



Vision 2050



Central Sheep and Wool Research Institute
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VISION 2050



CENTRAL SHEEP AND WOOL RESEARCH INSTITUTE
Avikanagar via Jaipur 304501 Rajasthan

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शरद पवार
SHARAD PAWAR



कृषि एवं खाद्य प्रसंस्करण उद्योग मंत्री
भारत सरकार
MINISTER OF AGRICULTURE &
FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA

MESSAGE

The scientific and technological inputs have been major drivers of growth and development in agriculture and allied sectors that have enabled us to achieve self reliant food security with a reasonable degree of resilience even in times of natural calamities, in recent years. In the present times, agricultural development is faced with several challenges relating to state of natural resources, climate change, fragmentation and diversion of agricultural land to non-agricultural uses, factor productivity, global trade and IPR regime. Some of these developments are taking place at much faster pace than ever before. In order to address these changes impacting agriculture and to remain globally competent, it is essential that our R&D institutions are able to foresee the challenges and formulate prioritised research programmes so that our agriculture is not constrained for want of technological interventions.

It is a pleasure to see that Central Sheep and Wool research Institute (CSWRI), Avikanagar, a constituent institution of the Indian Council of Agricultural Research (ICAR) has prepared Vision-2050 document. The document embodies a pragmatic assessment of the agricultural production and food demand scenario by the year 2050. Taking due cognizance of the rapidly evolving national and international agriculture, the institute, has drawn up its Strategic Framework, clearly identifying Goals and Approach.

I wish CSWRI, Avikanagar all success in realisation of the Vision-2050.

(SHARAD PAWAR)

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FOREWORD

The diverse challenges and constraints human population is facing because of fast growing population and ever increasing food requirement, feed and fodder needs for livestock and, natural resources degradation, climate change, emergence of new parasites and pathogens, slow growth in sheep farm income and new global meat and wool trade regulations, demand a paradigm shift in formulating and implementing the sheep research and development programmes. The emerging scenario necessitates the institute to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science in sheep husbandry in next four decades. In this endeavour, vision 2050 will be a way forward for inciting new hope for the future besides highlighting the issues and strategies relevant under livestock production system under the threat of global warming and climate change in coming decades.

The research contributions of Central Sheep and Wool Research Institute (CSWRI), Avikanagar over the last five decades, more specifically for livestock farmers in harsh and difficult topographies and their adoption brought about visible improvement of farmer's income by increasing productivity of sheep and reduction of economic losses due to morbidity and mortality. Indian sheep husbandry is undergoing visible changes under climate change scenario shifting its production system towards more economic and profit oriented mutton production across different agro-ecological zones of the country.

It is expected that the possible scenario, future map and forward looking concepts presented in the Vision 2050 document will prove

useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the sheep vis-à-vis agricultural sector so as to ensure food and income security with a human touch.

Dated the February, 2013
New Delhi

(S. Ayyappan)

Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
Krishi Bhavan
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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 and rabbit production, health, utilization, training and transfer of technologies to the beneficiaries. The institute is actively engaged in research for enhancing productivity of sheep and rabbits 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., pelt, milk, skin and manure which are not given much attention in present years. 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 and Davendra Kumar 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 investors, researchers, consultants, marketing strategists and all those involved in mutton and wool production and utilization.

Dated the February 2013

(SMK. Naqvi)
Director
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Context

More than half a century, the Central Sheep and Wool Research Institute, Avikanagar under the aegis of Indian Council of Agricultural Research (ICAR) has served the sheep husbandry in the country. The Institute is engaged in research, training and extension activities related to sheep and rabbit production. Nevertheless, in the context of fast changing global scenario, managing the changes in commiseration with time scale and becoming internationally competitive is a challenge. We need an analytical and forward looking approach in sheep research policies incorporating cutting edge technologies to attain and sustain higher mutton and wool production in the country. The concept of 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 present Vision 2050 is prepared in view of newer challenges currently faced in sheep production and those expected in the near future under evident climate change and shrinking grazing resources, intermixing of native breeds, emergence and re-emergence of diseases, marketing trend for wool and meat, non remunerative wool price and sharp rise in mutton price. The main motto of present Vision 2050 is to enhance productivity of sheep and rabbit for livelihood security, economic sustenance of farmers and wholesome and hygienic meat for consumers and wool for industries in the country.

The institute is mandated to conduct research on sheep and rabbit in specific areas of genetics and breeding, physiology, nutrition, health, wool and meat science. The salient achievement of institute in respect of mutton, wool and rabbit production including reproduction and health are prolific sheep, carpet and fine wool production, angora and broiler rabbit production, 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.

In order to meet the growing demand of mutton in the country the concept of

introduction of prolificacy (Fec^{+B}) gene from litter bearing Garole and Kendrapada sheep breeds in less prolific sheep have been introduced for evolving prolific sheep to produce twins and triplets. Increased prolificacy, lambing rate and total body weight in prolific sheep indicates great potential for augmenting mutton production by introgression of prolific gene from Garole in non-prolific breeds.

Improved rams of Malpura, Muzzafarnagri, Deccani, Nellore, Madras Red and Ganjam breeds developed in the institute and network projects and distributed to sheep farmers resulted in increase in body weight and meat yields. Chokla, Marwari, Magra and Avikalin sheep breeds produced ideal carpet type wool of 30-35 μ diameter, 35% medullation and 5-6 cm staple length. Superior rams supplied for breeding in farmer's flocks resulted in increase in body weight and wool yield.

Avikalin sheep which is dual purpose for wool and mutton production has been accepted well in Tamil nadu and Karnataka due to better economic returns. Bharat Merino sheep is a promising import substitute and improver breed for fine wool sheep. 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 20 μ and medullation of <2.00%. Bharat Merino sheep are well accepted by the farmers of Karnataka in Kolar and Satyamangalam areas.

Farmers in north temperate region adopted the package of practices developed by NTRS centre of Institute for Angora fibre production. Angora rabbit production has picked up in Himachal Pradesh, Uttarakhand and other colder regions. The Angora fibre yield which was 300-400 g per rabbit earlier has now increased to 900-1000 g annually. In broiler rabbits, 5-6 kits per quarter beyond 6 months of age and 1.8-2.0 kg weight at 84 days of age has been attained. The superior germplasm of Soviet Chinchilla, Grey Giant, White Giant and New Zealand White (especially Soviet Chinchilla and Grey Giant) meat breeds has been extended to different parts of the country. Broiler rabbit production technologies resulted into better body weights in these breeds. The broiler rabbits excelled under the sub-temperate climate Kodai Hills at SRRC, Mannavanur and have been well accepted by the farmers of Kerala, Tamil Nadu and Karnataka for meat production. In addition, black brown strain developed by the

institute is showing excellent performance and producing a unique black fur skin (pelt).

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, 18-20% fat and 15-18% bone with dressing yield of 52-54%. Supplementary feeding

schedule for field flocks developed and 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. The feed blocks are source of sustenance/scarcity feed for livestock species in drought prone zones.

The techniques for artificial insemination in sheep using liquid semen were developed, simplified and improved. This technology was extended to organized farms and farmer's flock and semen of Awassi, Garole, Patanwadi and Malpura sheep breeds were used extensively. Lambing rate of 60% was achieved with chilled semen. Progesterone impregnated intra-vaginal sponges were developed indigenously for estrus induction and synchronization in sheep and goats and are commercialized. One kit containing 50 sponges, 1 speculum and 1 plunger cost Rs. 460. Till date more than 15000 sponges have been supplied to different agencies including ICAR and SAU institutes, State Govt. Farms, KVKs, organized farms and NGOs. These sponges are utilized for fertility management and artificial insemination programme.

A sheep flock health management system has been developed. This has reduced outbreak of diseases as well as mortality rate to <5 per cent per annum as compared to earlier estimate of 10-15% in field flocks. The modified worm management programme includes one strategic drench during mid to late monsoon and one need based tactical drench during autumn/winter. This saves annually Rs. 12 per sheep with net annual gain of Rs 100 per sheep. In the Targeted Selective Treatment (TST) approach only worm infested sheep (approx. 23%) are selected on the basis of conjunctiva colour of eye for treatment. Direct benefit of TST application in sheep flock resulted into reduction of annual expenditure on anthelmintics from Rs. 7.0 to Rs. 0.81 per sheep.

Hand knotted carpets have been developed from Magra wool and nylon in 90:10 proportions has 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 resulted into the value addition and employment generation in rural areas.

As a part of 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 genetic and feed resources and production system. The deficiency in mutton leads to sharp rise in price and dependency on import. In future attempts are required to increase life time production, per animal productivity, reproductive and feed efficiency for increasing mutton production. Being a research institute, research and development on these aspects need to be strengthened to meet the demand of mutton and wool in the country.

Wool production is showing decline in the country and also in the world. 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 with better price support for

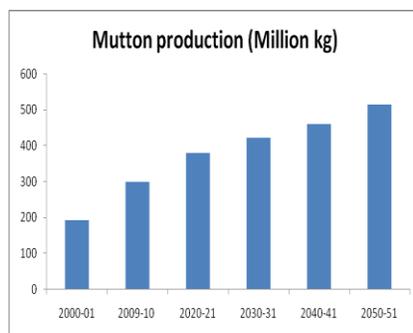
wool and incentive from woollen industries would help in growth of wool industry through R&D programme.

Challenges

Climate change and shrinking grazing resources, intermixing of native breeds, emergence and re-emergence of diseases, growing demand of mutton, import of wool, slump in wool price and sharp rise in mutton price, early disposal of lambs for mutton etc. are some of the challenges before sheep husbandry in the country which require short, medium and long term policy and research interventions.

In sheep rearing, mutton contributes from 70-80% of earning of the farmers as the demand of mutton is growing in the country especially in the J&K and southern states resulting in sharp rise of mutton price. The demand of mutton in the country would be around 579 million kg in 2030 and 763 million kg in 2050. Thus there is an urgent need to improve the body weights and feed conversion efficiency of sheep by breeding, feeding, health 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, minimum amount of 30 g of meat /day/head should be taken which makes 10.95 kg of meat /head/annum. At present availability of meat is only 5.5 kg/head/annum. From the above figures, it is clear that there is wide gap between demand and availability 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 vast scope for processing. At



present, condition of the majority of slaughterhouse is not satisfactory. Adequate slaughter facilities are not available to produce meat under sanitary conditions. Animals are slaughtered both in authorized and unauthorized places which makes meat inspection impossible. Floor

slaughter is practiced for large 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. Slaughterhouses are regulated by the local bodies that are mostly reluctant to develop these premises. Meat produced in such environment is a potential source of disease for human beings. It is only due to our cooking method which is very effective in destroying all the pathogens that we are safe. 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 grow at faster rate to meet demand of consumer 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 without any hesitation.

Escalating global market opportunities for the Indian meat sector requires private investment in meat processing through state-of-the-art technology of integrated plants. Modern integrated plants with state-of-the-art facilities for slaughtering and dressing of animals, carcass deboning, packing, chilled and frozen storages, byproducts processing and effluent treatment etc are needed. Moreover slaughterhouse byproducts needs to be utilized for production of carcass meal, meat-cum-bone meal, tallow, bone chips and other value-added products. At present, there are 70 meat processing plants and 29 APEDA approved Indian abattoirs-cum-meat processing plants in India. This strength needs to be further increased.

Well-integrated marketing system for meat and meat products is lacking in India. The main reasons are monopoly of meat trader, lack of co-ordination between production and demand and too many middlemen in the trade and inefficient management in slaughterhouse. There is a dire need to modernize the meat production and marketing system to produce quality meat and meat products at reasonable prices. 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 100% export oriented slaughter houses in the country need to be strengthened.



Wool contributes 15-20% to the income of sheep farmers. Over the period, the price of wool in the country in relation 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

available but carpet wool can be produced for the existing demand of the industries.

Global wool production has shrunk by 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 synthetic fibres, higher production cost and change in policy in leading wool producing countries such as Australia and New Zealand. If similar trends continue then the global production will reach below 1200 m kg by 2050 however, It has been suggested that wool being eco-friendly natural fibre with comfort and warm, will maintain its position in world textile.

The current wool production in India 44.4 m kg and it is expected that it will increase to 65 m kg by 2050. The requirement of apparel wool is completely met through import from other countries like Australia. 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 woollen industry and consumption of woollen products in India is continuously increasing by 1% per annum. Keeping this in view demand of wool may rise from 139 million kg in 2010-11 to 200 m kg in 2050 excluding 150 m kg of wool rags from shoddy products. Since the global supply of wool is decreasing, it will be difficult to meet the requirement of woollen industry in years to come. China has visualized the situation and focused on wool production. As a result its production has increased from 220 m kg in 1992 to 337 in 2008-09 with a growth of 7-8% per annum. Wool production in India is almost stagnant at 45 m kg since last two decades. Looking in to the demand and availability of wool in domestic as well as International market, it is a great challenge to meet the demand of wool in the country.



Angora rabbit rearing is predominant in temperate region of the country in the state of Himachal Pradesh, J&K and Uttarakhand. The high thermal insulation properties and whiteness of Angora fibre fascinate the consumers for Angora blended

products especially shawls. NTRS Garsa of CSWRI and Animal Husbandry Department of Himachal Pradesh has made consistent efforts and popularized the Angora rabbit rearing. The marketing of angora wool was also well supported by Ministry of Textile, Central Wool Development Board. This resulted in increase of Angora wool



production to 30 tons during 2000. The market price of Angora wool was Rs 1600-1800 per kg in the year 2011-12 however, fluctuation in market price of Angora wool and higher feed cost adversely affected the rabbit

rearing. Because of these factors, population sharply declined from 50000 (in 2000) to 11000 (in 2007).

The popularity of Angora wool products and development of diversified products from Angora wool will increase the domestic consumption. The present annual world production of angora wool is 10000 tons. China contributes 90% of total Angora wool production and exports about 5000 tons. Keeping in view the huge potential in export market and raising domestic consumption, it is predicted that 100 tons of Angora wool will be required in the country by 2020 and 150 tons by 2050. In order to meet the Angora wool requirement, the yield of Angora fibre per animal and total population, the target should be 1.2 kg per animal and 1.00 million respectively. The R&D support in the form of economic feed ration, health cover, procurement of Angora wool, support price for wool and introduction of better genetic resources in the long run are needed to sustain the Angora rabbit rearing in temperate region.

Broiler rabbits are efficient meat producers and yield nutritious meat, which is low in cholesterol, fat, sodium and calorific value but high in

protein. Non-availability of germplasm in adequate numbers, quality and economical feed, lack of technical



knowledge, healthcare, extension, organized marketing, post-harvest technology in terms of meat/fur processing etc are some of the limitations in providing a concrete base to this promising and income generating enterprise. Precisely these anomalies need to be removed in the future. Backyard rabbit farming and support from financial institutions will sustain the rabbit rearing for meat in the country.

India possesses vast diversity in sheep genetic resources in the form of 42 well established breeds which are spread in different agro-climatic zones of the country. With 73.99 million heads, India outnumbered Australia in 2009 claiming 2nd rank in sheep population (FAOSTAT 2010). However, majority of the sheep population (51%) are of nondescript type. With diminishing grazing resources and increasing demand of mutton and wool, there is 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 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. Increased lignification of plant tissues resulting in reduced digestibility leads to reduced nutrient availability for animals is ultimately reflected in reduction in production which impact on food security and income of livestock smallholders.

By the year 2050, the world will require an estimated additional quantity of 1305 million tons of grain, of which 40% would be used for feeding livestock. A major contributory factor to this extra demand is expected to be substantial increases in poultry and pig meat production. A less food-competing route to increasing the supply of animal protein to increase the production of ruminant animal products, utilizing forages and fibrous co-product feeds, as part of feeding systems and this route may be designed to optimize rumen function and overall feed conversion efficiency.

Generally, about 5 to 10% of the land area in every village is reserved for community pastures 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 to keep a watch and supply to regions facing seasonal shortage. It is also necessary to introduce various non-traditional fodder crops for growing 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.

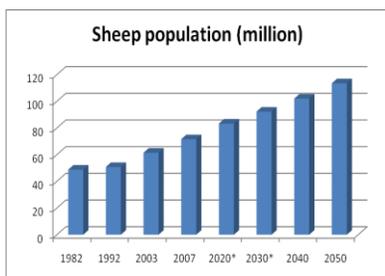
Climate change is seen as a major threat to the survival of many species, ecosystems and the sustainability of livestock production systems. It is expected that the sheep systems based on grazing (extensive production system) and the mixed farming systems (Semi-

intensive production system) will be more affected by climate change than an industrialized system (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. At present shelter management in sheep is the most neglected aspect of sheep husbandry which may become still more important due to impending climate change in the future. Adequate shelter and proper management has the potential to increase sheep production by 2050.

The extension infrastructure for animal husbandry particularly sheep husbandry are comparatively poor to that available for crop production. The State AHD's maintain services only for health and breeding covers. Integrated approach for sheep breeding, health, reproduction and management is required as poor reproduction shall never allow any economically important trait to give its best, so is the case with poor health or management. Little effort is made to transfer improved production technologies to the sheep farmers.

Institutional credit also needs to be targeted to 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 target the entrepreneurs who can invest in sheep husbandry to gain maximum benefit must be explored. This approach will help to build the model for broiler sheep to meet the ever increasing demand for meat.

Operating Environment



The problem of shrinkage of grazing resources, scarcity of water, climate change, declining interest of new generation for sheep rearing/ migration, poor health care support, unorganized marketing structure for meat and wool, dependence on imported wool, ineffective financial support from institutions, poor risk

management strategies, frequent drought and other disasters are some of the factors operating for deteriorating sheep production in the country.

The sheep population in the country has been gradually increasing at the rate of >1 % annually and would be around 83.30 million in 2020 and 92.30 million in 2030 and 113.50 million in 2050. Similarly mutton production was 125 million kg in 1980- 81, 230 million kg in 2001-02 which will be around 380 million kg by 2020, and 422 million kg in 2030 and 515 million kg in 2050. However mutton requirement in the country would be 533 million kg by 2020, and 579 million kg in 2030 and 763 million kg in 2050 indicating deficits of 28.7, 27.1 and 32.5% by 2020, 2030 and 2050 respectively. The deficit will further aggravate if present trend of early slaughter of lambs will continue.

Wool production in the country was 31.98 million kg in 1980- 81 which increased to 44.5 million in 2010- 11 and expected to be 53, 60 and 65 million kg by 2020, 2030 and 2050 respectively. However, expected requirement and demand of wool in the country would be 150, 180 and 200 million kg in 2020, 2030 and 2050 respectively. 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.

These deficiencies can be rectified by employing better and newer management options affecting entrepreneurs and application of mitigating strategies. The challenge for research and development is to initiate integrated approaches of breeding, reproduction, health, feeding management and marketing in cost-effective manner for enhancing wool and meat production.

In view of greater demand for mutton than other food commodities a different infrastructure for hygienic slaughter, value-addition, processing and marketing will be required. This is a challenge as well

as an opportunity for sheep husbandry. However it is a difficult task to produce required quantity of meat and maintain meat price under control and hence challenge for all of us. These challenges also provide opportunities for augmenting farm income, generating employment and involving a number of additional stakeholders in the food-supply chain. For research and development organizations, the main challenges are: (i) to develop promising technologies and management options to raise individual productivity of the animals to meet growing demand for mutton in a situation of shrinking and deteriorating grazing resources and rise in meat price and (ii) create required infrastructure and institutional arrangements for production, post-harvest processing and marketing of high-value and perishable commodities and their value-added products with more emphasis on development of diversified shelf stable meat products that are convenient and does not require refrigeration for storage. The urbanization and changing living style is creating demands for consumer friendly meat products with low calorie, cholesterol, salt and high dietary fibre and fortified products.

In rabbit sector, non-availability of quality germplasm, quality and economical feed, post-harvest technology in terms of meat/fur processing, organized marketing, problem of inbreeding, lack of technical knowledge, rabbit healthcare, small and scattered units are some of issues which need focus in research priority.

Angora rabbit fibre is a specialty fine fibre having diameter of 12 -14 μ . German Angora rabbit was popularized in Kullu valley of Himachal Pradesh and has now become a main centre of Angora hair production and processing. About 10- 20 tons of Angora rabbit wool is produced annually in Himachal Pradesh and Uttarakhand and utilized for various woolen products especially Angora shawls for domestic and international markets.

India's sheep husbandry largely depends on the monsoon grasses on common property resources (CPR). Changing rainfall pattern would further aggravate scarcity of grazing resources in western and central India. The evident climate change will lead to dry area becoming drier and wet area wetter with longer spell 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 effect.

The heat-related diseases and stresses, extreme weather conditions, adaptation process to new environment and emergence or re-emergence of infectious critical diseases are dependent on environmental and climate change conditions hence likely to

adversely affect the sheep production. Moreover sheep, being most hardy and adapted to harsh climate as compared to large ruminants have better chances of thriving / surviving in hot and dry areas which are expected to increase due to climatic change in southern states like Andhra Pradesh, Karnataka and Tamil Nadu. Sheep husbandry is severely affected by health hazards if infectious diseases like PPR etc are not controlled. Strategies to study the host resistance for these diseases, introgression of information for resistant livestock, for vaccine production etc are expected.

Most of this century is likely to witness soaring temperature, erratic weather patterns with more intense monsoons, increased cyclonic activities, severe droughts, floods, melting glaciers and rise in sea levels. This will result in greater instability in sheep production and will 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. Sheep husbandry will face hard challenges in many fields by 2050. Policy planners, decision makers, research institutions and extension services have to work together and support sheep rearing activities to prevent loss of production, worsening of animal products, enlargement of land desertification and the worsening of animal health under the effects of the climate change.

Opportunities

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 vast and diverse 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 mutton production. Sheep husbandry is severely affected by health hazards if infectious diseases like PPR etc are not controlled. Strategies to study the host resistance for these diseases, introgression of information for resistant livestock, for vaccine production etc are expected. Sheep husbandry is severely affected by health hazards if infectious diseases like PPR etc are not controlled. Strategies to study the host resistance for these diseases, introgression of information for resistant livestock, for vaccine production etc are expected.

Identification of 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 meet the growing demand of carpet wool in the country. Mechari, Nellore, Deccani, Mandya and Madras Red are mutton type breeds found in southern region. For increasing mutton production in these breeds by an integrated approach of feeding, breeding, management and health cover may 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. The propagation of these strains 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 if implemented through farmer's cooperatives/ breed societies/ programmes of State AH department/ etc will generate large size dataset on field production performance along with pedigree information. Advanced software packages and statistical procedures such as use of animal models, random regression models, Bayesian statistics, *etc.* will then be used on the huge dataset. Such information shall help in accurate estimation of genetic parameters for the sheep breeds in farm as well as field. This will help in selection and identification of superior germplasm in the field and their further propagation in nucleus flock for rigours genetic selection for growth / carpet wool like production traits. Open Nucleus Breeding System (ONBS) will be implemented for evaluating elite rams and will be used for accelerating genetic gain in the farmer's flock. ONBS shall 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 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 and higher rate of genetic improvement in mutton/wool production. Simultaneously, programmes for identifying genetic resistance of sheep to inactivated or attenuated virus particles/ vaccines/ infections shall be carried out and host-vector relationship will be understood in greater details. Molecular information with regards to resistance shall also help to create genomic selection indices where restriction on the basis of resistant marker or QTL is incorporated as a criterion for selection. Information with regards to

host-antigen will also help new generation vaccine production for better preventive strategies.

Rabbit for meat and fibre production has been established in certain pockets of the country. Introduction of superior rabbit strains and genetic improvement of available rabbit breeds through selection and development of package of practices would further increase the meat and wool production. Fur processing technologies which are in infancy stage needs further strengthening for increasing higher return from rabbit. The utilization of rabbit hair through blending with wool, silk, polyester etc requires attention for better value addition and employment generation. Rabbit rearing for meat production has been established on commercial scale in southern states and further development requires established market for meat. A network project on broiler rabbit production will give a big boost to rabbit farming for meat and fur in the country.

An important by product obtained from broiler rabbits is the skin, which is covered with soft luxurious fur. At present most of the demand for fur pelts for making fur garments is met out of illegal trade in pelts from wild animals and through import. Therefore, there is a good scope for obtaining good quality pelts at cheaper rates from broiler rabbits reared under farm conditions. Similarly, there is need to exploit further the popularity of angora wool products, their high profitability, their potential for employment generation and foreign exchange earnings.

Fixed time AI with chilled liquid semen found useful for producing progeny of elite animals. Facilities of 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 in the flock.

Different system of lamb rearing for mutton production has been developed. Sheep are 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 known as semi-intensive feeding where sheep are grazed on grazing lands and deficiency if any are met from supplementary feeding in form of concentrate mixture or tree leaves or agricultural byproducts has been developed. This system of sheep production would sustain the production in view of deteriorating environment.

The intensive system of lamb rearing for mutton production has 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 of organic meat is growing in the country; research on this aspect would help in meeting the safer and quality meat for consumer as well as international market. The use of herbal and biological drugs for treatment of diseased animals would reduce the residues of harmful chemicals in the animal produce and would be useful 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 beside Felt and Khadi sectors for utilization of wool produced in the country. There is a scope of blending wool and other fibres for value added products.

More than 75% earning in sheep rearing comes from sale of meat. The development of marketing structure for disposal of finisher lambs and spent animal, as separate identity 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 documented and scientific procedure for their industrial preparation, packaging, shelf life, keeping quality and marketing have to be documented. There is good scope of increasing export meat and processed mutton to Middle East, South East Asia and African Countries. For this, desirable body weights and carcass quality including disease free zones are to be developed and maintained. Moreover, the sheep in the country are raised on natural resources and mutton produced in the country is free from chemical residues.

Goal / Target

It is required to achieve 884 million kg mutton and 65 million kg wool in the next 40 years in the country. 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 month of age. At present one lamb from non prolific sheep attained 23-25 kg at 6 month 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 month of age thus there is every possibility of increase in mutton production by two times in 50-60% of mutton breeds in the country.

The accelerated lambing system in sheep for achieving target of 3 lambs in two years has been taken up in the last XI plan and continuing in present XII plan. In conventional system, two lambs in 2 years are achieved. Here our target is to achieve one more lamb in two years and 9 lambs in life time against 6 lambs under conventional system. Thus mutton production will increase by 1.5 times over existing system of one lamb per year in about 55-60 % of animals. The accelerated breeding programme will be carried out to achieve the target. In addition, the reduction in mortality will further increase the number of lambs / animals available for slaughter and will increase sheep production in the country.

There will be only one target to increase sheep production without increasing the sheep population. To achieve this target, there is need of Accelerated Synchronized Artificial Reproduction (ASAR) of high producing animals in "all in all out" manner so that a definite number of marketable age sheep can be supplied to the market. This ASAR can be accomplished by application of various reproductive technologies. Many reproductive technologies, such as estrus synchronization, artificial insemination and in vivo embryo transfer are available in well developed stage and can be used for increasing sheep production in the countries. These technologies are being used regularly in developed countries.

However, except baring estrus synchronization using intra-vaginal sponges and AI with liquid semen, other reproduction technologies need further development, improvement and refinement. In addition, there is need to develop and optimize other related reproductive 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. These new generations assisted reproductive technologies can result in embryos at a reasonable cost with high genetic merit for accelerated improvement of sheep

population. Nevertheless, before a large-scale application of these technologies is made, it is essential to solve the problems related to these technologies.

Male lambs in field flock are put to slaughter an early age of 3-4 month when they hardly attain body weight of 12-14 kg. Provision of support from entrepreneur for procurement of these lambs and intensive feeding on stall up to slaughter stage will improve mutton production and quality and wholesome mutton for consumers.

All-in-all-out system of lamb rearing for mutton production to increase slaughter rate and carcass yield with nutritional intervention, feed technology, processing and storage to deal with multitude problems of wastage, nutrient availability and scarcity/emergency feeding, societal development through productivity augmentation in migratory and sedentary flocks and specialized nutrition for augmenting nutritional health, combating stress and meeting consumer preferred quality traits in livestock produce will improve the overall productivity of lambs. The importance of developing sustainable animal ration through a conceptual framework that allows the integration of sound management practices based on the 3 Ps (Profits, People and the Planet) is considered a prudent path for the future.

The importance of FCE to produce more food with lower emissions per unit feed used needs to be recognized, with strategies incorporating new forage types, the importance of physical as well as chemical nutrition (to optimize rumen function) and improved management. Further, the efficiency of production systems is affected by factors other than feed efficiency including the effects of endemic diseases, inadequate access of smallholders to information, technologies and well-ordered markets, and overall poor management. A holistic approach that addresses nutrition, reproduction, health and welfare and overall management of animal is required for increasing FCE.

In earlier breeding programmes for sheep improvement, milk and pelt 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 nutrition of society. Introduction of milk trait in Indian sheep would result into better lamb weight, low morbidity and mortality and therefore increased mutton production.

Sheep pelt has great demand in the international market and fetches premium price. Higher premium price can be obtained if pelt is produced, processed and value added in the country. Efforts for locating the pelt production in southern states with provision of mutton and pelt will be of great help to farmers.

Fat tail or fat rump sheep has demand usually during Muslim festivals which otherwise also fetches premium price. Well known fat rump sheep breeds of Middle East countries need to be introduced along with prolificacy trait with multiple births for mutton production under intensive production for higher body weight gain and meat yield. Embryos/semens of fat rump sheep needs to be used from the rams available in the country or imported from their country of origin. Use of several molecular approaches will further help in identifying the genes for fat tail or fat rump in these sheep breeds.

Well known mutton breeds of sheep like Dorset, Suffolk and Dorper attained 40-45 kg body weight at 6 month of age against 22-25 kg in native breeds. These breeds may be imported for cross breeding programme to improve native genoplasm among those farmers and entrepreneurs who could manage them under intensive feeding and can offer better environment including housing and feeding. Earlier experiences with these breeds in the country should be kept in mind and suitable remedy should be developed to overcome the reason for poor performance.

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

The Indian wool is coarse in nature and there is little use in apparels. The profit margin from wool for the farmers is shrinking day by day. There is an urgent need to develop products that could cater the industries to consume lot of Indian wool. With this rationale several diversified handicraft, apparel, protective and industrial textiles can be developed. Institute has developed a process for uniform yarn from short staple spinning. There is a need to utilize and evaluate performance of this yarn as knitwear. It will help in utilization of

indigenous fine wool in knitting yarn production and development of diversified quality knit wears and better price realization of 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 possible to use the non suitable coarse wool in carpet yarn and harvest its high stiffness properties in terms of carpet performance and produce 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 could 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.

Development of infrastructure facilities like Common Facility Centres (CFC) in the States where rabbit rearing enjoys popular support, in terms of germplasm, housing, feeding, health care, marketing, training, testing and processing of raw materials, etc., should be taken up on urgent basis for the successful implementation of rabbit production. This can be taken up in the form of a network project on rabbit production in the country.

Our experience with the field/extension workers of the major sheep rearing states has shown that there is a wide gap in latest developments 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. will be targeted during the coming decades and trained in the latest technologies. Close liaison will be required for effective technology dissemination in these states. Also greater 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 transfer of technology programmes in the field.

Way forward

In sheep husbandry, future strategies 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 laboratories 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 weight gain through manipulating rumen environment and feed formulation at cheaper price need to be identified and implemented. The identification of sheep resistance to diseases and stresses will be given due importance in breeding programmes. Heat resistant sheep breed and proper shelter management systems may be developed to mitigate the adverse effect of climate change. Heat resistant sheep breeds may be selectively bred by identifying SNPs promoting enhanced resistance to climate change and using them as selective marker for routine breeding program.

Embryo technology for rapid multiplication of elite animals and import of embryos from outside and animals 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 industries 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 rising human population.

The changes in production system, climate and demand for disease and residue free meat and globalization of trade 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 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. Therefore, 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. immune-biology, 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 meet out the demand driven animal protein need of the human population. In this line many commercial entrepreneurship have already been started in some parts of the southern India. Adoption of micro climate environment in line with poultry enterprises will open up the scope for incorporating exotic germplasm like Suffolk, Dorset, Awassi etc for maximizing mutton production. Automization in feeding and rearing practices with micro chip based disease diagnostics will aid in whole farm nutrient and health management system.

The market research study will be undertaken to understand the market trends, structure, competitive landscape and the outlook of the Indian sheep husbandry market. This report can serve as an excellent guide for investors, researchers, consultants, marketing strategists and all those who are planning to foray into the Indian sheep husbandry market in some form or the other.

Today's national sheep research and extension systems face many challenges and opportunities. Serious limitations in planning and financial management of sheep research, in the organization and management of the research institutions and in technology transfer strategies will be identified through several analyses and assessments. Similarly, extension systems will be reoriented and financially supported to update service provision approaches and extension methods.

At the same time, developments in biotechnology and biosafety, climate change concerns, food insecurity, the growing relevance of agri-food chains, demands for greater rural producer empowerment, and in the changes in information and communication technologies

will be combined to provide many new opportunities for growth and renewal for national sheep research and extension systems.

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

The existing laboratories and animal farms and infrastructure will be modernized and well equipped for conducting research. The laboratories will be strengthened by creating art of facilities and unique equipments. Moreover the sheep farm will be modernized and automatized to improve conducive environment for optimizing production and labour efficiency. The post of scientist in the discipline of Pelt Technology, Dairy Technology, and Computer application, Social Science, Economics, Bioinformatics, Nanotechnology and Biotechnology etc will be created in future to cope up with the newer areas of research in these fields.

Referral accredited laboratory for sheep feed evaluation, meat and wool will be established in the institute. State of the art Artificial Insemination centre for sheep will be developed in 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 neighbouring countries, interpretation and forecasting of imagery of satellite disease related data and creation of disease free zones. Modern laboratory equipped with BSL4 standard with modern biotechnological, 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 course for them on various aspects will be developed.

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

Germplasm Resource Centres (GPRCs) for rabbits, upgrading the existing germplasm by introducing new higher yielding breeds, strengthening R&D in the field of rabbit nutrition and healthcare for providing good quality and economical pellet feed and reducing mortality and morbidity losses will be set up. Rabbit extension and training programmes for farmers and entrepreneurs in different parts of the country in collaboration with State Animal Husbandry departments and other development agencies will be strengthened.

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

Biotechnology cutting edges research for enhancing productivity of sheep will be used in future programmes. Identification of candidate genes controlling prolificacy, growth, meat, hind quarter muscling, wool and milk production and quality and wool lustre will be identified. 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 cell markers for the elucidation of gene expression profile. Cloning of genetically elite

sheep and production of transgenic animals will be directed towards achieving manufacture of biological medicinal products.

Nucleic acid based disease diagnostics and vaccines will be developed for early and effective diagnosis and control of important sheep diseases. Strict vigilance by sero surveillance, host-parasite interaction, vector biology (if involved) and nation-wide eradication programme of major infectious diseases will be undertaken in phased manner. 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 taken. 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. Probiotics microorganism 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-regulating metabolic efficiency for desired attributes studies. Microbial fuel cells and microbial ecology: applications in ruminant health and production research, e.g. bioremediation 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. Nutrigenomics and 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 in these emerging areas of reproductive technologies in near future.

Development of nano and biotechnology based functional finishing of wool and specialty hair fibre. 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 by using natural functional ingredients having health benefits, bio-preservation, environment-friendly packaging and quality control are required 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 and procurement of lambs at reasonable price for slaughter will be extended to farmers in the villages. This will improve the production and farmers will get better remuneration for their produce and consumer will get safe mutton at reasonable price.

Creation of GPS inventory of different breeds of sheep will be developed having information about native track, unique breed characters, information on important phenotypic traits, average production and reproductive performance, availability of superior breeding animals, its location and cost, information about 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 Animal Identification system will be developed.

A 5-point strategy will be adopted to achieve target, address challenges, smoothly adjust to changing environment and derive benefit from it

1. Molecular breeding approach and introgression of *FecB* gene from Garole/Kendrapada for prolificacy, nucleus breeding scheme using MOET technology for higher genetic gain, import of Awassi live animals /embryos for enhancing milk and mutton production, import of Karakul/other pelt breeds for pelt production and processing, import of fat tail sheep for mutton production, accelerated lambing system for higher life time production targeting 3 lamb crops in two years, economical and cheap complete feed incorporating desirable nutrients will be adopted for enhancing lamb, mutton, wool, pelt and milk production. Since over the years demand for animals with higher growth and feed efficiency will increase in the country among progressive farmers, import of Suffolk, Dorset and other heavy

breeds may be useful for increasing higher mutton production under intensive system.

2. Import of California Giant for higher meat yield and feed efficiency, import of German Angora for higher wool yield and quality, fur production and processing for value added products, health care and support system for reducing morbidity and mortality, rabbit farming under backyard farming, fur and wool processing units under small cottage industries, economical and cheaper feed for wool and meat production and marketing strategies for avoiding fluctuation in meat and wool price will be attempted for enhancing meat, fur, wool from rabbits.
3. 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, meat processing and value added products, pelt 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 Wool, meat, pelt, milk processing and value addition.
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 for food safety, disease surveillance, health care and diagnostics.
5. Transfer of technology and public private partnership activities will be strengthened by adopting technology validation, refinement and dissemination of technologies, industries-Institute-Farmers interface, interactive information system, Knowledge management system, marketing intelligence for live animals and their produce and capacity building and training.



हर कदम, हर डगर

किसानों का हमसफर

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