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Vision 2050

Central Sheep and Wool Research Institute

Indian Council of Agricultural Research

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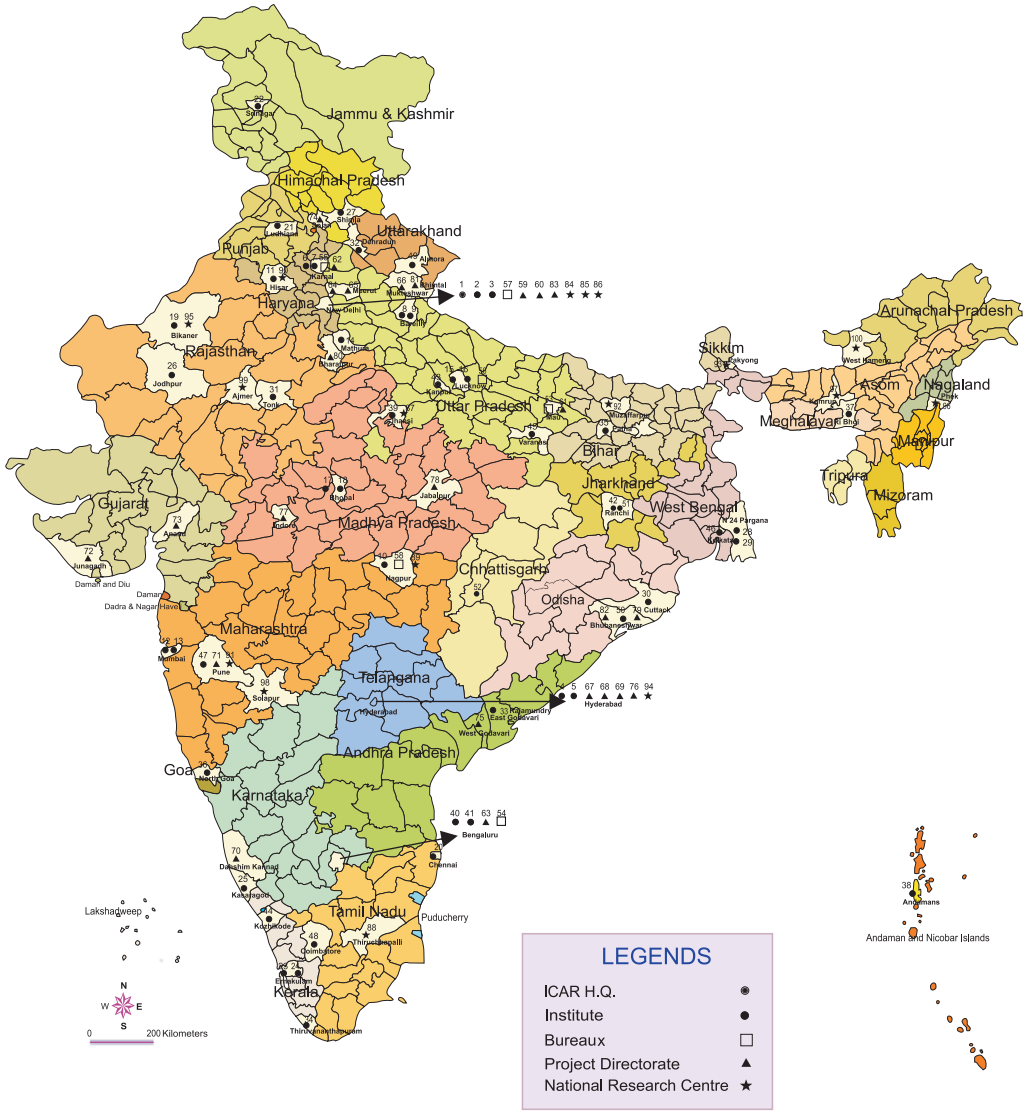

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities

Vision 2050

Central Sheep and Wool Research Institute
(Indian Council of Agricultural Research)
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संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-Central Sheep and Wool Research Institute (CSWRI), Jaipur has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

(S. AYYAPPAN)
Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
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Preface

The Central Sheep and Wool Research Institute, Avikanagar is a premier institution of Indian Council of Agricultural Research (ICAR) established in the year 1962 to conduct basic and applied research on sheep production, health, utilization, training and transfer of technologies to the beneficiaries. The institute is actively engaged in research for enhancing productivity of sheep to meet growing demand of wool and mutton in the country. Over the period, wool production in the country is remained static, on the other hand demand and production of mutton is increasing gradually. To meet the challenges, appropriate technology, efficient and sufficient infrastructure and financial sustainability are needed. The Institute developed its Perspective Plan 2025 and Vision 2030 during XI Plan period. The present Vision 2050 is prepared to address long term strategies for meeting demand of quality meat and wool and diversified produce viz., milk, skin and manure which are not given much attention in the past. The market research in sheep husbandry is utmost important to understand the market trends, structure, competitive landscape and the outlook of the market. Success in sheep development depends on individual actions of millions of rural families, whose decisions are shaped by the information, knowledge and technologies available to them. There is need to strengthen and reorient extension services to generate, adapt and transfer appropriate technologies for improved and sustainable production systems in sheep husbandry.

I would like to express my sincere gratitude to Hon'ble Secretary, Department of Agricultural Research and Education (DARE) and Director General, Indian Council of Agricultural Research (ICAR), New Delhi for invaluable guidance in preparing Vision 2050 of the Institute. I am grateful to Deputy Director General (Animal Science) for his keen interest and suggestions in preparing this document of the Institute. I am also thankful to Assistant Director General (Animal Production and Breeding) and Principal Scientists at Animal Science Division of ICAR for their valuable inputs in finalizing this document.

I appreciate the efforts of Drs A. Sahoo, Rajeev Gulyani, A.K. Shinde, D.B. Shakyawar, L.L.L. Prince, Davendra Kumar, C.P. Swarnkar and Y.P. Gadekar in bringing out this document. Vision 2050: Roadmap

to a sustainable sheep production is developed to address the issues to inspire an exchange of ideas among experts, policy makers, stakeholders, industrial leaders and general public. This can serve as an excellent guide for researchers, consultants, investors, marketing strategists and all those involved in mutton and wool production and utilization.

(S.M.K. Naqvi)
Director
ICAR-Central Sheep and Wool Research Institute

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Context

For more than a half century, the Central Sheep and Wool Research Institute, Avikanagar under the aegis of Indian Council of Agricultural Research (ICAR) has been actively engaged in research, training and extension activities related to sheep and wool production. The present Vision 2050 is prepared in view of newer challenges currently faced in sheep production and those expected in the near future under impending climate change and shrinking grazing resources, intermixing of native breeds, emergence and re-emergence of diseases, marketing trends for wool and meat with non remunerative wool price and sharp rise in mutton price. The Vision 2050 document will prove useful for researchers, policymakers and stakeholders in order to address the future challenges for growth and development of the sheep sector to ensure food and income security with a human touch. The main motto of Vision 2050 is to present the strategies and programs to enhance productivity of sheep for livelihood security, economic sustenance of farmers and to provide wholesome, hygienic meat for consumers and wool for industries in the country.

Sheep in the country are mostly reared by the landless labourers and marginal farmers, who are considered as the socially and economically disadvantaged sections in the rural society. It provides gainful employment and income to the weaker section especially in rural areas. About 5 million families are estimated to be engaged in various activities related to rearing of sheep and goats and utilizing their products (http://www.archive.india.gov.in). On an average, 15% of households in rural areas reported ownership of goat/sheep across the country. Around 70% of the goat and sheep in the country are reared by small and marginal farmers and landless labourers. Evidently, the ownership and distribution of small ruminants in the country is more equitable than that of land resources.

The institute is mandated to conduct research on sheep and wool in specific areas of

genetics and breeding, physiology, nutrition, health, wool and meat processing. The major salient achievements of institute are development of prolific sheep, improvement in carpet and fine wool production, higher lambing rates by estrus synchronization and AI, newer feed resources and their utilization in sheep feeding, disease diagnostics and health management, wool and meat processing and product development.

Improved rams of Malpura, Muzzafarnagri, Deccani, Nellore, Madras Red and Ganjam breeds were developed in the Institute and Network projects on Sheep Improvement. These improved animals were made available to sheep farmers which resulted in increase in mutton production. Improved Chokla, Marwari, Magra and Avikalin sheep breeds produced ideal carpet type wool of 30-35μ diameter, 35% medullation and 5-6 cm staple length. Superior rams supplied for breeding in farmer's flocks resulted in increase in wool yield of superior quality.

In order to meet the growing demand for mutton in the country the concept of transferring prolificacy (Fec+B) gene from litter bearing Garole and Kendrapada sheep breeds into less prolific sheep breeds has been introduced for evolving prolific sheep to produce twins and triplets. Increased prolificacy, lambing rate and overall body weight in prolific sheep indicates great potential for augmenting mutton production.

Avikalin is a dual purpose sheep for producing ideal carpet wool and have higher body weights for mutton production has been accepted well in Tamil Nadu and Karnataka farmers due to its adaptability and better economic returns. Bharat Merino sheep is a promising import substitute for fine wool and can be used as improver breed. It is suitable for fine wool production in temperate and sub-temperate regions. Bharat Merino produced fine wool of 2.4 kg annually with staple length of 8.00 cm, fibre diameter of 20μ and less than 2% medullation. Bharat Merino sheep are well accepted by the farmers of Karnataka in Kolar and Satyamangalam areas.

The artificial insemination technique in sheep using liquid chilled semen developed, improved and simplified in application under farmer's conditions. This technology extended to organized farms and farmer's flock and semen of Patanwadi used extensively. Lambing rate of 60% achieved with chilled semen.

Indigenously developed intra-vaginal sponges (progesterone impregnated) for sheep are commercialized with a cost of Rs 460 per kit (50 sponges, 1 speculum and 1 plunger).

So far >21000 sponges supplied to different agencies for fertility management and artificial insemination.

Malpura lambs in the field flocks attain 8-10 kg body weights at weaning age (3 month) and 16-18 kg at 6 month of age. Intensive feeding

protocol developed in the institute for mutton production enhanced the weaning body weight to 16-18 kg and finishing weight up to 30-33 kg in Malpura lambs with feed conversion efficiency of 19-20%, carcass content of 62-65% lean meat, 18-20% fat and 15-18% bone with dressing yield of 52-54%. Supplementary feeding schedule for field flocks was developed. Its adoption in farmer's flocks during pregnancy and lactation resulted in improvement of birth weight and subsequent growth up to slaughter age and reduction of morbidity and mortality losses in lambs. Area specific mineral mixtures have been developed for different agro-climatic zones of Rajasthan. Complete feed blocks of roughage and concentrate mixture have been developed to facilitate storage, transportation and fortification of low-grade roughage, improve intake, nutrient utilization and avoid feed selectivity.

Sheep flock health management has reduced outbreak of diseases as well as mortality rate to < 5 % per annum.

The modified worm management programme (single strategic drench during mid to late monsoon) found effective in management of gastrointestinal nematodes in sheep flocks of Rajasthan.

In the Targeted Selective Treatment (TST) approach only worm infested sheep (~20%) are drenched on the basis of conjunctiva colour. Thus expenditure on anthelmintic reduced by 90% through TST compared to conventional practices.

Hand knotted carpets developed from Magra wool and nylon in 90:10 proportions have adequate compressibility and resilience. Shawls developed from Bharat Merino wool with Angora wool in different proportions have features of softness, warmth and excellent handling. The techniques for the utilization of the indigenous wool developed in the Institute have been adopted by Khadi, felt and carpet industries and local artisans. This has resulted into value addition and employment generation in rural areas.

As a part of a large system, the Institute supports the vision for self sufficiency in mutton and wool production and utilization in the country. The demand for mutton and wool will increase in the country with ever increasing human population and purchasing power of the people in the future. The demand for mutton cannot be met from the existing sheep genetic resource reared under traditional extensive and/ migratory production systems. The wider gap in demand and supply of mutton leads to sharp rise in price which leads to dependency on import in future. To combat this situation, it is essentially required a paradigm shift in the sheep production from existing extensive to intensive and commercial system. Thus, inputs are required to increase life time production, per animal productivity, reproductive and feed efficiencies.

Research and development on these aspects need to be strengthened at the institute to address the burgeoning demands for mutton and wool in the country.

Wool production is showing decline trend globally and also in the country. Long term vision for wool production and processing is required to sustain the woolen industries and also the stakeholder engaged in sheep rearing. The production of carpet wool in north-western and fine wool in temperate region can be increased marginally through R&D programmes with better price and incentives from woolen industries.

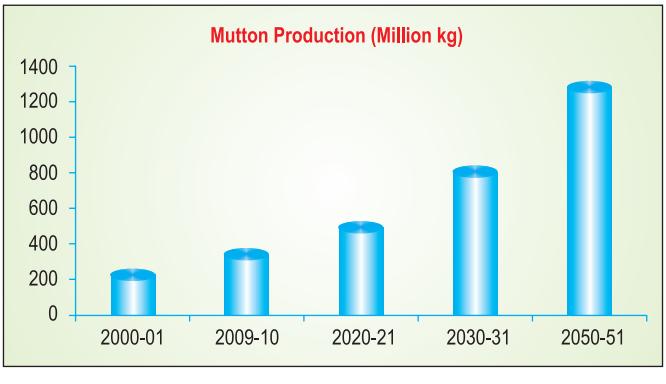
The leather industry plays a significant role in the Indian economy through providing employment and its' higher potential for exports. It employs about 2.5 million people, of which nearly 25% are women. India produced 37 million pieces of sheep skin in 2011-12. Tamil Nadu alone accounts for 70% of the country's tanning capacity and 40% of its leather exports. The leather processing is carried out in the unorganized sector and always been overlooked, especially in policy making and programme formulation aimed at development of the leather industry. ❑

Challenges

Increasing the reproductive efficiency, improvement in quantity and quality of feed and efficiency of feed utilization, introduction of disease resistance and early diagnosis of diseases, ensuring proper income to producers, transfer of technologies and knowledge to end user are some of the challenges before sheep husbandry in the country which require short, medium and long term policy and research interventions.

Other challenges are: climate change and shrinking grazing resources, intermixing of native breeds, emergence and re-emergence of diseases, growing demand for mutton, import of wool, slump in wool price and sharp rise in mutton price, early disposal of lambs for mutton etc.

Mutton Production: In sheep rearing, mutton contributes from 70-80% of earning of the farmers as the demand for mutton is growing in the country especially in the J&K and southern states resulting in sharp rise of mutton price. The estimated demand for mutton in the country would be around 986 million kg in 2030 and 1408 million kg in 2050. Thus, there is an urgent need to improve the body growth reproduction through breeding, nutrition, heath and management. The carcass yield of Indian sheep is relatively low as compared to the world average due to lack of proper feeding and low genetic merit. As per Indian Council of Medical Research (ICMR) recommendation, a minimum amount of 30 g of meat/day/head should be taken i.e. 10.95 kg of meat/head/annum. At present availability of meat is only 5.5 kg/head/annum. Majority of Indian population prefer sheep and goat meat than large ruminants. This could be one of the reasons for 98% of meat produced from small ruminants is consumed in the country itself with



meager export. From the above figures, it is clear that there is a wide gap between demand and supply which would further widen in future with increasing demand.

In India, meat is consumed either in curry form with high spices or as processed meat products. At present, only 2% of the meat is processed (APEDA, 2008), the remaining meat is sold in fresh or frozen form. The meat processing industry is still in infancy even though there is a vast scope for processing. At present, condition of the majority of slaughterhouse is not satisfactory. Adequate slaughter facilities are not available to produce hygienic meat under sanitary conditions. Animals are slaughtered both in authorized and unauthorized places which makes meat inspection impossible. Floor slaughter is practiced for animals with poor hygiene. Overcrowded slaughter in unaesthetic premises is quite common. Inadequate drainage facility and improper utilization of valuable byproducts like blood results in environmental pollution and offensive smell in premises and creates negative image of slaughterhouses in the minds of public. Meat produced in such environment is a potential source of disease for human beings. The meat industry in the country is yet to transform into an organized sector. Therefore, modern state-of-the-art slaughter and processing plants are required to meet demand of the consumers for safe and wholesome meat. If we want to compete with international market, we need to improve the quality of our produce so that it can be accepted after meeting international norms.

Slaughter of sheep has been increased over the period from 33.13% in 2007-08 to 47.05% in 2011-12 which has reflected in decline of sheep population by 9.06 % (BAHS, 2013). Export of meat from sheep/goat is also slowly increasing as shown in table. Most of sheep/goat meat is exported to United Arab Emirates, Saudi Arabia, Qatar, Kuwait and Oman.

Export of sheep/goat meat

	2011-12	2012-13	2013-14
Sheep/goat meat export (Million kg)	10.95	15.67	21.99
Price (Rs in lakh)	25254	42080	68650

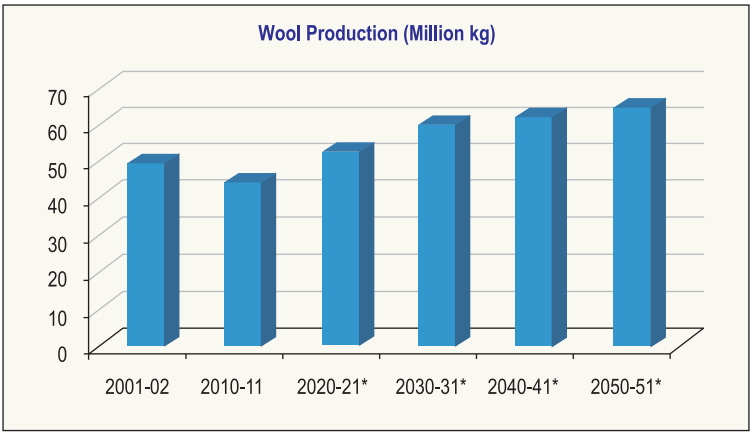
Source: DGCIS 2013-14

Escalating global market opportunities for the Indian meat sector requires private investment in meat processing through state-of-the-art technology. Modern integrated plants with facilities for slaughtering and dressing of animals, carcass deboning, packing, chilled and frozen storage, byproduct processing and effluent treatment etc are needed. Moreover,

programs need to be developed for utilization of slaughterhouse byproducts for production of carcass meal, meat-cum-bone meal, tallow, bone chips and other value-added products. A well-integrated marketing system for meat and meat products is also lacking in India. The main reasons include monopoly of meat traders, lack of co-ordination between production and demand, involvement of too many middlemen in the trade and inefficient management in slaughterhouses. Meat is nutrient dense food which makes it is a perishable commodity. In order to improve keeping quality of meat, cold chain is of crucial importance during transport as well as storage till it reaches the consumers. Cold storages, supply/value chain and standard slaughterhouses in the country need to be strengthened.

Wool production: Wool contributes only 15-20% to the income of sheep farmers. Over the period, the price of wool in the country in comparison to mutton has not increased, resulting in diversion of interest of farmers from wool to mutton. Fine wool cannot be produced in required quantity in the country owing to limitation of climate and breed availability but carpet wool production can be improved marginally. The existing demand of the Indian woolen industries cannot be fulfilled from domestic production and have to rely on import of wool.

Global wool production is also shrinking at the rate of 3% per annum and has declined from 3399 m kg in 1990 to 2106 m kg (greasy wool) in 2008-09. It is mainly due to stiff competition from manmade fibre, higher production cost and shifting from wool to meat in major wool producing countries like Australia and New Zealand. However, it has been reiterated that wool being eco-friendly natural fibre with comfort and warmth, should maintain its position in world textile.



The current wool production in India is 44.7 million kg and it is expected that it will increase to 65.0 million kg by 2050. The requirement of apparel wool is completely met through import from other countries like Australia and New Zealand. Demand of carpet wool is partially (40%) met from domestic market and rest through import from New Zealand, Argentina, Spain, etc. The installed capacity of woolen industry and consumption of woolen products in India is continuously increasing by 1% per annum. Keeping this in view demand for wool may rise from 139 million kg in 2010-11 to 200 m kg in 2050 excluding 150 million kg of wool rags from shoddy products. Since the global supply of wool is decreasing, it will be difficult to meet the requirement of woolen industry in years to come. China has visualized the situation and focused on wool production. As a result its production has increased from 220 million kg in 1992 to 400 million kg in 2012 with a growth of 7- 8% per annum (FAOSTAT 2012). Wool production in India is almost stagnant at 45 million kg since last two decades. Looking into the demand and availability of wool in domestic as well as International market, it is a great challenge to meet the demand for wool in the country.

Import of raw wool from Australia, New Zealand and many other countries are as under

Year	Wool import (Million kg)
2006-07	99.56
2007-08	93.07
2008-09	65.73
2009-10	68.26
2010-11	94.77
2011-12	76.29
2012-13	77.16

Source: DGCI&S, Calcutta

India possesses vast diversity in sheep genetic resources in the form of 42 well established breeds which are spread in different ago-climatic zones of the country. Out of 65 million sheep, majority of the sheep population (51%) are of non-descript type. With diminishing grazing resources and increasing demand for mutton and wool, there is an urgent need to genetically improve these animals through scientific breeding tools to enhance their productivity. Major emphasis is required on improvement of well adapted indigenous breeds to harness the better adaptive traits developed through natural selection. In the past, much

of the improvement in the productivity of sheep was mainly achieved through genetic improvement of indigenous sheep breeds.

Meeting requirement of feed and fodder for sheep under prevailing scenario of gradually diminishing grazing lands is one of the major challenge. Shrinking areas under community pasture land is a major limitation and would adversely affect the sheep husbandry in future. Some of the issues like increasing competition between human and animal population for grains and grain by-products, diversion of oil cakes and protein concentrates meant earlier for livestock for human food, agricultural waste to bio-fuel production, grain and other by-products for ethanol/methanol production are restricting the availability of feed to animals. Higher lignification of plant tissues especially of tree fodder resulting in reduced digestibility leads to reduced nutrient availability for animals. This is ultimately reflected in reduction in production which impacts on food security and income of livestock smallholders.

Generally, about 5 to 10% of the land area in every village is reserved for community pastures. However most of this land is being encroached or diverted by the local government for other purposes. Over the years, in the absence of controlled grazing and care, the productivity of these community pastures has been severely eroded. There is a need to develop suitable fodder shrubs, trees and grasses for development of pasture lands. The strategy should cover selection and breeding of high yielding and stress tolerant fodder crops and varieties and improving the yields through sustainable production practices. Efficient use of crop residues including timely harvesting of crop residues as well as proper processing and storage can also enhance the quality of the forage and prevent wastage. Hence, fodder banks need to be established in fodder surplus areas and supply to regions facing seasonal shortage. It is also necessary to introduce non-traditional fodder crops on marginally productive farm, wastelands and denuded community lands. There are many hardy grasses and legumes which can be grown on wastelands without irrigation. There are many fast growing shrubs and trees which can be lopped regularly as fodder. Such tree species can be established on field bunds, home gardens and along farm boundaries.

Climate change is seen as a major threat to the survival of many species including sheep, ecosystems and the sustainability of livestock production systems. It is expected that the sheep production system based on grazing (extensive system) and the mixed farming system (semi-intensive system) will be more affected by climate change than an intensive system. While new knowledge about animal responses to the environment continues to be developed, managing animal to reduce

the impact of climate remains a challenge. Reducing environmental stresses on sheep requires a multi-disciplinary approach with emphasis on animal nutrition, housing and animal health. Adequate shelter and proper management has the potential to increase sheep production in the future.

The livestock extension services in general and for sheep in particular are poor in comparison to agriculture. Little efforts have been made to transfer improved production technologies to the sheep farmers. The State AHD's maintain services only for health and breeding coverage. Integrated approach for sheep breeding, health, reproduction and management is required for augmenting sheep production.

Institutional credit also needs to target small and marginal sheep farmers as this sector has been under- invested and neglected by the financial institutions. Innovative schemes like sheep entrepreneur and cooperative models for efficient mutton production and marketing are lacking and need to be devised along with innovative technology dissemination systems. Conventionally, marketing of live sheep and meat and wool are unorganized and inefficient, which is a significant barrier for commercialization. There is ample scope for entrepreneurs in marketing and post-harvest technologies to exploit the enormous opportunities offered by high value commodities like processed meat and wool products. Moreover, there are strong possibilities for public-private-partnerships in wool and meat sectors. Use of prolific sheep to enhance mutton production can be adopted by the entrepreneurs. This approach will help to build the model for broiler sheep to meet the ever increasing demand for meat.

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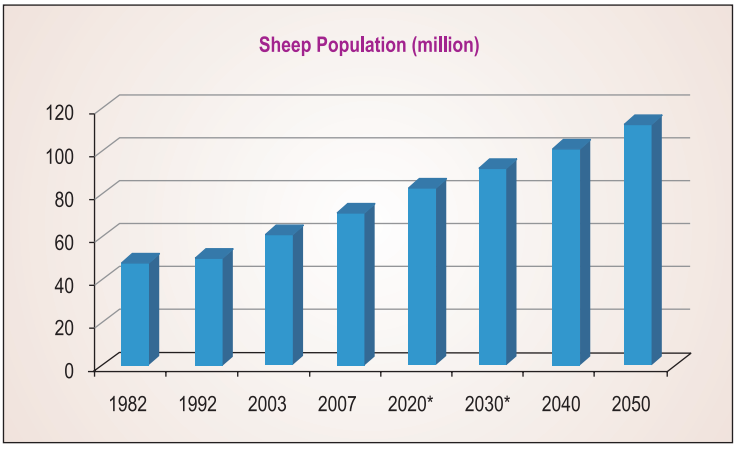
Operating Environment

Sheep are reared on grazing resources particularly in harsh climatic zones of the country. The shrinkage of grazing resources, increase in cultivation and industrialization, declining interest of new generation for sheep rearing/migration, poor health care support, unorganized marketing structure for meat and wool, dependence on wool import, ineffective financial support, poor risk management strategies, are some of the factors affecting sheep production in the country.

The sheep population in the country is gradually increasing at the rate of >1% annually up to 18th livestock census (2007). A sudden decline (9%) in the sheep population was reported in 19th Livestock census (2012). The estimated sheep population would be around 83.30 million in 2020 and 92.30 million in 2030 and 113.50 million in 2050. Similarly mutton production is 399 million kg in 2012 which will be around 537 million kg by 2020, and 840 million kg in 2030 and 1317 million kg in 2050. However mutton requirement in the country would be 813 million kg by 2020, and 986 million kg in 2030 and 1408 million kg in 2050 indicating deficits of 33.90, 14.80 and 6.46% respectively.

Wool production in the country is 44.7 million in 2011-12 and is expected to be 53, 60 and 65 million kg by 2020, 2030 and 2050 respectively. However, estimated demand for wool in the country would be 150, 180 and 200 million kg in 2020, 2030 and 2050, respectively.



Therefore the country's requirement would not match with the current production trend. Thus about 97 million kg by 2020 and 120 million kg by 2030 and 135 million kg in 2050 of raw wool will have to be imported from sheep producing countries if suitable steps are not taken to increase wool production in the country.

These deficiencies can be rectified by employing better and newer management options to attract new entrepreneurs and application of mitigating strategies. These challenges can be met by research and development with integrated approach of breeding, reproduction, health, feeding management and marketing in cost-effective manner for enhancing sheep productivity in the country.

In view of increasing demand for mutton enhancement of infrastructure for hygienic slaughter, value-addition, processing and marketing will be required. Though, it is a difficult task to produce required quantity of meat and maintain meat price under control, but a coordinated effort in improving sheep productivity can ease the situation to a great extent. The demand for consumer friendly meat products with low calorie, cholesterol, salt and high dietary fibre and fortified products is increasing progressively due to the urbanization and changing living style. For R&D organizations, the main challenges are: (i) development of promising technologies and management options to raise per animal productivity and (ii) creation of required infrastructure and institutional facilities for production, post-harvest processing and marketing of high-value products and cold chain facilities for perishable commodities with more emphasis on development of diversified keeping quality of meat products.

Nutritional requirement of sheep in the country largely depends on the monsoon grasses on common property resources (CPR) and stubbles. Changing rainfall pattern would further aggravate scarcity of grazing resources in north-western and southern India. The evident climate change will lead to dry areas becoming drier and wet areas wetter with longer spells of droughts in dry areas, which will subsequently create scarcity of grazing resource and water. Sheep in comparison to other livestock species are capable of adapting to adverse situation of climate change and its vagaries. They can also escape from drought or famine affected areas by migrating to other areas and avoid its adverse effects.

The thermal stress, extreme weather conditions and emergence or re-emergence of infectious diseases are likely to adversely affect the sheep production. Sheep being most hardy and adapted to harsh climate as compared to large ruminants have better chance of thriving in hot

and dry areas which are expected to increase due to climatic change in central plateau and southern states like Andhra Pradesh, Karnataka and Tamil Nadu. However, sheep husbandry is severely affected by health hazards if infectious diseases like PPR etc are not controlled in time. Strategies to study the host resistance for these diseases, introgression of information for resistant livestock, for vaccine production etc need to be drawn.

This century is likely to witness the soaring temperature, erratic weather patterns with more intense monsoons, increased cyclonic activities, severe droughts, floods, melting glaciers and rise in sea levels. This would result in greater instability in sheep production like other livestock and may threaten farmers' livelihood security. Thus, producing mutton and wool matching with increasing demand under climate change scenario is a serious challenge. This would require increased adaptation and mitigation research, capacity-building, changes in policies, and cooperation at regional and global levels. Policy planners, decision makers, research institutions and extension services have to work together and support sheep rearing activities to prevent loss of production, deterioration of animal products, land desertification and the worsening of animal health under the effects of the climate change. ❑

Opportunities & Strengths

Some of the opportunities in Indian sheep production system are: (i) genetic improvement of native sheep for overall productivity, (ii) improvement in efficiency of production by utilizing biotechnology and genomics tools, (iii) enhancement in nutrient and drug delivery systems by newer approaches of nanotechnology and (iv) minimizing the wide gap in demand and supply of meat through intensive production and organized marketing.

Institute has well established infrastructure and expertise for identification of prolific gene and its use in breeding programme. Garole, Kendrapada and Edka sheep may serve as valuable source for introgression of prolificacy traits in non-prolific sheep breeds available in the country. Marker assisted selection and removal of non-carrier animals from breeding programme will increase the carrier population of prolific sheep for higher mutton production.

Identification of candidate gene/marker and their use in breeding programme would improve meat and wool production. Marwari, Chokla and Magra are well known carpet wool breeds found in western parts of Rajasthan. The selection and genetic improvement of these breeds would increase the production of carpet wool in the country. Mecheri, Nellore, Deccani, Mandya and Madras Red are mutton type breeds found in southern region. For increasing mutton production in these breeds an integrated approach of feeding, breeding, management and health cover would be attempted. Bharat Merino and Kashmir Merino sheep strains developed in the country for fine wool production are well suited to temperate and sub-temperate climate. Their propagation in temperate region will increase production and possibly meet the requirement of quality apparel wool.

Individual animal identification and performance recording at farmer's flock need to be implemented through farmer's cooperatives/ breed societies/programs of State AH department etc. and it will generate large size data base along with pedigree information. Advanced software packages and statistical procedures such as use of animal models, random regression models, Bayesian statistics, etc. can be used for data analysis. Such information will help in accurate estimation of genetic parameters for sheep breeds in farm as well as field for selection and identification of superior germplasm for further propagation in nucleus

flock for rigorous genetic selection for production traits. Open Nucleus Breeding System (ONBS) need to be implemented for evaluating elite rams and for accelerating genetic gain in the farmer's flocks. ONBS can be complemented with multiple ovulation embryo transfer (MOET) for enhanced genetic improvement. This may help in ensuring availability of genetically superior males for natural service or their extensive use through AI.

An integrated approach of selection and breeding based on molecular and phenotypic information of the traits will be used for rapid genetic gain in mutton and/or wool production. This will be achieved through: Identification of QTLs, major/candidate genes, SNPs, genetic markers followed by validation of their association with mutton/wool production traits in sheep. Prediction of genetic merit of an individual sheep from genome-based data combined with phenotypic information and use of genomic selection programme in conjunction with the traditional selection methods will enable us to achieve a faster rate of genetic improvement in mutton/wool production. Simultaneously, programmes for identifying markers for resistance of sheep to inactivated or attenuated virus particles/vaccines/infections shall be carried out and host-vector relationship will be studied in greater details. Molecular information with regards to resistance shall also help in creating genomic selection indices where restriction on the basis of resistant marker or QTL could be applied as a criterion for selection. Information with regards to host-antigen will also help new generation vaccine production for better preventive strategies.

Fixed time AI with chilled liquid semen has been found to be useful for producing progeny of elite animals. Facilities for storage of frozen ram semen and embryos would be useful for cryo-banking of superior germplasm. The technologies of frozen semen of elite rams as well as the MOET perfected in the country would support sheep improvement by faster multiplication of superior germplasm.

A different system of lamb rearing for mutton production has been developed. Sheep are generally raised on grazing resources, which includes community lands, barren lands, stubbles and shrub lands. Over the period the forage supply from these lands are deteriorating owing to higher grazing pressure and stocking density. An alternative system of sheep rearing is known as semi-intensive feeding where sheep are grazed on grazing lands and deficiency, if any are met from supplementary feeding in the form of concentrate mixture or tree leaves or agricultural byproducts has been developed. This system of sheep production would also sustain the production in view of deteriorating environment.

The intensive system for lamb rearing for mutton production has also been developed for harvesting maximum weights at an early age with higher feed efficiency. The post-weaning gains of 150-170g daily in native lambs have been achieved. Newer approaches of restructuring meat of animals by feed additives in the ration need to be explored for producing desirable quality meat.

The demand for organic meat is growing in the country; research on this aspect would help in meeting the requirement for safer and quality meat for consumer as well as for international market. The use of herbal and biological drugs for treatment of diseased animals would reduce the residues of harmful chemicals in the animal products and would be beneficial for organic meat production.

Complete feed blocks prepared from roughage and concentrate mixture in varying proportions have been developed. Feed block can be stored for 6-8 months without deterioration of quality for feeding to animals during drought and famine periods. Complete feed block of roughage and concentrate fortified with minerals and vitamins would be beneficial in rearing of sheep under intensive system.

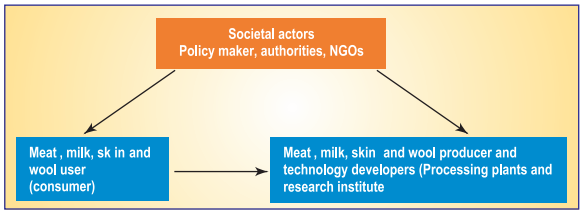
There is great scope of developing cost effective disease diagnostic kits and vaccines, development of GIS mapping and forecasting of sheep diseases and establishment of disease free zone for meat production.

Carpet sector has good potential in domestic as well as international markets besides Felt and Khadi sectors for utilization of wool produced in the country. There is a scope of blending wool and other fibre for value added products.

The development of marketing structure for disposal of finisher lambs and spent animals separately would provide better return to the farmers. The meat from finisher lambs can be marketed as different cuts with variable price. India has rich diversity of culinary specialties and these recipes have to be developed and scientific procedure for their preparation, packaging, shelf life, keeping quality and marketing have to be documented. There is a good scope of increasing export meat and processed mutton to Middle East, Southeast Asia and African countries. For this, desirable body weights and carcass quality including disease free zones need to be developed and maintained. Moreover, the sheep in the country are raised on natural resources and mutton produced in the country is expected to be free from chemical residues.

Goals and Targets

Our goal is to improve per animal productivity and efficient utilization of product for livelihood security, women empowerment especially in arid, semi-arid and hilly areas. To accomplish this goal, the targets set by the year 2050 would be (i) carcass weight of 20.0kg in mutton breeds, (ii) introducing dairy sheep and linking to cheese manufacturing and marketing, (iii) wool yield of 2.5-3.0 kg in carpet and fine wool sheep breeds and (iv) processing and value addition of sheep skin.



Multiple view on developing sheep husbandry

It is required to achieve 1408 million kg mutton and 65 million kg wool in the next 35 years in the country. The institute is targeting introduction of prolific gene in non-prolific sheep to increase twins/ triplets, accelerated lambing system to achieve target of three lambs in two years and intensive feeding of lambs to achieve targeted slaughter weight of 33-35 kg at 6 months of age. At present one lamb from non-prolific sheep attains 23-25 kg at 6 months of age. After introduction of prolific gene in non-prolific sheep, twins/triplets will be born and total live weight of 46-50 kg will be harvested at 6 months of age. Thus there is every possibility of increasing mutton production by two folds in 50-60% of mutton type sheep in the country.

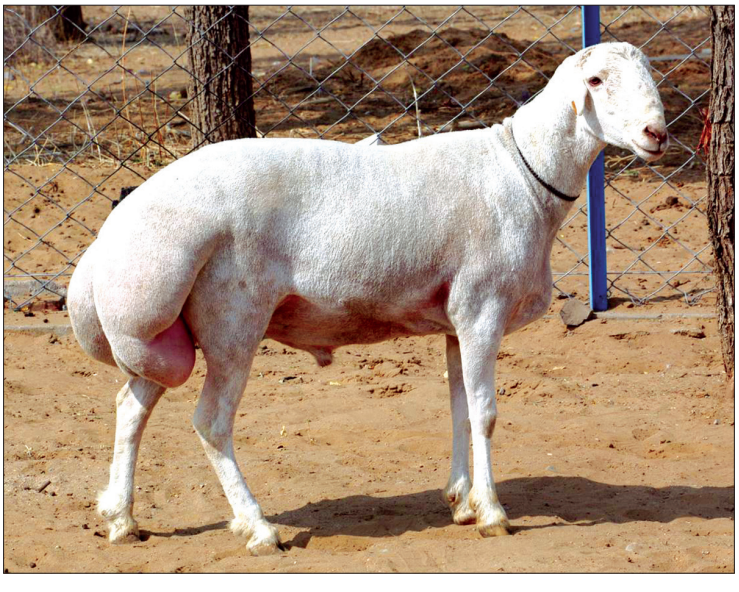
The accelerated lambing system in sheep for achieving target of 3 lambs in two years has been taken up in the later part of XI plan and is continuing in the present XII plan. In conventional system, two lambs in 2 years are achieved. Our target is to achieve one more lamb in two years or 9 lambs in life time against 6 lambs under conventional system. Thus, mutton production will increase by 1.5 times in about 55-60% of sheep in the country.

There is also need to increase production without increasing the sheep population. To achieve this target, reproductive efficiency of high

producing animals need to be enhanced. This can be accomplished by application of various reproductive technologies such as estrus synchronization, artificial insemination and in vivo embryo transfer and cloning.

In addition to estrus synchronization and AI with chilled liquid semen, other reproduction technologies such as controlled ovulation (for reducing puberty age and inter lambing period), superovulation, ovum pick-up, in vitro embryo culture, semen and embryo freezing, somatic cell nuclear transfer, transgenic sheep production, AI with frozen-thawed semen and early pregnancy diagnosis need further refinement and application. These technologies would result into more embryos production at a reasonable cost with high genetic merit for sheep improvement.

Fat tail or fat rump sheep in the country has created a good demand, especially during Islamic festivals, which otherwise also fetches premium price. Improved fat rump sheep breeds of Middle East countries need to be introduced in the country as they have better adoptability and growth in our environment. Further research on these sheep including prolificacy trait with multiple births for mutton production under intensive production needs to be carried out. Embryos/semen of fat rump sheep needs to be procured from the animals available in the country or imported from their country of origin. Gene responsible for fat tail or fat rump in these sheep breeds may be identified using molecular approaches.



Male lambs in field flock are normally put to slaughter at an early age of 3-4 month when they hardly attain body weight of 12-14 kg. Development of entrepreneurship for procurement of these lambs and put up under intensive feeding up to slaughter age (6-7 months) will boost mutton production of higher quality for domestic as well as for export market. The intensive system of lamb rearing for mutton production will be implemented in field flock through nutrition and feeding, feed and fodder technology and awareness development for rearing up to slaughter age. Further specialized nutrition will be attempted for augmenting nutritional health, combating stress and consumer preferred quality traits in meat. The economical and balanced ration will be formulated through a conceptual framework based on 3 Ps (Profits, People and the Planet).

The efficiency of production systems is influenced by several other factors including the endemic diseases, inadequate access to knowledge, information, technologies and structured markets and poor management practices. A holistic approach that addresses nutrition, reproduction, health and overall management of animal is required for increasing FCE. The importance of feed conversion efficiency (FCE) to produce more food with lower methane emissions needs to be realized.

In earlier breeding programs for sheep improvement, milk production was not given due importance. The introduction of milk trait in sheep would be a boon for the farmers and also for the livelihood and nutritional security further it would result into better lamb weight, lower morbidity and mortality and increased mutton production. The milk yield of local sheep can be improved by cross-breeding with dairy sheep breeds of Near and Middle East countries. Awassi dairy sheep of Middle East may be choice of animal for the country. Awassi in Near-East countries produced sheep milk with good links to the market, especially with regard to cheese production. A large number of dairy sheep farms (70% Assaf and 30% Awassi crossbred) in the Spain

Profitable Commercial Dairy Sheep Farming in Spain

In flock of 692 ewes with milk yield of 316 liters per ewe, total annual income accounts from milk (78.6%), lamb (13.2%), culled ewes (0.5%) and other sale (0.8% wool and manure) and European Union sheep subsidy (6.9%).

Total cost accounts on feeding (61.6%), labour (18.2%), equipment maintenance and depreciation (7.6%), finance (3.0%), animal health (2.5%), energy, water and milking supplies (2.2%), milk recording (0.5%), and other cost (4.4% assurance, shearing, fees etc.)

Dairy sheep provide profit of £ 7.4 per ewe annually

Source: Milan et al 2014

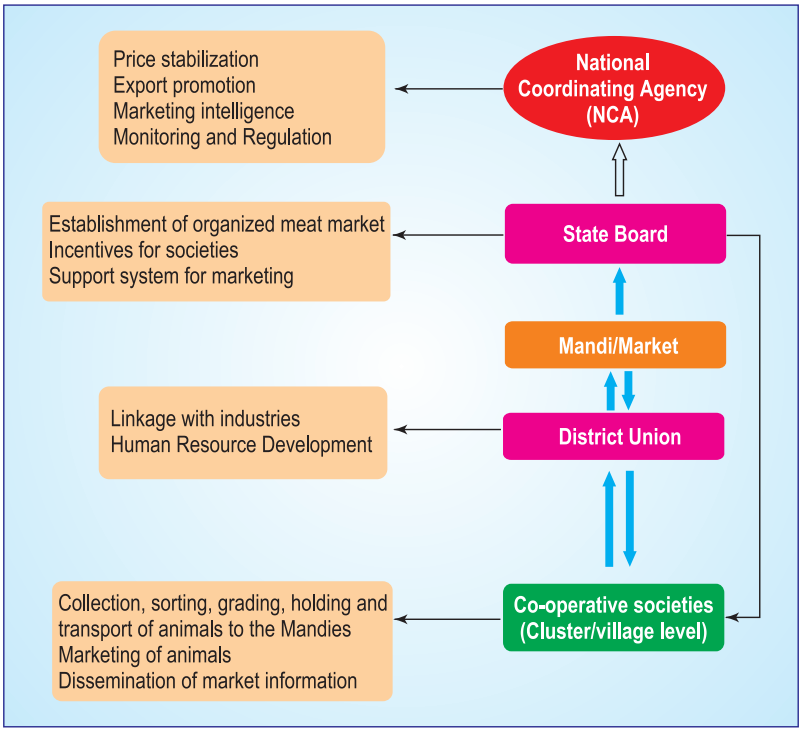
are adopting intensive system of farming with machine milking, planned mating and artificial insemination. Milk is sent to local dairy industries for cheese production, and 1.35 lambs/ewe/annum are harvested as milk-fed lambs. The dairy sheep farms showed more adoption of intensive production systems, which resulted in higher milk and lamb yields.

Provision of support system from state and central government for timely and regular vaccination, drenching and dipping of animals against diseases in sheep rearing zones will reduce the losses due to morbidity and mortality. This will also increase mutton production and save the precious animals from death.

The Indian wool is coarse in nature and has short staple. This wool can be used for carpet or felt besides other usage. On account of dwindling wool prices in the country, the profit margin from wool to the farmers is shrinking. There is an urgent need to develop diversified wool products. With this rationale, several handicrafts, apparel involving various combinations of wool and other natural or manmade fibre can be developed. The institute has developed a process for uniform yarn from short staple wool spinning. There is a need to utilize and evaluate performance of this yarn as knitwear. This will help in utilization of indigenous fine wool in knitting yarn production and development of diversified quality knit wears and better price realization for native wools. Formation of carpet yarn with core-sheath structure through SIRO/modified SIRO method on ring frame and wrapping technique in DREF spinning system will make it possible to use the non suitable coarse wool in carpet yarn and harvest its high stiffness properties in terms of carpet performance as well as in producing diversified handloom woven carpet from coarse-medium type wool produced from south India. Apart from thermal insulation, wool has ability to absorb and retain moisture for longer time. This property of wool can be gainfully utilized for preparation of various agro-textile and geo-textile products. Wool has special character of felting when it is rubbed with detergent solution and converted into a desired shape. It has great potential to develop diversified handicraft products such as mats, wall hangings, flower pots, soft toys of novel designs and colour combination.

In present system of sheep and goat marketing in the country, lack of facilities for holding, feeding and watering of animals in mandies, lack of sorting and grading while purchasing from producer, lack of transportation facility for sheep and goat, purchase of animals in bulk without considering weight and body condition, large number of middleman/intermediaries, secret/hidden bid, etc. are some of the issues need attention in future planning.

Environmental issues like methane emission, over grazing and soil erosion/pasture degradation, slaughterhouse effluents, disposal of carcasses, disposal of wool processing/dying waste, etc. needs attention in planning and policy for protecting environment from pollution.



Sheep Marketing Model

There is a wide gap in technological developments in research institutions and their application in the field. Therefore, the field level extension functionaries of the major sheep rearing states like Rajasthan, Andhra Pradesh, Himachal Pradesh, Jammu & Kashmir, etc. need to be targeted during the coming decades and regular training is provided on latest technological developments. Strong extension programme is required for effective technology dissemination in these states. Increased participation of social scientists will be required in the future for identifying problems of marketing, identifying factors impeding production and in planning, execution and impact assessment of technologies in the field.

Major strategies to improve sheep productivity will be taken up in phased manner as shown below:

Strategies for 5-10 Years

1. Introgression of prolificacy through Garole in non- prolific sheep, introduction of fat tail sheep for enhancing mutton production, and accelerated lambing system for higher life time production
2. Improvement of Marwari, Magra and Chokla for carpet wool production and Bharat Merino sheep for fine wool production through intensive selection. Identification of candidate gene for luster in wool and its application in breeding programme
3. Nutrition-reproduction interaction, improving meat yield and quality by nutrition and feeding
4. Disease surveillance, parasite management, neonatal mortality, health care and diagnostics
5. Technology validation, refinement and dissemination, knowledge management system and capacity building and training

Strategies for Next 10-20 Years

1. Introduction of fat-tailed sheep and improvement of milk yield of local breeds like Patanwadi and Malpura
2. Accelerated assisted reproduction of high producing animals in "All in All Out" system
3. Cryo-banking of superior and endangered germplasm, Semen freezing and AI in field and farm flocks
4. Rumen bio-geography for enhancing feed efficiency, health and production research, improving milk yield and quality by nutrition and feeding
5. Geographical Information System (GIS) in sheep husbandry for mapping grazing/pasture areas and seasonal feed availability
6. Identification of bio-molecules in milk and cheese for therapeutic value
7. Designer meat and meat products with their preservation
8. Use of nano technology and natural dye in wool processing
9. Diversified use of wool and wool waste

Strategies for Next 20-40 Years

1. Molecular breeding for improving growth, reproduction, quality and quality of meat and wool
2. Identification of candidate genes controlling prolificacy, growth, meat, hind quarter muscling, wool and milk production. Cloning

of genetically elite sheep for faster multiplication

3. Use of nutrigenomics in nutrition, therapeutic nutrition and biomarkers for micronutrient status in animals
4. Diseases and climate resilient sheep, production of multi-component subunit vaccines
5. Nano and biotechnology approaches in wool processing, diversified use of waste wool for biomedical, geo-textile and industrial application
6. Electronic tags or chips in animal body for identification of animals suffering from disease. Traceability of animals at various stage from production to end use

❑

Way Forward

In sheep husbandry, the future strategy will be to improve productivity, efficiency and wholesome production. For improving productivity the use of biotechnological, molecular and nanotechnology approaches in breeding, feeding, reproduction and health research will be undertaken. The laboratory facilities with equipments will be developed. Traceability of animals at various stages of production from primary producers to end user will be strengthened. Individual identification system for records and other management options will be implemented. GIS will be developed for mapping grazing/pasture areas and seasonal feed availability to migratory/transhumance sheep.

To improve efficiency of feed to gain weight through manipulating rumen environment and feed formulation at cheaper price will be identified and implemented. The identification of resistance to diseases and stresses traits in sheep will be given due importance in breeding programs. Identification of heat resistant sheep breed and proper shelter management systems will be developed to mitigate the adverse effect of climate change. These breeds will be selectively bred by using molecular markers such as identifying SNPs related with enhanced resistance to climate change and using them as selection marker in breeding programme.

Embryo technology for rapid multiplication of elite animals and import of embryos and animals from outside to enhance mutton production will be implemented in certain pockets having optimum environment. Diversified use of wool not suitable for textile will be taken up in research agenda and its use as cottage industry in rural areas will be implemented. In future more emphasis will be given on development of cost effective, healthier meat products in order to meet the demand of ever increasing human population.

The changes in production system and climate will bring changes in disease pattern and epidemics. Advanced computer and information technologies will be developed for electronic surveillance of infectious and metabolic diseases, profiling and identification of most susceptible animals. Gene profiling of diseased and healthy animals along with specific biomarkers for each disease and their detection at the farm level by farmers/veterinarians would be a part of future scenario. Electronic tags or chips in animal body will be implanted that could provide disease

signals to associated electronic system for subsequent management to prevent death and production losses. In addition, biomarkers for early detection of infectious or non infectious diseases for their subsequent diagnosis and therapeutic management will be identified. Host-pathogen interaction w.r.t. immunobiology, identifying specific gene/protein for protection would help in generation of multi-component subunit vaccine instead of conventional vaccine used separately for each disease.

Commercial sheep farming involving challenge feeding of weaner lambs to harvest maximum finishing weights will help to meet out the demand driven animal protein need of the ever growing human population. On these lines, many commercial entrepreneurs have already started project in some parts of southern India. Adoption of micro climate environment like in poultry enterprises will open up the scope for incorporating exotic germplasm like Suffolk, Dorset, Awassi etc for maximizing mutton production. Automation in feeding and rearing practices will aid in whole farm management system.

Market research studies will be taken up to understand the market trends, structure, competitive landscape and the outlook of the Indian sheep farmers. Such reports can help in developing intelligent system for investors, researchers, consultants, traders and policy planners in boosting the sheep productivity in India.

The present national sheep research and extension system faces many challenges and opportunities. Serious limitations in planning and financial management of sheep research, organization and management of the research institutions and in technology transfer strategies need to be identified. Further, extension systems will be reoriented and financially supported to update service provision approaches and extension methods.

Developments in biotechnology and biosafety, climate change concerns, food insecurity, the growing relevance of agri-food chains, demands for greater rural producer empowerment, and the changes in information and communication technologies will be combined to provide new opportunities for growth and renewal of national sheep research and extension systems.

There is a need to strengthen the farmer's ability to generate, adapt and transfer appropriate technologies for improved and sustainable production systems in sheep husbandry. Further there is need to provide assessment, policy advice and assistance to reorienting extension services towards creating a pluralistic, demand-led and market orientated system, new financing mechanisms and use of Information and Communication Technologies (ICTs) for monitoring and evaluation.

Sheep husbandry is greatly affected by natural disasters like

drought and famine in the arid and semiarid regions, flood in the eastern region, snow fall and landslide in the north temperate regions and cyclone and volcano in the coastal regions of the country. These disasters are increasing in frequency and imposing economic and social burden on an already impoverished nation. Lastly Disaster Reduction Programme should address: Preparedness planning, monitoring and early warning system, assessment of impact and needs relief programme and rehabilitation and reconstruction programme in affected areas.

The existing laboratories and animal farms and infrastructure in the institute will be modernized and equipped for conducting problem oriented research. The laboratories will be strengthened by creating advanced facilities and required equipments. Moreover, the sheep farm will be modernized and full automation will be done to provide conducive environment for optimizing production and labour efficiency. The posts of scientists in the discipline of Leather Technology, Dairy Technology, Textile Technology, Nanotechnology Computer Application, Bioinformatics, Economics and Social Sciences, etc., will be proposed in the institute in future to cope up with the newer areas of research in these fields.

Referral accredited laboratories for sheep feed evaluation, meat and wool will be established in the institute. State of the art artificial insemination facility for sheep will be developed at the institute as well as at different locations for large scale multiplication of superior germplasm. International referral laboratory for small ruminant diseases will be established with diagnostic support, training and consultancy to national and international clients. Besides, disease surveillance and control at national level, the institute will play an active role in international market with its disease surveillance data bank, prevention of trans-boundary diseases to neighboring countries, interpretation and forecasting of imagery of satellite disease related data and creation of disease free zones. Modern laboratory with advanced biotechnological and information technology facilities with satellite surveillance of disease along with sufficient and efficient faculty/man-power will be created.

The extension wing of institute will be strengthened to transfer the technology developed by the institute and its impact assessment on improving livelihood and production. Use of Information Technology and other communication systems for transfer of technology will be given priority in extension activities.

Training of farmers, trainers and other targeted groups is one of the important aspects for dissemination of knowledge and information to end users. The facilities for training will be strengthened and e-courses

on various aspects will be developed.

KVK, Technology Park and Information Centre specifically dedicated to all aspects of sheep husbandry will be established at Avikanagar to improve its reach among the sheep farmers in the country.

Administrative reforms like implementation of ISO 9001 will be maintained on priority to improve work culture, efficiency and service quality. To achieve a proactive, responsive, accountable, sustainable and efficient research administration issues like organizational structure, ethics in research, personnel administration and transfer policy, financial management systems, e-governance, etc. will be addressed and strengthened. In view of decreasing dependence on government sponsored research programs, contract research involving industry-scientist partnership, people participatory program (PPP) will be initiated.

Biotechnological cutting edge research will be taken up in future programs for enhancing productivity of sheep. Identification of candidate genes controlling prolificacy, growth, meat, hind quarter muscling, quality wool and milk production will be taken. Expression profiling of novel genes will be attempted for various economically important traits. Embryonic stem cells will be cultured and characterized by different embryonic stem and cell markers for the elucidation of gene expression profile. Cloning of genetically elite sheep will be taken up for faster multiplication. Production of transgenic animals will be directed towards achieving manufacture of biological medicinal products.

Institute will participate in nation-wide programme on vigilance by sero-surveillance, host-parasite interaction, vector biology (if involved) and eradication of major infectious diseases. Development of pen-side diagnostic tests, evolving genetically resistant sheep breeds for chronic bacterial and parasitic infection, manipulation of disease susceptible genes by silencing technology, gene profiling and diagnosis will be undertaken. Resistant lines for Haemonchus contortus and other diseases will be developed.

Use of nutrigenomics in physical and chemical nutrition, rumen bio-films and its role in therapeutic nutrition will be studied. Probiotic microorganisms from different wild and domestic animals and birds and rumen microorganism and biomarkers for micronutrient status in animals will be identified, isolated and characterized.

Epigenetic regulation or neonatal/fetal programming of gene expression and exploring its involvement in dietary conditioning will be studied. This will increase the scope of nutrient-gene interaction for up- or down-regulation of metabolic efficiency of desired attributes.

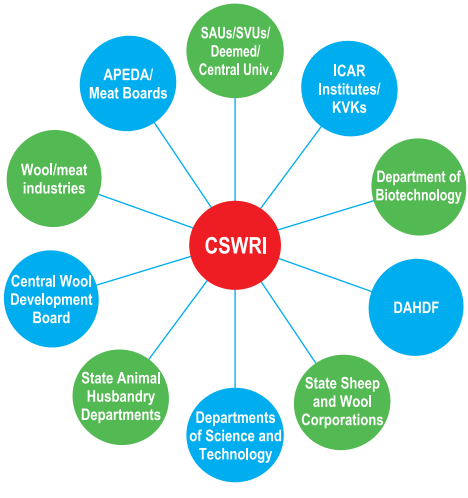
Microbial fuel cells and microbial ecology applications in ruminant health and production research, e.g. bio-remediation and bio-energy applications will be studied. Challenged feeding for commercial trait-specific and market-driven demand traits like mutton, milk and wool production will be targeted. The functional and qualitative nutrition research and its application will be strengthened.

The combination of advances in somatic cell nuclear transfer, the development of induced pluripotent stem cells and the completion of the sequencing of genomes will ensure a bright and exciting future for sheep industry. Therefore, more focus will be given to these emerging areas of reproductive technologies in near future.

Nano and biotechnology based functional finishing of wool and specialty hair fibre will be developed. Protein/amino acid extraction from fine wool and its waste will be explored for biomedical application. Novel technologies for development of value-added meat products using natural functional ingredients having health benefits, bio-preservation, environment-friendly packaging and quality control will be applied for efficient utilization and improvement in keeping quality of meat and meat products.

Contract farming concept will be introduced in the sheep husbandry where all inputs like feed, vaccine, treatment etc will be provided to farmers by entrepreneur and lambs at slaughter age will be procured at reasonable price. This will improve the production and farmers will get better remuneration for their produce and consumer will get safe mutton at reasonable price.

GPS inventory of different breeds of sheep will be developed to get the information about native track, unique breed characters, important phenotypic traits, average production and reproductive performance, availability of superior breeding animals, its location and cost, system of rearing and marketing channels. Individual identification of sheep with traceability of their main produce such as mutton, wool and other unique products under the system of National



Linkages of Institute with other organizations

Animal Identification system will be developed.

Existing linkages with R&D agencies working in sheep sectors will further be strengthened under the collaborative mode.

A 5-point strategy will be adopted to achieve the targets, address challenges and smoothly adapt to the changing environment to derive maximum benefits from it.

1. Molecular breeding approach and introgression of Fec B gene from Garole sheep for prolificacy, nucleus breeding scheme using MOET technology for higher genetic gain, introduction of Awassi/fat tail sheep for enhancing milk and mutton production, accelerated lambing system for higher life time production targeting 3 lamb crops in two years, economical and low cost complete feed incorporating desirable nutrients will be adopted for enhancing lamb, mutton, wool, and milk production
2. Wool processing/value addition and development of new programs for coarse wool utilization in industrial and agriculture application, carpet designing, natural dye and eco- friendly woolen textiles.
3. Meat processing and value added products, milk processing and cheese manufacture and restructuring meat from spent ewes for value added products will be adopted for enhancing production of value added products from meat, milk, etc.
4. Disease surveillance and preventive measures, curative health care practices, disease diagnostics and control measures, shelf life and food safety measures, bio-containment and disease free zones for meat production activities will be strengthened.
5. Transfer of technology and public private partnership activities will be strengthened by adopting activities like technology validation, refinement and dissemination, industry-institute-farmers interface, interactive information system, knowledge management system, marketing intelligence for live animals and their produce, and capacity building and training.

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