The Pakistan Business Council

FOSTERING ECONOMIC GROWTH

LEVERAGING ARTIFICIAL INSEMINATION FOR ENHANCED DAIRY AND MEAT PRODUCTION

Policy Brief

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The PBC works closely with relevant government departments, ministries, regulators and institutions, as well as other stakeholders including professional bodies, to develop consensus on major issues which impact the conduct of business in and from Pakistan. The PBC has submitted key position papers and recommendations to the government on legislation and other government policies affecting businesses. It also serves on various taskforces and committees of the Government of Pakistan as well as those of the State Bank, the SECP and other regulators with the objective to provide policy assistance on new initiatives and reforms.

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- To provide for the formation and exchange of views on any question connected with the conduct of business in and from Pakistan.
- To conduct, organize, set up, administer and manage campaigns, surveys, focus groups, workshops, seminars and fieldwork for carrying out research and raising awareness in regard to matters affecting businesses in Pakistan.
- To acquire, collect, compile, analyze, publish and provide statistics, data analysis and other information relating to businesses of any kind, nature or description and on opportunities for such businesses within and outside Pakistan.
- To promote and facilitate the integration of businesses in Pakistan into the World economy and to encourage in the development and growth of Pakistani multinationals.
- To interact with governments in the economic development of Pakistan and to facilitate, foster and further the economic, social and human resource development of Pakistan.

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FOODS
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NIMIR

OLP

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PEPSICO

PSL
PAKISTAN SERVICES LTD.

PSX
PAKISTAN
STOCK EXCHANGE
LIMITED

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reckitt

SAIF GROUP

SAP

Sapphire

Servis

Shan

SICPA

SIEMENS

Soneri Bank

SOORTY

SPEL
Synthetic Products
Enterprises Limited

Standard
Chartered

systems

TAPAL

TCS
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PROTECTS
Tetra Pak
WHAT'S GOOD

TG

TOYOTA
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TPL

TTE
Transsion Tecno Electronics

Tufail
Chemical Industries Ltd.

UBL
where you come first

Unilever

Young's

The PBC Affiliates

engro elengy terminal

engro fertilizers

engro polymer & chemicals

HINUCON Private Limited

HUBCO

International Steels Limited
Shaping Tomorrow

LCI
LUCKY CORE INDUSTRIES
Formerly ICI Pakistan Limited

LMC Lucky Motor Corporation

Pakistan Cables

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Executive Summary

This policy brief examines the potential of artificial insemination (AI) to revolutionize Pakistan's dairy and meat production sectors, addressing key challenges and proposing strategic recommendations for effective implementation. Pakistan is one of the top milk-producing countries globally, with dairy farming significantly contributing to the rural economy. However, low productivity per animal, poor animal health management, and limited access to modern breeding techniques hinder the sector's growth. Similarly, while Pakistan is among the top producers of beef and mutton, the meat industry struggles with low yields, inefficient production practices, and inadequate infrastructure.

Artificial Insemination: An Overview

Artificial insemination (AI) involves the introduction of semen from selected male animals into the reproductive tract of a female to achieve fertilization. AI offers numerous advantages over natural breeding, including enhanced genetic diversity, better control over breeding outcomes, increased productivity, disease control, and genetic preservation. Despite these benefits, AI requires specialized knowledge, infrastructure, and technical expertise for successful implementation.

Benefits of AI for Dairy and Meat Production

AI can significantly enhance livestock productivity by improving genetic traits such as milk yield, weight, meat quality, and disease resistance. It allows for precise timing and control of breeding outcomes, leading to higher conception rates and reduced reproductive diseases. Economically, AI offers substantial returns on investment by increasing farmer incomes through higher productivity and better-quality livestock.

Challenges and strategies

The adoption of AI faces several challenges, including inadequate infrastructure, lack of trained personnel, and limited awareness among farmers. To address these issues, the following strategies are recommended:

- Strengthening AI Infrastructure: Invest in semen production and service delivery units, expand AI services, and upgrade existing equipment.
- Incentivize private sector to play a leading role in the delivery and spread of AI services and knowledge to farmers
- Import bulls and establish local semen production units to promote cross-breeds that enhance milk and meat productivity with a focus on increasing milk and meat production for local consumption and exports
- Capacity Building and Training: Implement comprehensive training programs for inseminators, veterinarians, and farmers, in conjunction with private sector players.
- Awareness Campaigns: Launch nationwide campaigns to educate farmers about AI benefits and proper breeding practices, and develop targeted extension materials in local languages.

Conclusion

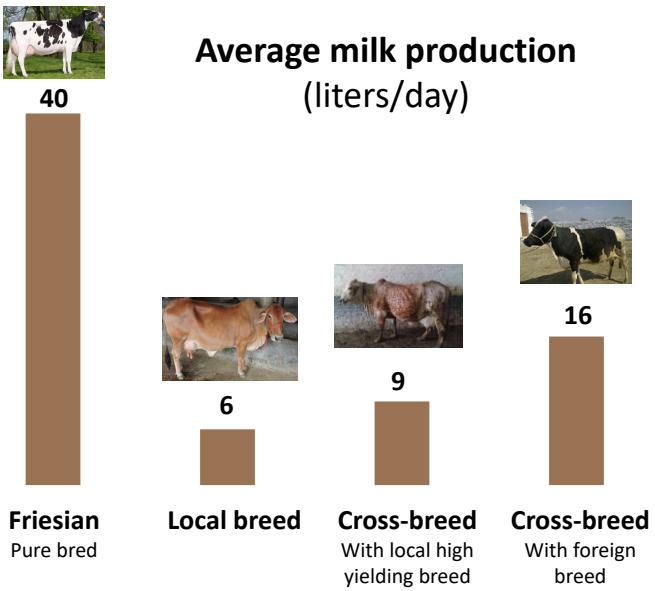
Artificial insemination holds immense promise for transforming Pakistan's dairy and meat production sectors. By addressing infrastructural gaps, enhancing capacity building, raising awareness, and implementing supportive policies, Pakistan can fully leverage AI to improve livestock productivity, meet local demand, and expand its export potential. The strategic adoption of AI will enhance food security, increase farmer incomes, and drive economic growth, ensuring a sustainable and resilient agricultural sector for Pakistan.

Introduction

Pakistan's dairy and meat sectors are pivotal components of the nation's agricultural landscape, contributing substantially to the rural economy and food security. It contributes almost 14 percent in the national GDP of the country. As the fifth largest milk producer in the world, Pakistan boasts a rich tradition of dairy farming ingrained in its rural communities. This sector is predominantly characterized by small-scale farming practices, with millions of households actively engaged in milk production rearing a massive 185 million goats, cows, and buffaloes. However, despite the widespread participation of farmers and the significant production volumes, the sector remains fairly neglected and grapples with challenges that hinder its full potential.

Similarly, the meat production industry in Pakistan plays a crucial role in meeting the dietary needs and preferences of its population. With a focus on beef, mutton, and poultry, the country ranks as the tenth largest producer of meat at a little over 5 million tonnes of meat. However, the industry faces obstacles that impede its efficiency and growth, ranging from low meat yields per animal to inadequate infrastructure for processing and storage.

Figure 1: Average Milk Production (Liters/Day)



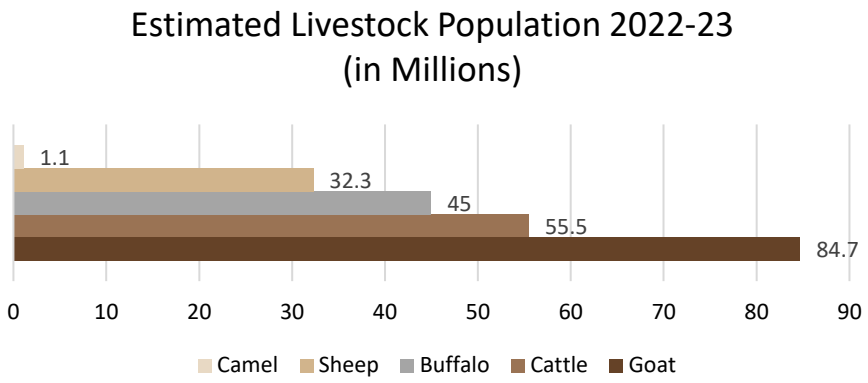
Artificial insemination (AI) is pivotal in enhancing livestock production as it offers precise control over breeding outcomes, reducing diseases, and increasing dairy productivity. Compared to natural breeding, it results in higher conception rates, healthier stock, and increased milk yield. Crossbreeds using local cows and semen from high-yielding foreign breeds also typically have much higher productivity. The graph shows the advantage in milk yield from cross breeds with high potential seed. It should be noted that these are conservative averages. AI is also used to improve meat productivity by 50% or more in cross-breeds by using semen from superior quality meat cattle breeds like the Angus, Brahman, etc. While typical local breeds weigh around 400 kg, a cross-breed can easily weigh around 600 kg or more. The gains from enhanced meat productivity can be realized quickly and strategically targeted towards increased meat export.

This policy brief aims to explore the role of artificial insemination (AI) in enhancing livestock productivity within Pakistan's dairy and meat sectors. By addressing key issues and proposing strategic interventions, this brief seeks to inform policymakers and practitioners about the potential benefits of AI technology and its implications for the future of dairy and meat production in Pakistan.

Overview of the livestock sector

Pakistan's livestock sector plays a vital role in the country's economy, contributing significantly to agricultural output, rural livelihoods, and food security. According to Pakistan Economic Survey 2022-23[1], livestock contributes to 63 percent in agriculture and 14 percent in total GDP of the country. It also estimates the livestock population of the country in 2022-23 (based on the Livestock Census of 2006) at around 216 million heads with the population of goats, cattle, buffaloes, sheep, and camels as shown in the figure below:

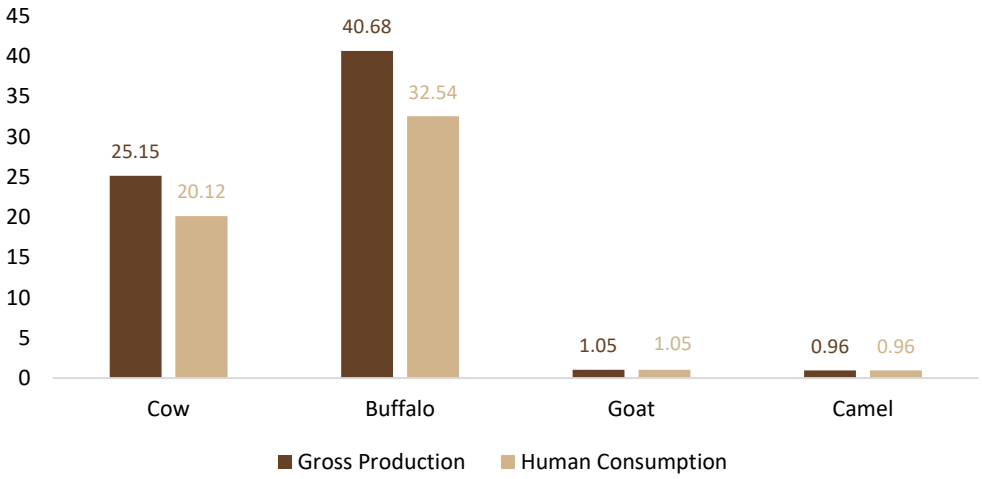
Figure 2: Estimated Livestock Population 2022-23 (Million)



Source: *Pakistan Economic Survey 2022-23*

The estimated gross production of milk during the year 2022-2023 was 67.8 million tonnes, whereas the human consumption was 54.7 million tonnes. The graph below shows the gross amount of milk production for the year 2022-23 by animal:

Figure 3: Estimated Milk Production and Human Consumption 2022-23 (Million Tonnes)



Source: *Pakistan Economic Survey 2022-23*

1 https://www.finance.gov.pk/survey/chapters_23/02_Agriculture.pdf

The dairy sector in Pakistan is characterized by its widespread prevalence, with millions of households engaged in milk production across the country. Small-scale farming is predominant, with farmers often relying on traditional methods of husbandry.

In terms of the global landscape of milk being produced, the Food and Agriculture Organization (FAO) reports Pakistan to be the 5th largest milk producer with a gross annual production of 67 million tonnes. Pakistani households typically possess 2-3 cattle or buffaloes and 3-4 sheep or goats, which collectively contribute to approximately 35-40% of their income, as per the findings of Pakistan Institute of Development Economics (PIDE)[2]. Moreover, 84% of households maintain a herd size ranging from 1 to 4 animals, while 14% possess 10 animals, with only 2% owning more than 10.

However, despite the vast number of participants, the sector faces numerous challenges. These include low productivity per animal, poor animal health management, and limited access to modern breeding and management techniques. Additionally, a considerable portion of milk produced is consumed within the producing households, limiting its availability for commercial purposes.

According to the Milk Production Survey of 2006 in Pakistan[3], it was found that on average, each cow, buffalo, and goat produced approximately 6.15, 7.93, and 1.42 liters of milk per day respectively across the country. The yield of milk is approximately 8-9 times less than that of the developed world. In other words, the milk produced by 8 or 9 Pakistani animals is equivalent to milk produced by one animal belonging to the developed countries[4].

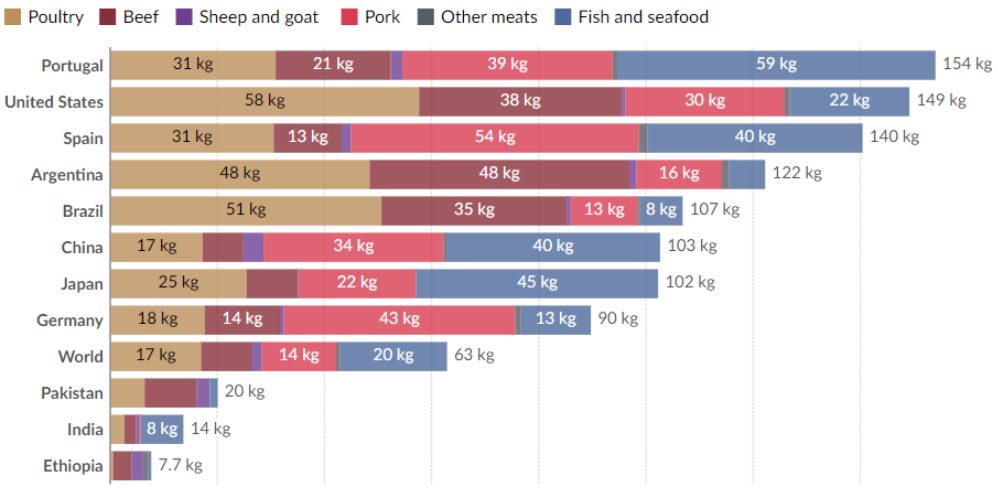
Similarly, meat production in Pakistan is a significant component of the livestock sector, with a focus on beef, mutton, and poultry. Livestock, such as cattle, buffalo, sheep, goats, and poultry, are raised for meat production, catering to the dietary preferences of the population. Pakistan ranks 10th among the top global producers of beef and mutton with domestic consumption heavily influenced by cultural and religious preferences; however, the industry encounters various challenges. These include low meat yields per animal, inefficient production practices, and inadequate infrastructure for processing and storage. Furthermore, most meat sales occur in wet markets, where hygiene standards often fall short, posing risks to consumer health.

Beef and poultry are the biggest components of the meat production. As of 2023, the total production of meat that year was approximately 5.5 million tonnes, with 2.5 million tonnes being beef and 2.1 million tonnes being poultry meat. The remaining 0.8 million tonnes of meat being produced is mutton.

2 https://pide.org.pk/blog/milk-production-in-pakistan/
3 https://www.pbs.gov.pk/sites/default/files/agriculture/publications/pakistan-livestock-cencus2006/special_report/Table%201.pdf
4 https://pide.org.pk/blog/milk-production-in-pakistan/

Based on the FAO data[5], total meat consumption per capita in Pakistan is approximately 20 kg per annum, which is much less when compared to the world average of 63 kg per annum. Beef is consumed the most on overage (9.7 kg) as compared to poultry (6.42 kg), mutton (2.50 kg), and other kinds of meat.

Figure 4: Meat Consumption Per Kg



Source: *Food and Agriculture Organization 2023*

Despite these challenges, Pakistan's livestock sector presents immense potential for growth and development. By addressing key issues and implementing strategic interventions, the country can enhance productivity, improve animal welfare, and contribute to economic prosperity and food security. Can artificial insemination be leveraged to address existing challenges and unlock the full potential of the livestock industry?

5 https://ourworldindata.org/grapher/per-capita-meat-type?country=CHN~USA~IND~ARG~PRT~ETH~JPN~BRA~OWID_WRL~ESP~DEU~PAK

What is Artificial Insemination?

Artificial insemination (AI) stands as a transformative technology in the field of animal husbandry, offering significant advantages over traditional breeding methods. It involves the deliberate introduction of semen from selected male animals into the reproductive tract of a female, with the aim of achieving fertilization and subsequent pregnancy. AI has gained widespread acceptance and adoption globally due to its numerous benefits and potential applications in livestock breeding.

The AI process begins with the collection of semen from high-quality male animals, typically through manual methods or mechanical devices. The semen is then evaluated for quality and processed for storage under controlled conditions, ensuring viability and longevity. When ready for use, the semen is inseminated into the female's reproductive tract at the optimal time in her estrous cycle (when the animal is in heat during breeding season), maximizing the chances of successful fertilization.

One of the primary advantages of AI is its ability to overcome geographical and logistical barriers associated with natural breeding, as the bull does not have to be transported to each location for breeding. By facilitating the widespread distribution of superior genetic material, AI enables farmers to access genetic diversity and improve the traits of their livestock population. Furthermore, AI offers greater control over breeding outcomes, allowing farmers to select desired traits such as milk yield, meat quality, or disease resistance.

Compared to natural breeding methods, AI offers several additional benefits, including:

- Increased efficiency and productivity: AI allows for rapid dissemination of genetic improvements throughout the livestock population, leading to enhanced productivity and profitability for farmers.
- Disease control: AI reduces the risk of transmitting reproductive diseases between animals, thereby improving overall herd health and reducing the need for costly veterinary interventions.
- Genetic preservation: AI enables the preservation of valuable genetic material from superior animals, mitigating the risk of genetic erosion and loss of valuable traits over time.

Moreover, AI offers significant advantages in terms of efficiency and resource utilization. Unlike natural breeding methods, which rely on the availability of male animals for mating, AI allows for precise timing and control of breeding outcomes. This results in higher conception rates, reduced gestation periods, and faster genetic progress within the herd. As a result, farmers can optimize their breeding programs, achieve higher reproductive efficiency, and minimize the risk of reproductive diseases and disorders.

Furthermore, AI plays a crucial role in disease control and prevention within the livestock population. By using semen from disease-free male animals, AI helps to mitigate the risk of transmitting reproductive diseases between animals during mating. This not only safeguards animal health and welfare but also reduces the need for costly veterinary treatments and interventions. Additionally, AI contributes to the preservation of valuable genetic resources by minimizing the spread of infectious diseases and maintaining the integrity of breeding stock.

Economically, AI offers substantial returns on investment for farmers and the broader agricultural economy. By improving the quality and productivity of livestock, AI enables farmers to increase their income and profitability through higher milk yields, better meat quality, and enhanced market competitiveness. Moreover, AI stimulates downstream economic activity in related industries, such as feed production, veterinary services, and agribusiness, creating employment opportunities and driving economic growth.

However, it should be noted that implementation of AI requires specialized knowledge, infrastructure, and technical expertise. Training programs for inseminators, proper equipment maintenance, and access to quality semen are essential components of successful AI programs. Moreover, raising awareness among farmers about the benefits of AI and providing support for its adoption are crucial steps in maximizing its impact on livestock productivity and welfare.

Current Status of Artificial Insemination in Pakistan

Natural breeding, by far, is the most common method adopted by the majority of Pakistan's farmers which presents numerous challenges in livestock production. Often, bull health status is overlooked (as the primary focus is the health of the cow), neglecting potential transmission of diseases or genetic issues. Additionally, the number of cows impregnated by a bull is often not accurately tracked, leading to reproductive inefficiencies. Typically, there is one leading bull in the village which is used for breeding purposes, which not only causes in-breeding over time, but can also affect overall conception rates in that area. On average, natural breeding yields a conception rate of only 30-40%, highlighting the need for more efficient methods.

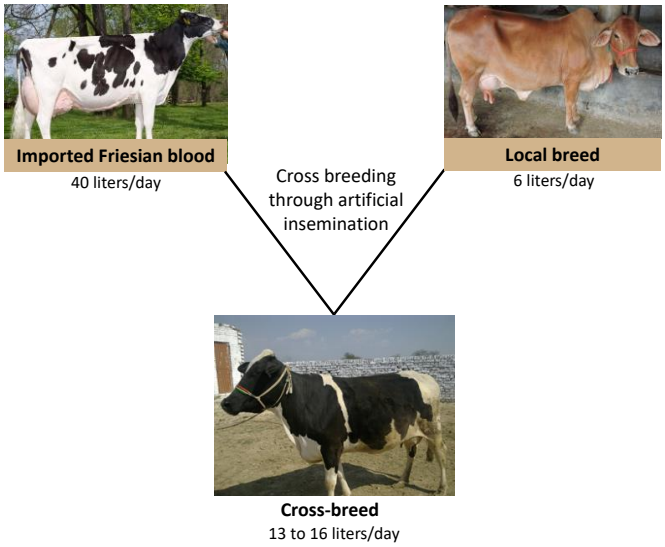
The introduction of artificial insemination in Pakistan dates back to 1956, first achieved by University of Veterinary and Animal Sciences (UVAS). Initially focused on one breed, AI has since evolved in Pakistan, with local organizations like the Livestock Production Research Institute (LPRI) in Okara playing a crucial role in preserving local breeds. Despite advancements, AI remains susceptible to human error, necessitating careful consideration and management.

For dairy farmers, estrous synchronization is paramount for efficient farm operations to ensure simultaneous impregnation of animals for consistent milk production throughout the year. This strategic approach enables farmers to optimize production. This is only possible with the high conception rates offered by AI. Therefore, dairy farmers of Pakistan, especially those of medium and large-scale farms, have almost all turned to AI for breeding purposes.

Moreover, farmers are also increasingly opting for crossbreeds. Pure Friesian breeds, while high-yielding, require a much cooler environment than what Pakistan has to offer and lack disease and heat resistance in this climate. Crossbreeding local breeds with foreign cattle can yield significant production increases, benefiting farmers on average anywhere between 25% to even 300%. So, where a farmer was getting an average of 6 liters per day from a cow, even an extra 2 liters daily can change a farmer's economics through the higher genetic potential offspring by using better semen using AI. These increases depend on the quality of breed being used, for example, if the seed of a Friesian is used then the gain can be much higher.

The farmer begins to reap the benefits of AI in terms of higher milk production only after the higher genetic potential offspring reaches maturity and is impregnated and starts producing milk. The first time that offspring is impregnated is around 18 months of age and another 9 months 10 days later will it start producing milk with its first calf. The usual goal from thereon is a 12-month calving interval. It should be noted that the artificial insemination for a crossbreed should not be for the cow's first calf as it can be dangerous for the cow. Usually, AI for crossbreeds is done in the third or fourth birthing cycles.

Figure 5: Cross breeding through AI



AI offers farmers the flexibility to select semen based on their preferences, with sex semen being particularly favored by dairy farmers as it guarantees female offspring, which are preferred for milk production.

The average cost of semen ranges from Rs. 700 to 2000, with an additional service fee of Rs. 1200 to 1800. The price of AI services goes up for crossbreeds and sex semen, going as high as Rs. 25,000 per AI. However, success is not guaranteed, prompting recommendations for natural breeding in some cases. Veterinarians often assess the internal health of animals to ensure successful impregnation, with breeding seasons varying for cows and buffaloes.

While AI is widely used in dairy cows, its adoption in buffaloes remains limited. Buffaloes also have silent heat cycles, typically in November-December, making detection challenging, whereas the breeding season for cows is usually in March and April. Nonetheless, AI remains a primary tool for breeding, with crossbreeding also being utilized to enhance production.

Meat is a sector with significant potential to generate foreign exchange through increased exports. While higher milk productivity is likely to meet high local demand in Pakistan, the gains from enhanced meat productivity can be realized quickly and strategically targeted towards export growth. In the meat industry, AI is utilized for breeds like the Brahman to improve traits such as high meat growth rate and muscle development, height, girth, and loin.

Several cattle breeds are popular among cattle owners for their superior meat quality, such as Angus, Brahman, and Hereford. While typical local breeds weigh around 400 to 500 kg, these high-yielding breeds can weigh between 800 to 1100 kg. Crossbreeding local cattle with these breeds can result in at least a 50% increase in meat productivity compared to non-descript local varieties. The Brahman breed is particularly favored in Pakistan as it can acclimatize more easily, having originated in India and been further developed in the US. In Pakistan, companies like Worldwide, Yonder, and CloudAgri are playing prominent roles in providing AI services.

Challenges

One of the major challenges facing AI implementation in Pakistan is the shortage of trained personnel and technical expertise. While there are inseminators trained in AI techniques, their numbers are insufficient to meet the demand, particularly in rural and remote areas where the majority of livestock farming takes place. Furthermore, the quality of training and the proficiency of inseminators vary widely, affecting the success rates of AI procedures and the overall impact on livestock productivity.

In addition to human resource constraints, inadequate infrastructure and equipment pose significant barriers to effective AI services in Pakistan. Semen collection and processing facilities may lack modern technology and resources, leading to issues such as poor semen quality and limited semen availability. Moreover, the transportation and storage of semen present logistical challenges, especially in regions with limited access to reliable refrigeration and transportation facilities.

Furthermore, low awareness and limited access to AI services among farmers hinder widespread adoption of the technology. Many farmers, particularly smallholders in remote areas, remain unaware of the benefits of AI and may continue to rely on traditional breeding methods despite their limitations.

Despite these challenges, there are examples of successful AI programs and initiatives in Pakistan, demonstrating the potential for improvement and expansion. Collaborative efforts between government agencies, non-governmental organizations, and private sector stakeholders have led to the establishment of AI centers and training programs in some regions. Companies like Engro FrieslandCampina and Nestle are also working with farmers to provide training and information on AI.

Moving forward, addressing the challenges associated with AI implementation in Pakistan will require concerted efforts from policymakers, practitioners, and stakeholders across the public and private sectors. Strategies to strengthen AI infrastructure, expand training and capacity-building initiatives, raise awareness among farmers, and improve access to quality semen are essential for realizing the full potential of AI technology in enhancing livestock productivity and advancing the dairy and meat sectors in Pakistan.

Case studies from other countries

Ethiopia, known for its sizable cattle population in Africa, faces challenges in enhancing the milk production due to the scarcity of high yielding animals and deficiencies in breeding. Artificial insemination (AI) technicians, who travel door to door, struggled to inseminate an average of only 3 cows per day, often missing the optimal insemination window.

To address this issue, the 'Improving Productivity and Market Success of Ethiopian Farmers' (IPMS) project, operating from 2005 to 2012 in partnership with the Ministry of Agriculture and regional agencies, introduced a "mass insemination" approach. This model involves highly trained mobile teams comprising AI technicians, extension specialists, veterinarians, and researchers replacing static AI technicians. In addition, it requires bringing cows to central locations for insemination, synchronized with hormones to enhance fertilization. This initiative significantly increased the number of cows inseminated with improved varieties.

In one instance, 1,400 cows in Tigray and the Southern Regional State received AI, with a 95% positive response to hormone treatment and a conception rate of 65% from 27% originally. Improved cows significantly increased farmers' income[6].

In 1987, the Bangladesh Rehabilitation Assistance Committee (BRAC) collaborated with the Government of Bangladesh's Livestock Department to initiate a vaccination program. This program trained para-vets, or veterinary assistants from rural communities, to serve local farmers. In 2000, the BRAC Bull and Buck Station in Mymensingh, central Bangladesh, began producing frozen semen from high-quality breeds as part of their AI program. This initiative trained para-vet entrepreneurs in AI techniques, enabling them to offer farmers access to semen from hybrid cattle breeds that yield more milk, along with training on livestock care. These entrepreneurs were provided with loans, quality supplies, supervision, and refresher training to effectively support rural farmers. By 2014, the AI program employed about 60 staff and had trained over 2,200 AI entrepreneurs who charged local farmers a certain amount per cow for the service. Additionally, the program successfully inseminated over 1,400,000 cattle in 2014. Marium, a dairy farmer benefiting from artificial insemination, now owns 7 cows and several calves, all of which were bred through AI. She attests to the improved milk quality and praises the support provided by BRAC AI workers in caring for her cows.Top of Form

In Cameroon, as in other African countries, there is a growing demand for milk and dairy products. However, indigenous zebu cattle, which make up the majority of milk producers, are considered "poor milkers" compared to breeds like Holstein and Jersey, which produce significantly more milk. To address this disparity and improve the milk-producing capacity of local herds, livestock research programs were established at the Bambui and Wakwa Centres of the Institute of Agricultural Research for Development (IRAD). IRAD Bambui focuses on artificial insemination as a solution and serves as the only functional AI center in the Central Africa Region, providing AI services to neighboring countries with similar cattle breeds. The center uses semen from Holstein-Friesian bulls to crossbreed with local cows, aiming to enhance the dairy potential of resulting crossbreds and increase heterosis. While previous attempts to introduce frozen semen were hindered by high liquid nitrogen prices, government support for cost reduction schemes could facilitate wider distribution. However, improving the breeding system in Cameroon and neighboring countries also entails organizing breeding societies, empowering research institutions to multiply valuable offspring for enhancing dairy production, and stabilizing Cameroonian dairy breeds adapted to local conditions[7].

6 Azage Tegegne and Dirk Hoekstra "Mass artificial insemination interventions to enhance dairy and beef production in Ethiopia" https://core.ac.uk/download/pdf/132635861.pdf

7 Agriculture for Impact https://ag4impact.org/wp-content/uploads/2016/02/Artificial-insemination-Case-Studies-New.pdf

Policy Recommendations and Implementation Strategies

To harness the benefits of artificial insemination for dairy and meat production in Pakistan, a multifaceted approach is necessary, addressing the supply side and demand side challenges and facilitating effective implementation of AI technology.

The most crucial supply side strategy is to strengthen AI infrastructure, with investments needed in semen collection and processing facilities, equipment upgrades, and the establishment of AI centers in rural areas. Moreover, capacity-building initiatives are essential, requiring comprehensive training programs for inseminators, veterinarians, and farmers to ensure proficiency in AI techniques and reproductive health management. Collaboration with academic institutions and international organizations can aid in standardizing training modules and fostering knowledge exchange among practitioners.

The service delivery model is already working quite successfully in certain areas in Punjab, especially with higher animal population density. In areas with lower animal density, financial incentives and support programs will act as key drivers for AI adoption, requiring the introduction of subsidies, grants, and innovative financing mechanisms to offset initial costs and facilitate participation. Public-private partnerships in quality assurance and accreditation can enhance transparency and accountability in service delivery, fostering trust among stakeholders. Overall, a collaborative approach involving government agencies, research institutions, and civil society organizations is essential to leverage AI technology effectively.

To promote AI using semen from high-yielding meat cattle breeds like the Brahman, Angus, etc., the government should facilitate the import of these bulls and the establishment of local semen production units. Importing bulls and producing semen locally would reduce the cost of AI, making high-quality semen more affordable and accessible. This strategy would significantly enhance the genetic potential of Pakistan's livestock on a much larger scale.

On the demand side, awareness campaigns and farmer education efforts play a vital role in promoting AI adoption, necessitating nationwide initiatives to educate farmers about AI benefits and proper breeding practices. Targeted extension materials in local languages and partnerships with community leaders can enhance outreach, particularly in remote areas. Collaboration with the private sector entities already working on dairy development is essential as their existing connectivity through milk collection centers in the rural landscape can be leveraged.

Furthermore, the establishment and enforcement of regulatory standards are crucial to ensure adherence to best practices and quality assurance in AI practices. Monitoring and evaluation mechanisms are imperative to assess the effectiveness of AI programs and inform evidence-based decision-making.

The provincial Livestock Breed Acts of Punjab and Sindh are meant to regulate breeding services, improve genetic potential, and protect indigenous breeds of livestock. This gives government entities like the Livestock Breeding Service Authority the mandate to register artificial insemination practitioners, livestock breeding farms, and breeding companies. These entities need to be strengthened to be able to fulfill their regulatory role.

A fresh livestock census is long overdue, the last one being held almost two decades ago back in 2006. Numerous floods and other natural disasters since then may have changed the numbers drastically. It is crucial that Pakistan has a fresh and clear picture of its livestock population so that policies can be drafted accordingly. This will reveal a clearer picture of Pakistan's milk and meat production by geography and will make it easier to plan which areas to target for AI intervention first as low hanging fruits. Pakistan can also then focus more comprehensively on increasing its meat exports of around 300 million dollars by targeted AI intervention to increase meat productivity.

Conclusion

By leveraging AI, Pakistan can unlock the full potential of its dairy and meat production, improve farmer livelihoods, and contribute to sustainable agricultural development and food security. By improving genetic diversity and enhancing breed characteristics, AI can significantly boost livestock productivity, addressing critical challenges such as low yields, disease control, and inefficient breeding practices. The implementation of AI allows for the rapid dissemination of superior genetic material, leading to improved milk yield, meat quality, and overall herd health.

To fully realize these benefits, it is essential to strengthen AI infrastructure through investment in semen production units for easy and cheaper accessibility, the establishment of AI centers in rural areas, and upgrading existing service delivery infrastructure. Comprehensive training programs for inseminators, veterinarians, and farmers are crucial to ensure proficiency in AI techniques and reproductive health management. Raising awareness among farmers through nationwide campaigns and targeted extension materials will further promote the adoption of AI technology. Collaborative efforts between government agencies, research institutions, and the private sector are essential for the successful implementation of AI.

It is worth repeating that by using AI, Pakistan can significantly improve its dairy and meat production, meet local demand more effectively, and expand its presence in international markets. It is important to increase milk productivity to first be able to meet the country's own demands, and possibly export it too. But meat productivity enhancement presents a very strong case for AI as a 50% increase in meat productivity makes a significant difference in the meat production economics and presents a quick way of increasing meat exports. The strategic adoption of AI will enable Pakistan to harness the full potential of its livestock resources, ensuring long-term prosperity and development for the nation's agricultural landscape.

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