dairy Development Department Balochistan for their fruitful discussions and suggestions.

Conflicts of interest: The authors declare no conflict of interest.

References:

1. Steinfeld, H. (2006). Livestock's long shadow: environmental issues and options. Food & Agriculture Organization.
2. McKenna, E. (2018). Livestock: Food, Fiber, and Friends. University of Georgia, Press.
3. Shang, Z., Gibb, M., Leiber, F., Ismail, M., Ding, L., Guo, X., & Long, R. (2014). The sustainable development of grassland-livestock systems on the Tibetan plateau: problems, strategies and prospects. The Rangeland Journal, 36(3), 267-296.
4. FAO., (2018). The Future of Food and Agriculture—Alternative Pathways to 2050; FAO: Rome, Italy, 2018; p. 224.
5. Herrero, M., Thornton, P., Gerber, P., & Reid, R. (2009). Livestock, livelihoods and the environment: understanding the trade-offs. *Current Opinion in Environmental Sustainability*, *1*(2), 111-120.
6. Herrero, M., Grace, D., Njuki, J., Johnson, N., Enahoro, D., Silvestri, S., & Rufino, M. (2013). The roles of livestock in developing countries. *animal*, *7*(s1), 3-18.
7. Mottet, A., & Tempio, G. (2017). Global poultry production: current state and future outlook and challenges. *World's Poultry Science Journal*, *73*(2), 245-256.
8. Enahoro, D., Mason-D'Croz, D., Mul, M., Rich, K., Robinson, T., Thornton, P., & Staal, S. (2019). Supporting sustainable expansion of livestock production in South Asia and Sub-Saharan Africa: Scenario analysis of investment options. *Global food security*, *20*, 114-121.

9. .Mizrahi, I., Wallace, R., & Moraïs, S. (2021). The rumen microbiome: balancing food security and environmental impacts. *Nature Reviews Microbiology*, *19*(9), 553-566.
10. Hashmi, H., Belgacem, A., Behnassi, M., Javed, K., & Baig, M. (2021). Impacts of Climate Change on Livestock and Related Food Security Implications—Overview of the Situation in Pakistan and Policy Recommendations. *Emerging Challenges to Food Production and Security in Asia, Middle East, and Africa: Climate Risks and Resource Scarcity*, 197-239.
11. .Mehrabi, Z., Gill, M., Wijk, M., Herrero, M., & Ramankutty, N. (2020). Livestock policy for sustainable development. *Nature Food*, *1*(3), 160-165.
12. Pakistan Bureau of Statistics, Govt of Pakistan, (2023). Headquarters: 21, Mauve Area, G-9/1, Islamabad; Pakistan 44080. pbs.gov.pk.
13. Economic Survey of Pakistan, 2021-2022. Govt. of Pakistan, Finance Division, Economic Advisor Wing, Islamabad.
14. Hameed, A., Tariq, M., Buerkert, A., & Schlecht, E. (2022). Constraints and prospects of utilising mountain pastures in Gilgit-Baltistan, Pakistan. *Pastoralism*, *12*(1), 41.
15. Steinfeld, H., Wassenaar, T., & Jutzi, S. (2006). Livestock production systems in developing countries: status, drivers, trends. *Rev Sci Tech*, *25*(2), 505-516.
16. .Wanjala, G., Astuti, P., Bagi, Z., Strausz, P., & Kusza, S. (2023). Livestock breeding for welfare, adaptation and sustainability: an overview of the novel traits and breeding concerns in sheep, dairy, beef and poultry. *Állattenyésztés És Takarmányozás*, *72*(1), 1-21.
17. Arain, S., Rehman, Q., Azeem, M., Jahanzaib, M., Waheed, A., Riaz, A., & Shazinosh, M. (2023). Biotechnological therapies for animal reproduction in the livestock sector. *Pure and Applied Biology (PAB)*, *12*(2), 1269-1285.
18. Government of Punjab, (2014). The Punjab Livestock Breeding ACT, 2014. Accessed on March 10, 2023 from https://faolex.fao.org/docs/pdf/pak143420.pdf.
19. Naeem, I., Siddiqi, S., Siddiqui, A., & Hasan, R. (2022). Exploring stakeholders' experiences and perceptions regarding barriers to effective surveillance of communicable diseases in a rural district of Pakistan: a qualitative study. *BMJ open*, *12*(11).
20. Gongal, G., Rahman, H., Thakuri, K., & Vijayalakshmy, K. (2022). An Overview of Transboundary Animal Diseases of Viral Origin in South Asia: What Needs to Be Done?. *Veterinary Sciences*, *9*(11), 586.
21. Shaikh, T., Waseem, S., Ahmed, S., Swed, S., & Hasan, M. (2022). Infectious disease surveillance system in Pakistan: challenges and way forward. *Tropical Medicine and Health*, *50*(1), 46.
22. Center for Disease Control (CDC), (2009). Accessed on March 10, 2023 from: http://www.cdc.gov/ncidod/dbmd/diseaseinfo/brucellosis_g.htm.
23. York, L., Heffernan, C., & Rymer, C. (2018). A systematic review of policy approaches to dairy sector greenhouse gas (GHG) emission reduction. *Journal of Cleaner Production*, *172*, 2216-2224.
24. Tariq, M. (2020, December). Opportunities for Improving Feed Use Efficiency for Sustainable Dairy Production in Pakistan. In *Proceedings* (Vol. 73, No. 1, p. 11). MDPI.
25. Lemes, A., Garcia, A., Pezzopane, J., Brandão, F., Watanabe, Y., Cooke, R., & Gimenes, L., (2021). Silvopastoral system is an alternative to improve animal welfare and productive performance in meat production systems. *Scientific Reports*, *11*(1), 14092.
26. Jankowiak, A. (2021). Strengthening the Role of Local Clusters In Current Global Value Chains. *Transformations in Business & Economics*, *20-25*.
27. Tarawali, S., Herrero, M., Descheemaeker, K., Grings, E., & Blümmel, M. (2011). Pathways for sustainable development of mixed crop livestock systems: Taking a livestock and pro-poor approach. *Livestock science*, *139*(1-2), 11-21.
28. Devendra, C., & Thomas, D. (2002). Crop–animal systems in Asia: importance of livestock and characterisation of agro-ecological zones. *Agricultural systems*, *71*(1-2), 5-15.