



VISION 2030



CENTRAL SHEEP AND WOOL RESEARCH INSTITUTE
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CENTRAL SHEEP AND WOOL RESEARCH INSTITUTE
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Foreword

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resources degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all the institutions of ICAR, have revised and prepared respective Vision 2030 documents highlighting the issues and strategies relevant for next twenty years.

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 of utility from wool to meat and intensification of sheep production across different agro-ecological zones of the country.

It is expected that the analytical approach and forward looking concepts presented in the Vision 2030 document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

(S. Ayyappan)

**Dated the 6th July, 2011
New Delhi**

Preface

The Central Sheep and Wool Research Institute, Avikanagar is a premier institution of Indian Council of Agricultural Research established in year 1962 and engaged in research, enhancing productivity of sheep and rabbit and its product utilization, transfer of generated technology and human resource development. Comprehensive and integrated approach has been taken by the Institute for genetic improvement of native sheep, development of prolific sheep, enhancing feed resource and its utilization, extensive/intensive/semi intensive mutton production, improvement in reproductive efficiency, disease diagnostics and control measures, capacity building in wool and meat processing, product development and transfer of technologies to stakeholders. The Institute developed its Perspective Plan 2025 during XI Plan period. The present Vision 2030 is prepared in view of newer challenges faced currently 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, slump in wool price and sharp rise in mutton price. The main motto of present Vision 2030 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 woolen industries in the country.

I would like to express my sincere gratitude to Hon'ble Secretary, Department of Agricultural Research and Education and Director General, Indian Council of Agricultural Research, New Delhi for his invaluable guidance in preparing Vision 2030 of the Institute. I am grateful to Deputy Director General (Animal Science) for his keen interest and suggestions in developing Vision 2030 of the Institute. I am also thankful to Assistant Director General (Animal Production and Breeding) and scientists at Animal Science Division of ICAR Head Quarter for their valuable suggestions in finalizing this document.

I appreciate the efforts of Drs S.M.K. Naqvi, A. Sahoo, A.L. Arora, B.N. Tripathi, Rajeev Gulyani, D.B. Shakyawar and A.K. Shinde in bringing out this document. I am sure that Vision 2030 of the Institute would provide a road map to leverage the power of science for achieving higher, sustainable and inclusive growth in wool and meat production.

S.A. Karim
Director

Central Sheep and Wool Research Institute, Avikanagar

Preamble

Sheep husbandry plays an important role in the economic sustenance and livelihood security of poor farmers in harsh climatic zones of the country. Sheep provide mutton, wool, milk, pelt, skin, manure, etc. wherein mutton and wool are the primary produce of sheep and milk, pelt and skin and manure the secondary produce. During last decade, sheep population has shown increasing trend in the southern states especially in drought prone area. Sheep contribute 263 million kg of mutton, which is expected to reach 356 million kg by 2030. On the other hand, with economic empowerment of Indian consumers, demand for mutton is progressively increasing throughout the country particularly in J&K and Southern states. The most discouraging trend observed recently is the early disposal of surplus male lambs by farmers making it difficult to achieve the mutton production target.

Wool as raw material provides opportunity to large segment of artisans in processing to value added products. Moreover, there is wide scope of earning to the tune of 300 to 400 % by value addition. Wool of different grade and quality are produced across the country: fine wool in north temperate, carpet wool in northwestern and hairy wool in southern and eastern region of the country. Limited scope exists for fine wool production in temperate sub temperate zone of the country, whereas carpet wool can be produced in sufficient quantity in western part of country. It is also a reality that presently country is importing about 60 % of carpet and 90 % of apparel wool to meet the requirement of laid down wool processing infrastructure in the country. The wool import from New Zealand and Australia in future will continue, since farmers are opting for heavier animals/breeds for mutton production, as the income from wool is less than mutton. At this stage, subsidies need to be provided to support wool production and save money on import of wool. Northwestern region has well established sheep breeds for carpet wool production hence research and development activities should be strengthened in the region by encouraging farmers to produce quality wool, along with subsidies for wool production fetching, better price for wool and woolen industries participation and financial support to growers.

Although presently milk and pelt of sheep has little significance in the country, still some of Indian sheep breeds like Patanwadi and Malpura produce about 0.8 to 1.00 kg of milk daily in early lactation whereas well established dairy breeds like Awassi yield up to 300kg in a lactation period. Since native tract of the Awassi in middle eastern countries which has similar agro-climatic condition as prevalent in India, there is need to import the germplasm for extensive use in our breeding plan

for up grading the native sheep of the country improving milk production, higher body weight gain thus improving economic status and nutritional food security of the sheep farmers in critical climatic zones of the country.

Pelt from well known sheep breed like Karakul fetches higher price in the international market. It is widely popular among high end elite society to meet their requirement of fashionable leather products. Earlier attempts made to establish the pelt production unit at ARC, Bikaner whereas the program was discontinued due to political interference for slaughter of day old lambs. There is huge scope in the country for pelt production to secure interest of farmers in arid region for the purpose of meat for consumers or their own family and pelt for industries in the country for developing value added products. There is need to import pelt producing sheep and introduce in native stock for strengthening activities of pelt production and processing. Moreover we achieved target of three lamb crops in two years under prolificacy program hence one day old lamb can be slaughtered for pelt production and other lamb can be reared for meat and wool production. Fat tail sheep have special features of thriving and producing in harsh climate of desert as fat deposited in tail serve as source of energy during feed scarcity period. These breeds have potential in the dry region for augmenting mutton production and pelt production and need to be imported.

Under the scenario of intensive land reclamation for conventional agriculture and shrinking of community grazing land along with visible climate change effects, farmers are shifting production system from extensive to semi intensive and intensive. Moreover, in view of higher income from meat (70 %) than wool (15 %), sheep farmers are opting for animals of heavier breed with higher feed conversion efficiency for mutton production. Under existing scenario of sharp rise in meat price, large farms with more than 1000 sheep under stall feeding on cultivated fodder are coming up for mutton production in Southern states, these type of production system would likely to further intensify in future.

Rabbit husbandry was introduced in the sub Himalayan region of the country way back in seventies whereas now the demands has picked up in broiler rabbits for meat in Southern region. Angora rabbits for wool production and processing in Himachal Pradesh was established earlier at Kullu, Himachal Pradesh which has become a centre of Angora shawl manufacturing and marketing. Therefore, research and development has to be undertaken to strengthen and popularize rabbit as backyard farming and for large scale commercial production under provision of contract farming. The critical issue in Angora wool production is the cost of feeding which has to be reduced so that rabbit farming can pick up in right earnest.

The production enhancement could be achieved by integrating improvement and up gradation of genetic resource, novel feed and feeding practices, application of novel reproductive technologies, efficient disease control through sensitive

diagnostics and vaccine and processing and marketing of animal products. The transfer of technologies to farmers and training for capacity building and dissemination of technologies through information interactive system for wide scale application are to be taken up.

'CSWRI Vision 2030' document identifies new challenges and opportunities in sheep and wool sector in the next two decades. Developing appropriate technologies and adopting strategies to reshape the sheep husbandry targeting livelihood security of weaker strata of society and to produce mutton and wool at competitive price. To make sheep husbandry more remunerative and diversified, milk, pelt and skin production and processing in addition to programs on meat and wool production need be given due importance in research and development programs.

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Sheep Husbandry

Sheep rearing provides meat, wool, milk and manure to the nation. Mutton is major produce of sheep and preferred all over the country especially in Jammu and Kashmir and Southern states. Wool is used by a number of rural based cottage industries, woollen mills and carpet industries as raw material providing employment opportunity to large segment of rural and urban population. Milk from sheep is of limited importance except in states of Jammu and Kashmir, Rajasthan and Gujarat where it is utilized by shepherd's family as fluid milk as well as for product preparation. Sheep manure constitutes an important source of earning in Southern states where it is used in orchards.

Global meat demand is gradually increasing and expected to be doubled by 2030 while mutton production is not increasing with the demand. Across the world, little attention has been given to sheep husbandry that has led to sharp rise in mutton price. Indian sheep produces average 10 kg carcass as against world's average of 17 kg. Further, climate change in the recent past has influenced sheep production resulting in reduction of flock size and early age disposal of surplus male lambs. Still sheep husbandry is the mainstay of rural livelihood and economic sustenance in critical region of the country hence, in order to increase meat and wool production and augment income of poor sheep farmers and alleviate poverty and malnourishment, CSWRI has reaffirmed its commitment to address challenges of low mutton and wool production, high morbidity and mortality losses, feed and fodder crunch, poor reproductive efficiency, high meat price, wool import and climate change effects. Extensive sheep research using cutting edge technology, policy support and institutional innovations are required for reshaping sheep husbandry to meet the future demand of meat and wool for consumer and industries and for nutritional security of poor farmers.

Sheep husbandry contributes 263 m kg mutton, 48.5 m kg wool, 56.3 m kg skin and 190 m kg manure (GOI, 2010). Increasing urbanization, growing human population and rising incomes would generate demand for quality protein of animal origin. The quantity of wool production varied widely in different region of the country: as per recent figures, 11.42 m kg of fine wool is produced in the north temperate region but lacks in optimum staple length, 22.77 m kg of ideal carpet wool in the north Western region, 11.55 m kg of very coarse/hairy and colored fleece in southern region and 2.08 m kg of hairy types and unsuitable for woollen textile is produced in eastern region.

The average wool yield per sheep in India is only 0.7 kg as against the world average of 2.70 kg. Wool yield is expected to further decrease in future with increase in hairy sheep in southern states and decrease in wooly sheep in Northwestern region. Sheep population of India constitutes 6 % of the world but wool production is only 1.10 % of the world production. Presently, 100 million kg of wool (both apparel and carpet types) are being imported from Australia, New Zealand and other countries to meet the requirement of laid down processing capacity of woolen industries. There is little possibility of enhancing apparel wool production in the country but there is a potentiality of increasing carpet wool in required quantity for meeting the demand of carpet industries.

Sheep husbandry and economy

Sheep rearing is source of livelihood and income generation for shepherd communities who are economically poor, uneducated, socially backward, migratory and generally left out of decision-making process in the society. The sheep rearing ensure them self-employment and family labor under extensive system and acts as a cushion at the time of distress like drought and famine. Sheep act as movable asset of high liquidity and a source of household nutritional food security. Sheep contributes Rs 3518.40 crores through meat, Rs 226 crores from wool, Rs 683.83 crores through offal Rs 682.05 crores through manure, Rs 231.84 crores through skin, Rs 9.77 crores through blood, Rs 82.10 crores through increment in stock totaling to Rs 5433.99 crores to nation's economy. Sheep husbandry provides export earning of Rs 250 crores from meat and animal casing and processed meat. Woolen industry provides employment to about 2.6 million people and earns more than Rs 5000 crores of foreign exchange through exports.

As targeted growth rate of 10 % in Indian economy and 4 % in agriculture, the contribution of livestock sector is important. The livestock sector is presently growing faster than any other agricultural sectors. As per projections of National Planning Commission, by 2020 livestock sector will be the most critical agricultural sector in terms of added value in view of its substantial dynamics.

Small holder sheep husbandry

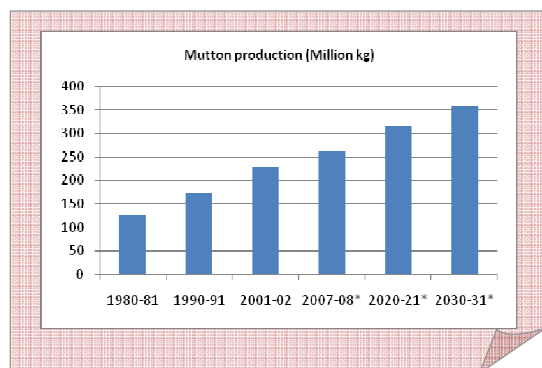
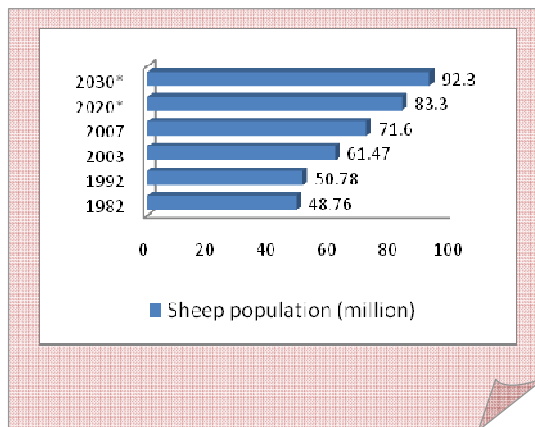
Small and marginal farmers and landless laborers raise sheep on community land under the system of minimum input and marginal output system of production management. Flock size in irrigated and cultivated areas remains small and mostly integrated with agricultural production. In dry region, where crop cultivation always depends upon monsoon rain, sheep flocks are large and managed on community land and migration. It has been observed that flock sizes over the period have been declining rapidly due to shrinking grazing resources from 100- 120 in 1990 to 70- 80 in 2000 and 35- 40 in 2008 in semi-arid Rajasthan. If this trend continues, flock size may further reduce to less than 25 per household by the year 2030. This is a serious problem, when demand of mutton is growing and import of wool is increasing, the declining activities of sheep may cause agrarian distress. In future, small flock of 25- 30 sheep reared under stall feeding on agricultural produce/byproduct would be choice system for sheep rearing. Moreover, the shrinkage of grazing land will continue in future and development of an alternative system for rearing of small flock on stall feeding in urban and peri urban areas would be required for livelihood security of small stakeholders. A large number of smallholders would shift to post-harvest and sheep related activities to augment their income.

The research focus should be to evolve technologies and management options to suit needs of small holding of sheep farmers and also to involve them in meat and wool production supply chain through novel institutional mechanisms.

Deteriorating production environment

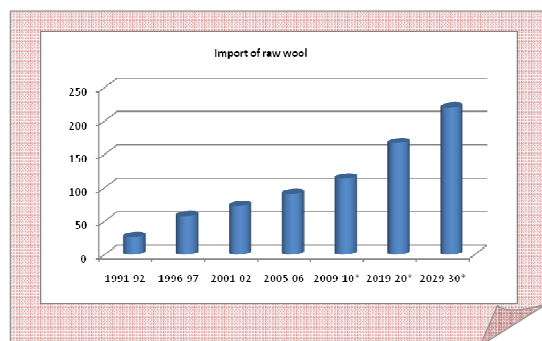
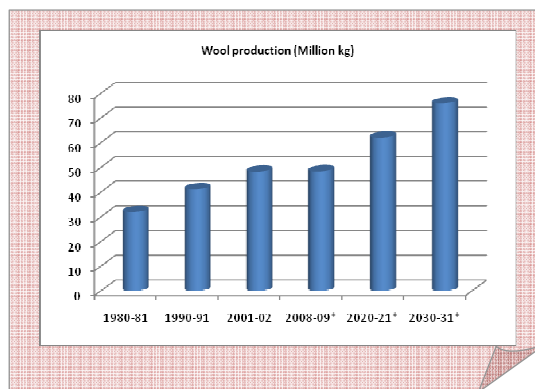
Shepherd's problem is magnifying as the quality of production is worsening. The problem of shrinkage of grazing resources, scarcity of water, climate change, declining interest of new generation for sheep rearing/migration, poor health care support, unorganized marketing structure for meat and wool, dependence on imported wool, ineffective financial support from financial institutions, poor risk management strategies, frequent drought and other disaster are some of factors responsible 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.



Similarly mutton production was 125 million kg in 1980- 81, 230 million kg in 2001-02 which will be around 316 million kg by 2020 and 356 million kg in 2030. During the period mutton requirement in the country would be 533.5 million kg by 2020 and 579.5 million kg in 2030 indicating deficits of 31.2 and 37.2 % by 2020 and 2030 respectively. The problem 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 48.5 million in 2008-09 and expected to be 62.1 and 76.0 million kg by 2020 and 2030 respectively. However, expected requirement and demand of wool in the country would be 229 and 296 million kg in 2020 and 2030, respectively. The demand of wool in the country is increasing and the laid down wool processing infrastructure in the country would require 229 million kg by 2020 and 296 million kg



by 2030. The country's requirement would not match with the current production trend thus about 167 million kg by 2020 and 220 million kg by 2030 of raw wool will have to be imported from sheep producing countries. These deficiencies can be rectified by employing better management options and application of mitigating strategies. The challenge for research and development is to initiate integrated approaches of breeding, health, feeding management and marketing

in cost-effective manner for enhancing wool and meat production.

Growing mutton and wool demand

Indian Council of Medical Research (ICMR) recommends 30 g of meat/day/head while presently annual availability of meat is only 15 g/head against the requirement. It is evident that the domestic production is meeting only 50 % of requirement indicating a wide gap between the requirement and the availability. Ever booming population, urbanization and increasing per capita income would put tremendous demand for processed, packaged, convenient and ready-to-eat or ready-to-serve heat and eat meat products requiring minimal preparation. Demand for the livestock based food is higher and would likely increase in comparison to food grains. It is expected that by 2030 demand for meat will be 15 million tons of which 5 % will be contributed by sheep amounting to 0.579 million tons.



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.

Under the scenario of stiff competition from man made synthetic fibre with concomitant higher cost of production of natural fibre and global change in wool producing trends, the global greasy wool production is shrinking by 3 % annually reaching from 3399 m kg in 1990 to 2106 million kg in 2008- 09 which is likely to further decrease to 1200 m kg by 2030. India has well established, organized and decentralized woolen sector that consumes 50 m kg apparel grade and 100 m kg

carpet grade wool. The requirement of apparel grade wool is met through import from Australia, USSR, UK and USA. Demand of carpet grade wool is partially met (40%) from domestic market and rest through import from New Zealand, Argentina, Spain, etc. The installed capacity in woolen industry and consumption of woolen products in India is continuously growing by 1% per annum hence the demand of wool would raise in future. Since, the global supply of wool is decreasing it would be difficult to meet the requirement of woolen industry in years to come. Situation of wool production in India was not very satisfactory during last two decades which was almost stagnant. However, the demand of raw wool has grown by 7.5 % during the period. Looking into future demand of wool and availability in domestic as well as international market, it is a challenge to meet the demand of wool of the country.

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 now has become a main centre of Angora hair production and processing. About 30- 40 tons of Angora rabbit wool produced annually in Himachal Pradesh and Uttarakhand and utilized for various woolen products specially Angora shawls for domestic and international markets.

Climate change and sheep husbandry

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 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 even migrate 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 (cattle and buffalo) 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.

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 2030. 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.

Technology landscape

Recent developments in field of biotechnology, nanotechnology, molecular biology and information technology are expected to provide significant new opportunities for productivity enhancement of sheep. These developments are also posing new challenges of capacity-building and human resource development. There is a need to develop organizational policy and guidelines aimed at inventions and accelerating innovations employing state of art infrastructural facilities in sheep husbandry to harness opportunities by integrating modern and conventional research approaches. CSWRI is the custodian of huge *ex-situ* collection of genetic stock of sheep and rabbit, nutritional manipulation, improving reproductive efficiency, health package for reducing morbidity and mortality along with value addition of meat and wool for enhancing production which will facilitate their sustainable use in development of local stock over time through conventional and frontier area of scientific techniques.

Emergence of sheep business

Live animal, meat and wool marketing in India is unorganized and inefficient wherein a major chunk of profit accrued is pocketed by middlemen involved in the supply and marketing chain of production to consumption. New opportunities have emerged with the opening of the trade, as a result issues related to sanitary and phyto-sanitary measures need to be appropriately addressed. A three-pronged strategy is needed to reduce post-harvest losses that include: (i) shortening supply/marketing chain by linking primary producers to markets, (ii) promoting processing of food commodities in production catchments to add value before being marketed and (iii) developing small-scale cold chain using conventional and non-conventional sources. This would require active participation of stakeholders, research institutions, development agencies and industries under public- private- partnership mode.

Market intelligence at domestic and international levels and linkage of producer with meat and wool industries and input suppliers would be of immense value in ensuring better price to end users in the supply chain. Forward and backward linkage of primary producers with meat and wool industries and input suppliers under contract farming mode would accelerate the growth of sheep production and sources of income of primary producers. Subsidies at input level to evolve, specific commodity zone including disease free as well as marketing zones for developing internationally competitive production and marketing system with objective of producing hygienic and quality mutton and wool at competitive prices for consumers in the country. Minimum support price, subsidies and geographical indicator to indigenous wool would facilitate the development of sector in future.

Central Sheep and Wool Research Institute

The Central Sheep and Wool Research Institute, Avikanagar is one of premier animal science institutions of Indian Council of Agricultural Research, New Delhi. The institute was established in 1962 near Malpura, Rajasthan to conduct applied and basic research on all aspects of sheep and rabbit production and product utilization. The institute has three Regional Stations: Northern Temperate Research Station (NTRS) established in 1963 in temperate location at Garsa near Kullu, Himachal Pradesh, Southern Regional Research Station (SRRS) in 1965 at Mannavanur, near Kodai Kanal in sub temperate climate of Nilgiri hills, Tamil Nadu and Arid Research Campus (ARC) in hot and dry arid region at Bikaner in 1974. The Institute has 10 Network Farm/Field Unit on Deccani, Chokla, Magra, Muzzafarnagri, Nellore Patanwadi, Madras Red, Ganjam sheep breeds spread all over the country. A Mega Sheep Seed Project started in XI Plan on Mandya, Sonadi, Mechari and Chotta Nagpuri for ensuring quality breeding rams for genetic improvement.

CSWRI 2030

The Central Sheep and Wool Research Institute is moving ahead with the objective to improve productivity of sheep and livelihood security of poor farmers and welfare of consumers in the food and fibre supply chain. The efforts will be made to become leading institution for sheep and rabbit research and development in the country and abroad and responsive to need of farmers.

Vision

Ensure higher meat and wool production, value addition of primary produce and provide livelihood security and economic sustenance of farmers and welfare of consumer through technological innovations and sustainable integration.

Mission

Harness research and development for higher and sustainable meat and wool production.

Focus

1. Improving productivity of sheep through integrated management of genetic resources, grazing land and market structure,

2. Promoting adaptation and preparedness to face challenge of climate change evolving mechanisms for effective drought and flood proofing strategies,
3. Developing Public Private Partnership mode of research and development with SHG and industries for wool and meat processing,
4. Fostering linkages and collaborations with public and private and national and international organizations,
5. Promoting innovations and improving human resource capacity by involving all stakeholders in the food and fibre supply chain.

Harnessing science

The Central Sheep and Wool Research Institute would strive to harness power of science in increasing sheep productivity by genetic manipulation for mutton and wool production, improving nutritional status/feed conversion efficiency, improve reproduction and value addition of wool and meat, improving sanitary and phyto-sanitary value of meat, reducing cost of production and minimizing morbidity and mortality losses through conventional techniques as well as new science and technology. In the present context, when demand for meat is increasing rapidly and grazing resources are deteriorating; new technologies for enhancing productivity of sheep are required.



Genetic resource improvement

In the past, much of the gains in the productivity of sheep were achieved through genetic improvement of native sheep breeds which will be continued. India possesses vast genetic resource of 42 well established mutton, carpet and fine wool producing breeds in different climatic zones of the country. In order to improve mutton, wool and milk production, efforts would be made for conservation and productivity improvement by developing a three breed cross of native sheep through breeding and

introgression of *Fec B* gene from Garole and milk yield support from Patanwadi. An integrated approach of selection and breeding based on molecular and phenotypic information of the traits will be used for desired and rapid genetic gain in meat production. For improving reproductive efficiency, marker assisted selection based on genes responsible for prolificacy, fertility, etc will be given importance.

Substantial genetic variation exists between and within breeds as regard to resistance to diseases of parasitic and microbial origins which will be exploited to develop disease resistant sheep. Molecular mechanism of resistance/susceptibility and delineation of markers to identify them through the single nucleotide polymorphisms (SNPs) will be incorporated in the selection program. Open Nucleus Breeding System (ONBS) will be implemented for evaluating elite rams and used for accelerate genetic gain in the farmer's flock in participatory approach. Breeding sheep for better adaptability with regard to various climatic stresses and low green house gas emission are very

crucial for sustainable production system. The single nucleotide polymorphisms (SNPs) present in adaptability related genes will be identified, validated and used in the marker assisted selection.

In earlier programs milk and pelt production was not given due weightage due to obvious limitations although well established breeds for pelt and milk production are available in India and abroad. 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.

Moreover, sheep pelt has great demand in the international and domestic markets and fetch premium price and that market price is around \$25 per pelt. Coat prepared from pelt can be sold at market price of \$500- 20000 in international outlets. 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 under prolific sheep program. Out of twins and triplets, one lamb can be sacrificed for pelt production and other lambs can be reared up to marketable age and weight for mutton production. Fat tail sheep has demand on Muslim festivals otherwise also fetches premium price. Well known fat tailed dominant sheep breeds of Middle Eastern countries need to be used along with prolificacy trait with multiple births for mutton production under intensive production for higher body weight gain and meat yield. Embryos/ semen of fat tailed sheep (Awassi or other breeds from Turkey) needs to be imported.

Rabbit production though a recent venture in the country, it has promising scope for meat and angora hair production. Broiler rabbit can play a major role as an alternative source of white meat under scenario of growing demand of meat in the country. We have already achieved 2 kg target finishing weight at 12 weeks of age with 30 g ADG and 30 % feed conversion efficiency. Broiler rabbit can be popularized as small scale backyard unit as well as large scale commercial enterprise. Therefore, rabbit production deserves better attention in future policy for meat production.

Angora rabbit for fibre production is popular in Himachal Pradesh. German Angora at NTRS, Garsa is now an inbred colony with relative low production trait of 900 to 1000 g annually. Hence to introduce genetic variability and improve production level, import of German Angora may be taken up on priority. Over the period, large number of Angora rabbit units was established in Himachal Pradesh, which acted as source of income for farming community. It has been observed that market trend and price of Angora wool fluctuate widely. There is need to vitalize the Angora rabbit farming and making it a profitable enterprise and protect the interest of producers against price fluctuation and climate change would be great help to farming community. New research and development activities for revitalizing rabbit farming need to be documented.

Biotechnology for sheep improvement

Biotechnology approaches for enhancing productivity of sheep will be used in future programs. Identification of candidate genes controlling prolificacy, growth, meat, hind quarter muscling, wool and milk production and quality will be identified using micro array technology. 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.

Enhancing feed base and nutrition manipulation

Nutritional security is an important aspect for sustaining sheep productivity vis-à-vis demand in the country. Therefore, feed resource base would be expanded by exploring newer feed resources, maximizing utilization of locally available feedstuff, increasing nutrient availability from low quality roughages and research on nutrigenomics will be initiated to harvest maximal output from minimum feed/nutritional input. Innovative and farmers' friendly feed technology, processing and storage practices would be developed to deal with problems of scarcity and emergency. Work on nutritional preparedness for combating consequences of natural disasters like drought, famine, flood, earth quake etc will be undertaken. Nutritional manipulation for mutton, wool, pelt and milk production would be targeted for enhancing productivity of migratory and sedentary flocks. Specialized nutrition formulations will be developed for augmenting nutritional health, combating stress in human beings and meeting demands of consumer for preferred nutrients from livestock produce.

Enhancing reproductive efficiency

To enhance the litter size, strategy to maximize ovulation rate and minimize post-fertilization wastage, novel therapeutic reagents for fertility regulation and natural or artificial control of reproduction through elucidating the mechanism of follicular development will be tried. Control of ovulation (apocrine, paracrine and endocrine control), deciphering the sub-cellular and molecular events of ovulation, fertilization and embryo implantation and reduce embryonic mortality, embryonic stem cell culture and membrane bound and sub-cellular/nuclear damage during freeze-thaw process of rams semen would be targeted. Research priority for semen technology in sheep will be directed to develop the protocol for short term ram semen preservation, post-thaw fertilizing ability of ram

semen (molecular and cellular integrity of sperms), non-invasive fixed time artificial insemination technique for field application and to develop technology of spermatogonial stem cell transplantation as alternative to semen freezing and AI will be tried. Accelerated lambing system with provision of three lamb crops in two years will be tried in organized farms to improve over all productivity. The protocol for round the year mating to achieve above target will be developed. Elite germplasm through fixed time AI using fresh or short term preserved semen can be successfully used in AI programs for up gradation of sheep. To propagate, elite germplasm, ram rearing centre need to be established in different parts of the country.

Emergence and re-emergence of diseases

Sheep productivity is greatly affected by morbidity and mortality losses, more in lambs than adults due to a number of infectious and non-infectious diseases. These losses would be prevented by instituting flock health technology, improved and economically viable therapeutic measures and timely investigations using appropriate diagnostic tools, pathological diagnosis duly supported by histopathology, conventional microbiology and molecular biology techniques. The research will be undertaken on diseases of economic importance and multi-factorial etiology and non-infectious diseases, which are impediment in profitable sheep production. In phased manner, strict vigilance by sero-surveillance, host-parasite interaction and vector biology in vector-borne diseases will be undertaken through nation-wide eradication program for major infectious diseases launched by appropriate agency. Development of pen-side diagnostic tests, genetically resistant sheep breeds for chronic bacterial and parasitic infections, manipulation of disease susceptible genes by silencing technology and application of microarrays for gene profiling and diagnosis will be undertaken. Isolation, pathogenicity testing and microbiological and molecular characterization of pathogenic microbes will be continued to enrich veterinary type culture.

On gastrointestinal parasitism hypobiosis in *Haemonchus contortus*, effect due to migration, climate change, livestock rearing, monitoring, problem of anthelmintic resistance, implementation of community dilution strategy for reversion to susceptibility in parasites and TST approach would be taken up. The work on identifying the genetic markers for resistance/resilience to gastrointestinal nematodes and non-chemical and sustainable control strategy for worm infestation by nutrition and biological methods will be continued.

Post-harvest and value-addition

Mutton and value added products

More focus will be given to primary and secondary levels of value-addition and processing. Research will be carried out for hygienic and wholesome meat production and product preparation. Production and processing for pelt/fur of sheep/rabbit origin would be developed for enhancing income of primary producer with wider employment opportunity. Sheep milk rich in fat and other nutrients is widely used for cheese preparation in European countries. Facilities will be created for preparation of cheese from sheep milk. Value addition of meat of restructured spent sheep would be utilized by development of suitable tenderization protocol for product preparation and value addition. The facilities for packaging of meat products will be created with the purpose of protecting them against physical, chemical and microbiological spoilage and delivering them in safe and wholesome conditions to the consumers.

Wool and value addition

Some of the value added products from wool in future would be targeted on technical textiles viz. high thermal insulation blankets, bullet-proof cloths, fire-retardant fabric, chemical and bio-warfare protective textile and medical felts. In addition, blended products with specialty hair fibre, cotton, viscose, nylon and polyester will be targeted. Utilization of coarse and hairy wools for powder manufacturing and protein/amino acid extraction, engineering of yarn structure, wool felt packing materials for different industrial applications would also be explored.

Disaster management in sheep rearing

Sheep husbandry is affected by natural disasters like drought and famine in the semiarid and arid regions, flood in the eastern region, snow fall and landslide in the north temperate region and cyclone and volcano in the coastal region of the country. In years to come, the frequency and intensity of disaster of varying nature is likely to increase. Therefore utmost priority in research agenda will be given to protect animals from disaster consequences in a well-planned manner including preparedness strategies. Preparedness planning would include: (i) monitoring and early warning system (ii) assessment of impact and relief programs and, (iii) rehabilitation and reconstruction programs in affected areas.

Technology transfer systems

It has been observed that technologies related to sheep production developed in the institution has not been widely accepted by the farmers due to their poor socio-economic and educational background while health care has been partially adopted hence full advantage of these technologies have not been realized by the end users. It is of utmost importance to continuously work to develop new and better technologies for improving productivity of sheep and value addition of meat and wool. Extension services play a catalytic role and facilitate accelerated transfer of improved and tested technologies, knowledge and information to the farmers through an effective delivery system. There is strong need for the production of literature, visual aids, mass communication materials and other recent delivery systems for effectively linking the institution and stakeholders for transfer of technologies. Due to explosion in information technology, innovative delivery system needs to be developed to reach the end users in shortest possible time. Extension in agriculture and animal husbandry is a state subject therefore, it is important to develop effective linkage with state AH department and also to develop a mechanism to involve private operators, voluntary agencies and Shelf Help Groups (SHG) for delivery of the technologies in farmers flock. Call centre, knowledge management system with online repository/data base audio, video, multimedia based interactive information system and online services will be developed for the livestock owners. Facilities for demonstration of technologies developed by the Institute, Farm School on radio and television, technology park and science museum under PPP mode will be created. For solving problems of farmers, industries and developmental agencies on the topics of sheep rearing and marketing, Mobile, SMS alert and e- learning systems will be developed.

Strategy and Framework

A 5-point strategy will be adopted to accomplish the vision and the goals of Central Sheep and Wool Research Institute and to enhance efficiency of meat, wool, milk, pelt production and utilization, disease diagnostic and transfer of technology by mission mode approach.

1. Enhancing lamb, mutton, wool, pelt and milk production

- Introgression of *Fec.B* gene through Garole/Kendrapada inheritance in non-prolific breeds for multiple birth and prolificacy,
- Molecular breeding approach under optimum feeding and management,
- A nucleus breeding scheme using MOET technology for accelerated genetic gain,
- Import of Awassi live animal/embryo with twin objective of enhancing milk and mutton production,
- Import of Karakul/other breeds for pelt production,
- Accelerated lambing system for higher life time productivity targeting three lamb crops in two years,
- Economical and cheap complete feed incorporating desirable nutrients.

2. Enhancing meat, fur, wool from rabbits

- 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 for small land holders under backyard farming,
- Fur and wool processing units under small cottage industries,
- Economical and cheaper feed for wool and meat production,
- Marketing strategies for avoiding fluctuation in meat and wool price.

3. Wool, meat, pelt, milk processing and value addition

- Wool processing/value addition and development of new programs for wool utilization,
- Carpet designing, natural dye and eco friendly woolen products,
- Meat processing and value added products,
- Pelt processing and value added products,
- Milk processing and cheese manufacture,
- Restructuring meat from spent ewes for value added products.

4. Food safety, disease surveillance, health care and diagnostics

- 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.

5. Transfer of technology and public private partnership

- Technology validation, refinement and dissemination of generated technologies,
- Industries-Institute-Farmers interface,
- Interactive information system,
- Knowledge management system,
- Marketing intelligence for sheep and their produce,
- Capacity building and training.

Epilogue

Sheep husbandry is a back bone of rural economy and prosperity of farmers in almost all topography of the country. Major challenges in sheep husbandry are shrinking grazing land, shifting sheep population and their utility, livelihood security of poor farmers, early disposal of lambs, increasing demand and price of mutton, poor price for Indian wool and import of wool from other countries, etc. Major opportunities are vast genetic resources, population, diversified production, growing demand for mutton, quality carpet wool and trained manpower and organized meat and wool industries. Institute approach to develop improved technologies and transfer to end users would augment farmer's income, reduce import of wool and promote mutton production and availability at competitive price, wholesome and hygienic meat, value added woolen and meat products. The Institute plans to develop and strengthen infrastructure for overall development of sheep sector for poor farmers living below poverty line in harsh climatic zones of the country. The Institute would also focus on other produce like pelt and milk of sheep in addition to wool and mutton for augmenting income and nutritional security of poor farmers. Institute will frame strategies and approaches to address issues of climate change, growing demand of meat, quality meat production, marketing trend of meat and wool, developing heat and eat culinary specialties of the country and value added wool products. The objective of the program will be to commercialize the rich culinary specialties of different region of the country. Broiler rabbit for meat and Angora for fibre production would be promoted in areas with infrastructural support for rabbit production, processing and marketing under backyard and large scale commercial farms under contract farming.

6. Annexure 1: Strategy and Framework

Goal	Approach	Performance measure
Enhancing mutton production	<p>To improve mutton production potential of sheep through molecular breeding approach under optimum feeding, intensive selection and management</p> <p>Introgression of Prolificacy through Garole/Kendrapada inheritance</p> <p>Intensive feeding system on complete feed</p> <p>Accelerated lambing system for higher life time productivity</p>	<p>Developed new strain of prolific sheep for enhancing mutton production</p> <p>Increased and hygienic mutton availability and security to the consumer</p> <p>Commercialization of lamb rearing for mutton production.</p> <p>Improved livelihood security and better socio-economic status of sheep farmers.</p>
Enhancing wool production	<p>Improvement of Bharat Merino sheep for fine wool production.</p> <p>Improvement through intensive selection of Marwari, Magra and Chokla for carpet wool production</p> <p>The lustre and strength of wool fibre for producing quality yarn and carpet.</p>	<p>More income from wool</p> <p>Better opportunity for woolen industries.</p> <p>Employment opportunity in wool processing and product manufacture. Reducing import dependence on other countries such as Australia and New Zealand</p>
Pelt and fur production and value addition	<p>Pelt from indigenous sheep and Karakul breed.</p> <p>Fur animal rearing and processing practices from indigenous and imported germplasm.</p>	<p>More income from pelt in addition to meat.</p> <p>Better pelt for leather and other industries.</p> <p>Quality pelt and employment generation.</p>
Fat tail sheep for enhancing mutton production	<p>Intensive feeding system on complete feed</p> <p>Meat with special fat for specialty products</p>	<p>Higher and quality mutton production for consumers</p> <p>Meeting requirement of community for special occasions</p> <p>More income from sheep in harsh environment</p>

<p>Milk production and product processing</p>	<p>Milk production from Malpura and Patanwadi</p> <p>Import of Awassi germplasm</p> <p>Mozzarella cheese and milk of therapeutic value</p>	<p>Nutritional security of poor farmers in harsh climate and better growth of pre weaner lambs.</p> <p>More income and livelihood security</p> <p>Diversified Mozzarella cheese for urban consumer</p>
<p>Food safety, disease surveillance, Health care and Diagnostics</p>	<p>Diagnostic tool and prompt biotechnological and conventional tests</p> <p>Hygienic standards and testing facilities for safe meat in respect of diseases communicable to human from processed meat and meat products</p>	<p>Healthy sheep, less mortality and reduced economic losses to farmers</p> <p>Safe and wholesome meat for human consumption</p>
<p>Transfer of technology and Public private partnership</p>	<p>Technology validation, refinement and dissemination activities.</p> <p>Industries-Institute-Farmers interface</p> <p>Interactive information system</p> <p>Knowledge management system</p> <p>Marketing intelligence for sheep and its produce</p> <p>Capacity building and training</p>	<p>Proven and tested technologies for development will be popularized.</p> <p>Contract farming for better production and competitive price</p> <p>More access to technologies by the end users</p> <p>Learning materials on sheep production</p> <p>Better price for produce in the domestic and global markets</p> <p>More trained persons in sheep husbandry</p>

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of
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