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Vision 2050

National Research Centre on Mithun

Indian Council of Agricultural Research

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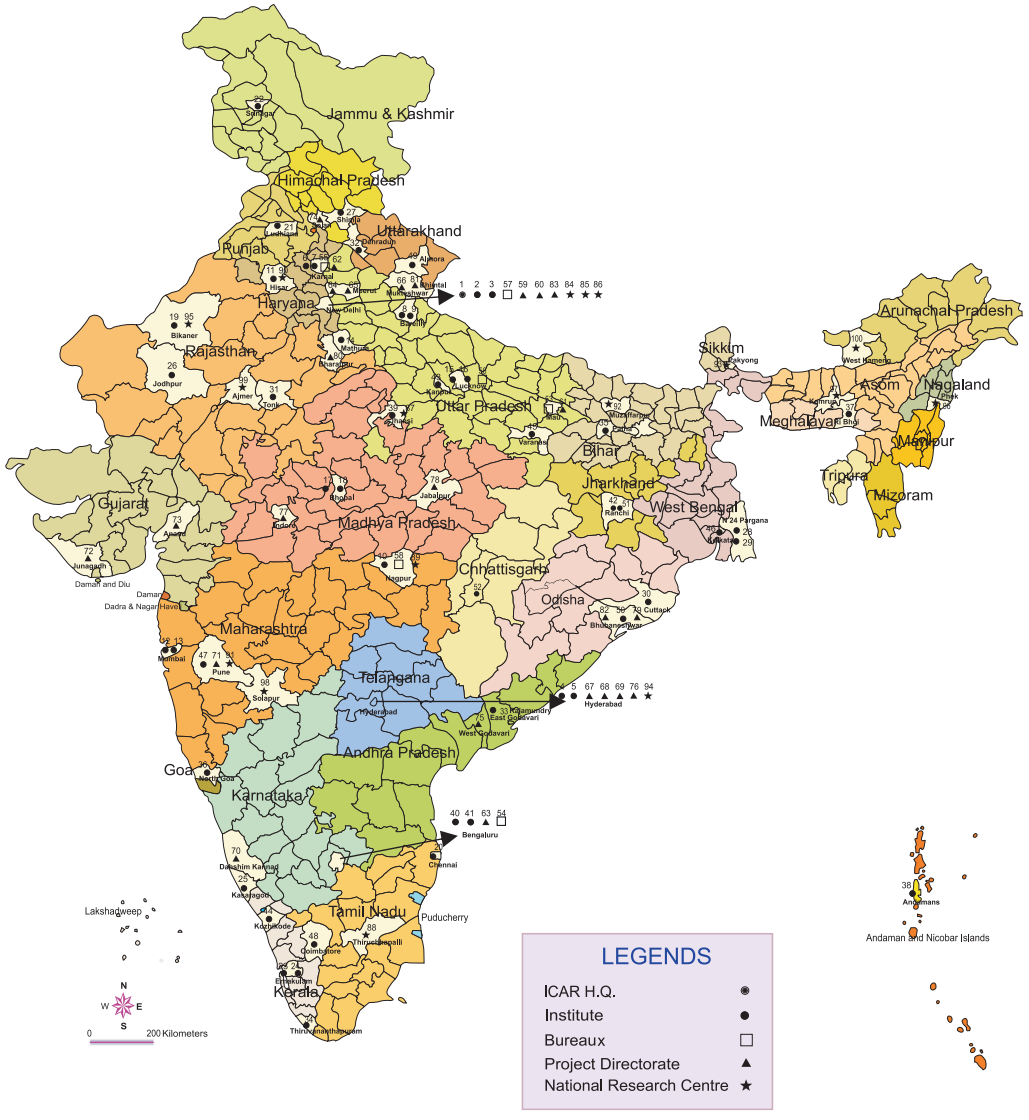

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities

Vision 2050

National Research Centre on Mithun
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संदेश

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

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

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

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

(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

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

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

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

Vision-2050 document of ICAR-National Research Centre on Mithun (ICAR-NRCM), Nagaland has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

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

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Preface

Mithuns (*Bos frontalis*), a unique livestock species, are reared by the farmers of four States of North-Eastern-hilly region (viz., Arunachal Pradesh, Nagaland, Manipur and Mizoram). Mithun plays an important role in the socio-economic status of poor farmers, thereby contributing in overall economy of tribal people of mithun inhabited States. Though, according to 19th Livestock Census (2012), mithun population has registered a growth of 12.98% over the previous census, the total population of mithun is only 0.29 million, which is very low. The existence of this magnificent species is threatened by increased inbreeding, inter-species breeding with cattle and indiscriminate destruction of the habitat.

ICAR-National Research Centre on Mithun (ICAR-NRCM), being only institute of its kind, is exclusively dedicated to this species. This institute has been playing a pivotal role in providing the scientific inputs for overall improvement of the present scenario of mithun rearing and thereby contributing to a great extent for conserving agro-ecological balance, economic development and preservation of cultural uniqueness of the diverse ecological environment of North-Eastern states.

We prepared Vision 2030 to address the challenges that have been already in place. The present document 2050 is prepared to articulate the challenges which are be likely to be encountered by mithun and mithun-rearers due to fragile ecology and climate change scenario of the region. This document is also aimed to capitalize the opportunities for developing strategies through various appropriate technologies and to prepare a road map for sustainable growth and development.

I hope this document will be able to throw some insights in the desired direction for future research workers in the field of mithun husbandry by formulating and implementing various programmes.

I would like to express my deep sense of gratitude and indebtedness to Dr. S. Ayyappan, Honorable Secretary (DARE) & Director General, ICAR for his guidance and direction to prepare this valuable document.

I also express my deep sense of gratitude to Dr. K. M. L Pathak, DDG (AS) for his constant help and valuable suggestions. I express my sincere thanks to Dr. B. S. Prakash, ADG (AN&P), who has helped us to review this document critically for bringing it into the present shape.

My sincere and special thanks also are due to Dr Chandan Rajkhowa, Immediate-Past Director and Dr. N. Haque, Principal Scientist, who in fact conceived and formulated this document. I also express my sincere thanks to all the Scientists and other staff members of this Institute for their inputs, suggestions and tireless efforts to prepare this valuable document.

(Abhijit Mitra)
Director
NRC-Mithun, Nagaland

Contents

Context

Mithun (*Bos frontalis*), being a socio-cultural emblem of mithun rearing States (viz., Arunachal Pradesh, Manipur, Mizoram and Nagaland), has got clear link with agricultural practices, environment, ecology and overall economy of the mithun inhabited States. Since time immemorial, it has been regarded as an inseparable component during celebration of socio-cultural and religious ceremonies.

Presently, the existence of this animal is at stake both from social and environmental point of view. The forest area in which these valuable animals inhabit is decreasing day by day due to some faulty agricultural practices like Jhum with shorter cyclic period, indiscriminate felling of trees and other factors.

The young generations are lured to other easy ways of income generation and are less interested in continuing the comparatively more labour intensive mithun rearing practices. In some areas, mithun cows are being bred with local cattle bull (crossbreeding) for increasing milk production with higher butter fat content. It poses a great threat to the existence of this unique animal before evaluation and full exploitation of its inherent genetic potentials. Mithuns are having sufficient genetic variations in terms of their physical and productive characters. It seems to be a unique animal in terms of vulnerability/resistance against different diseases compared to that of cattle. This animal is also very special in their feeding behaviour and maintaining themselves in free range system without material inputs from mithun rearers except salt. Considering the existing socio-ecological conditions and above mentioned characteristics of this species, there are ample scopes for improvement in growth, production and reproduction characters. Further, searching for specialties in disease resistance, rumen microbes, and meat, milk and hide products needs a long term planning.

The first systemic effort was made in this direction by National Research Centre on Mithun with the preparation of 'Vision 2020'. The next attempt was made by refining 'Vision 2020' to prepare 'Vision 2025' (Perspective Plan) and 'Vision 2030' to articulate the changes that have taken place and to address the new challenges that have emerged. It is now realized that mithun, mithun rearers and the fragile ecology of the hotspot zone would have to face several long term challenges

and threats that are emanating from increasing population pressure, deforestation and climate change, and opportunities to mitigate the ecological imbalances, considering sustainable mithun rearing as an ecologically viable proposition which might be an indicator in its natural habitat. So, this vision document has been revised as 'Vision 2050' to articulate the challenges to be faced by mithun, mithun rearers and the fragile ecology in their niche and the opportunities thereby comes up for delivering an appropriate strategy and roadmap by National Research Centre on Mithun (NRCM) for sustainable growth and development of mithun and its rearers.

It is noteworthy to mention here that the North-eastern region (NER) of India is one of the 25 global Biodiversity Hotspot. To qualify as a biodiversity hotspot zone, a region must meet two strict criteria: it must contain at least 0.5% or 1500 species of vascular plants as endemic and it have to have lost at least 70% of its primary vegetation (Meyers et al., 2000). Of the total 17000 flowering plants of the country about 5000 species is found in the NER.

The normal annual rainfall in NER ranges from 200-300 cm and by virtue of receipt of heavy rainfall, it falls in low-rainfall-variability (8-15%) category. However, of late, this region is losing its nature's gifted fame. In high rainfall areas, distribution of rainfall is of more concern as compared to its amount received. Erratic nature of rainfall, its intensity and frequency often make crop planting a difficult task in rain fed areas. The pine, a naturally dominated tree species in mid-altitudes, is encroached upon by another tree species viz., *Schema wallichii* (Das et al., 2009). Though, climatic consequences need to be thoroughly evaluated, but it indicates some changes in vegetation pattern which is a matter of concern for mithun rearing in its natural habitat.

Studies on rainfall and temperature regimes of NER indicate no significant trend in rainfall for the region as a whole (Das and Goswami, 2003; Das 2004). However, in South Assam Meteorological Subdivision (that covers mainly the hill states of Nagaland, Manipur, Mizoram and Tripura and parts of the Basail Hills in the Southern Assam), a significant change in seasonal rainfall has been observed with a considerable decrease in rainfall over the past century at an approximate rate of 11mm per decade (Das 2004, Mirza et al, 1998).

Analysis of long term temperature data of the region suggests a distinctly rising trend in surface temperature. The annual mean maximum temperature in the region is rising at a rate of +0.11°C per decade. The annual mean temperature is also increasing at a rate of 0.04°C per decade in the region (Das, 2004).

Extreme precipitation events (e.g., heavy rain, storm, cloud burst) may have their own impacts on the fragile geomorphology of the Himalayan part of the Brahmaputra basin causing more widespread landslides and soil erosion. *Jhum* (shifting) cultivation with shorter duration may further worsen the situation. In the wake of such a shift in climate change in the region, there is an urgent need for reassessment of the diversity of plants consumed by this animal. However, in mithun rearing states like Nagaland, mithun rearing as an alternative to *jhum* cultivation or mithun as an integral part of integrated farming system are being encouraged. And farmers are spontaneously joining in this venture as mithun rearing is observed to be more remunerative than *jhum* cultivation in long run.

In this regard, NRC on Mithun is giving more emphasis to combat challenges on ecology and environmental aspects, particularly on determination of carrying capacity of forests in terms of mithun rearing, nutritional evaluation and propagation of locally available feeds and fodders, evaluation of mithun rearing as an alternative livelihood proposition to traditional jhumias (shifting cultivators), development of sustainable mithun based farming system in the fields, assessment of performance of mithun under different climatic condition, development of suitable economic housing system for mithun and also studies on disease pattern of this animal in changing climatic scenario in different altitude and seasonal variations.

National Research Centre on Mithun (NRCM) was established by ICAR in the year 1988 in the State of Nagaland and Porba in Phek district was its site. The Institute was functioning from Shillong, Meghalaya during the period 1988 to 1994. The Institute was shifted to Porba in the year 1994 and started functioning from a rented house. However, due to the remoteness of the area with insufficient logistic support, the Institute was again shifted to Jharnapani and accommodated in the campus of ICAR Research Complex for NEH region, Nagaland. During the period 1988 to 1997 the Institute was functioning with a skeleton staff and could not achieve much progress. The Institute has started achieving a remarkable progress since 2000 and its activities have flourished by many folds and in many directions. At present, the Institute is functioning from its main centre at Jharnapani with state of the art infrastructural facilities and a field station at Porba in Phek district of Nagaland.

Being the sole institute in the country as well as in the world dedicated to this species, NRCM remains vigilant and responsive to changing scenario through development of novel technologies

and promoting problem solving innovations. It envisions challenges the mithun, mithun rearers and the fragile ecology in which they inhabit, is facing especially for ensuring sustainable development, environmental security and also the opportunities it bestow as an avenue for economic development and to be a model ensuring ecological balance as a component of this system.

Few of the significant achievements based on the commitment in the previous vision document of our institute are as follows:

- Cytogenetic album was prepared taking all the mithuns in the Institute herd.
- A prediction equation was developed to determine the body weight of mithuns based on the morphological traits
- Developed the technique for age determination of mithun by dentition pattern
- Genetic polymorphism in kappa casein (CSN3) gene of mithun was identified using PCR-RFLP technique. Phylogenetic tree was constructed on the basis of sequence of CSN3 genes of mithun and other species.
- A PCR based technique was developed to select mithuns for favourable genotypes of CSN3 which is suitable for cheese making. This will be useful for genetic improvement in terms of better cheese production.
- Developed a protocol for super-ovulation and embryo transfer in mithun
- Oestrus synchronization protocols for mithun have been developed using single and double injection of prostaglandin F2α, Co-synch protocol (GnRH- prostaglandin F2a combination), OvSynch protocol (GnRH- prostaglandin F2a-GnRH), controlled intra-vaginal drug releasing device (CIDR), OvSynch + CIDR and Heat Sync (using oestradiol cypionate; ECP).
- Methods have been standardized for preservation of mithun semen at refrigeration temperature using tris-egg yolk diluents. Cryopreservation of semen has also been standardized using tris-egg yolk diluent and citrate-egg yolk diluent with graded levels of glycerol.
- Developed a PCR based molecular technique for rapid detection of the transcripts of heparin - binding protein (Hbp) and osteopontin (Opn) in mithun seminal plasma.
- Artificial insemination protocol has been standardized and successfully used in field condition.

- Superovulation protocol has been standardized in mithun by using FSH. Protocol standardized for superovulation and embryo transfer resulted in the birth of BHARAT on March 27, 2012, PRITHVI on May 11, 2012 and MOHAN, the first mithun calf born through embryo transfer technology (ETT) from cryopreserved (-196°C in liquid nitrogen) embryo at the institute on May 12, 2012.
- Established the PCR based detection method for identifying fertility associated antigen in mithun seminal plasma.
- Developed area specific mineral mixture.
- Developed efficient drying process for hay making of thick stemmed fodders.
- Developed methods for incorporation of high moisture content agro-industrial by-products in feed block.
- Isolated 30 fibre-degrading and two tannin-degrading bacteria from rumen of mithun using the technique of serial dilutions and repeated tubing. These bacteria were characterized on the basis of the amplified sequences.
- Standardized the method for training mithun bulls for draft purpose
- Standardized PCR and sequence based analysis for identifying major rumen bacteria in mithun.
- Methods for identification of different virulent genes for *E. Coli* in diarrheic faecal samples using PCR have been developed.
- Bacteria associated with respiratory tract infection were isolated and identified from mithun.
- Rotavirus has been identified from mithun calves having diarrhoea.
- Antibiotic sensitivity pattern of clinically important bacteria isolated from mithun calves have been established.
- Seasonal and altitudinal pattern of gastrointestinal parasites and ticks infestation have been documented for hilly ecosystem.
- Developed value added mithun milk products and developed leather processing technology for mithun hide

The Institute has the following mandates envisioning to bring in excellence in profitable and productive mithun based livestock production system for the North-Eastern Hilly (NEH) tribal areas:

- Identification, evaluation and characterization of mithun germplasm available in the country.
- Conservation and improvement of mithun for meat and milk.
- To act as a repository of germplasm and information centre on mithun.

To bring in excellence in profitable and productive mithun based livestock production system, a critical analysis of social, environmental, ecological, agricultural practices, and overall economy of this area should be taken into consideration. Presently mithun is reared in forests in free-range or semi-intensive system with negligible input.

Total forest area, the mainstay of mithun, being in diminishing trend; promising mithun produces (like leather, meat and milk products), being unfamiliar to the local people; switching over to alternative rearing system (intensive system or semi-intensive system with additional material input), mithun being a forest loving animal and its unknown effect on ecology makes it mandatory to prepare a long term vision to bring in excellence in profitable and productive mithun based livestock production system.

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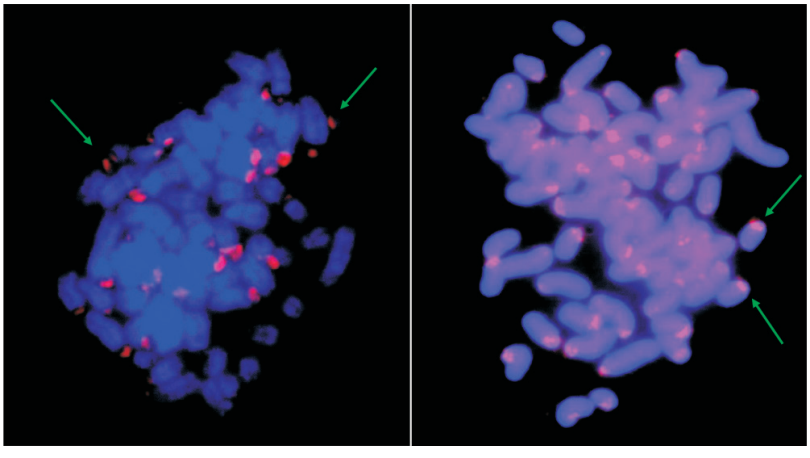

Mithun metaphase chromosome showing centromeric signals with rhodamine as a flurochrome in bovine probe

Challenges

Shifting cultivation (locally known as *"jhum"*) is thought to be one of the major contributing factors for reduced available forest area in this region. With the increased population the villagers are reducing the fallow period in order to allot *jhum* land. Reduced fallow period of 1-3 years is not enough for regeneration of the land for further use, resulting in degradation and encroachment of steep slopes with forests. The clearing of forest areas at regular and frequent intervals for *jhum* results in loss of primary forests and formation of secondary forests. This causes substantial loss of tree diversity and associate vegetation those are adapted to primary forests. Due to shortening of *jhum* cycle, quite often the secondary forests also do not get adequate time to regenerate. The repeated use of land with short *jhum* cycle finally converts the *jhum* follows into degraded waste lands (Tripathi and Barik, 2003).

The overall population of mithun has registered an increase of 16.90% during 19th Livestock Census in comparison to 16th Livestock Census (GoI, 2012). In 1997 (according to 16th Livestock Census) the mithun population was 124, 17, 3 and 33 thousand (GoI, 1997) against 249, 10, 3 and 35 thousand in 2012 (according to 19th Livestock Census) in Arunachal Pradesh, Manipur, Mizoram and Nagaland, respectively. However, the forest cover in the state of Arunachal Pradesh, Manipur, Mizoram and Nagaland was observed to be 6860, 1742, 1877 and 1422 thousand hectares during 1997 and 5154, 1693, 1594 and 863 thousand hectare during 2009, respectively (FSI, 1997; 2009) with an overall decreases of 21.82%. If this trend continues the biodiversity of this region will be affected further due to continuous deforestation as well as jhum cultivation will directly affect the rearing of mithun in the forest. So, our target will be to standardize a sustainable mithun production system without affecting the ecology in some designated forest areas of mithun rearing states.

Mithun is reared in the forest in free range system with almost zero input. Data on average birth weight, average growth rate, age at puberty, age at first calving, inter-calving period of mithuns reared in free range system are not available. However, the same under semi-intensive system was observed to be 20.09 kg, 400 g/day, 35 months, 44 months and 19.3 months, respectively.

Presently on an average two calves are available in every three years from a mithun cow reared under semi-intensive condition and the target is to have one calf in each year. There is a need to increase the birth weight to about 25-30 kg, average growth rate up to maturity about 700-900 g/day and reduction of age at puberty to about 25 months and age at first calving about 34 months.

The challenges to achieve these targets are to develop animals with high genetic worth for economically important traits, to assure availability of feed and fodder in its natural habitat through propagation of fodder trees and to provide supplement feeds during scarcity period particularly winter season and to develop an integrated fertility enhancement protocol.

Genomics refers to the comprehensive study of genes and their functions. Recent advances in bioinformatics and high-throughput technologies such as bovine SNP chip and next generation sequencing analysis are bringing about a revolution in our understanding of the molecular mechanisms of underlying biological processes and the functional aspects of economic traits. SNP chip, transcriptome studies and other genomic techniques are also stimulating the discovery of new genomic markers for various quantitative traits for the purpose of genomic selection of animals. Transcriptome sequencing (RNA-seq) will be a very interesting and informative alternative strategy to identify the genetic variations responsible for important traits in mithun which is still not having any resource genome database. On the other hand, assembling an individual animal's entire genome sequence or specific region(s) of interest is increasingly important for the scientists to perform genetic comparisons between animals with different performance traits. This will be very important and challenging study in mithun to construct the draft genomic assembly through the use of next generation sequencing techniques in comparison with other available bovine genome sequences.

Stress has to be given on manipulation of rumen microbial ecosystem through genetic/non-genetic techniques for cent percent utilization of lignocellulosic biomass. Model animals will have to be developed for improving fibre degradation. Exploiting rich biodiversity in terms of flora and fauna of this region, identification and characterization of neutraceuticals will be done for better nutrient utilization.

To attain these targets, at least about 20% of mithun population by 2030 and about 30-40% by 2050 are to be replaced with genetically upgraded elite animals and population to be increased to about 0.40 million by 2030 and about 0.50 million by 2050. This will be tried in collaboration with the State Governments and progressive farmers.

Though mithun meat is highly preferred in the region, but no organized market for mithun meat exists at present. Mithun production system linked with market should be developed to increase its visibility in the Animal Husbandry Sector of the NER. Development of commercially viable mithun rearing unit is yet to come. Scientific propagation of mithun population in farmers' field using modern biotechnological tools could not be implemented yet. Presently about 10% of the population is sacrificed. To make the mithun rearing system more remunerative, value added designer milk and meat products with high functional attributes and leather products are to be developed and sacrifice rate to be increased to about 15% by 2030 and about 20% by 2050, respectively with appropriate turnover rate. It will be helpful in enhancing the availability of organic meat and reduce the pressure of environmental pollution. This will be possible only with the increase in number of animals which is a challenging task. Natural Organic Standards Board of USA started to consider maintenance of biodiversity as one of the points in the check list before certification of organic production system for reaccreditation from 2009 which might also be an obligatory feature for our country in future.

Mithun is reared in an organic mode by default in free range system. Now, it is our responsibility to maintain this system with scientific inputs and passing it through certification process for better remuneration to mithun farmers. Maintenance of biodiversity of the hotspot zone is considered as one of the important points in the checklist before accreditation. So, *jhum* as well as determination of carrying capacity of the forest in terms of mithun rearing are the important issues to be taken into account for developing organic production system.

Exposure of mithun to external elements during scientific interventions might make these animals more prone to external diseases which need attention. Trans-border transmission of diseases is a bottleneck for overall development of mithun as all the four mithun-rearing States having international border. Special attention are to be given on trans-boundary diseases. Calf mortality in semi-range condition is observed to be as high as 20%. It has to be reduced to about 5% level at least in organized farms expected to be established by 2050. Developing animals with higher disease-resistance capacity against various diseases by 2045 will be another challenging area. Identifying genetic features in the mithun genome that are related to economically important traits like growth, meat quality as well as genetic basis for disease resistance might be helpful.

Future increase in environmental temperature and erratic precipitation pattern in this region might affect mithun physically as well as with emergence of new diseases and parasites and change in the vegetation pattern in the forest. Strategies for better management for improved productivity of mithun under climate-change scenario will have to be developed. Water economy for production of per kg boneless mithun meat has to be estimated both for free range as well as intensive system. Development of elite animals through selection having capacity to tolerate higher abiotic stress is another challenging task. Suitable measures have to be taken after epidemiological studies on prevalent diseases like FMD, Haemorrhagic septicemia and other emerging diseases under climate-change scenario. Development of rapid and cheap diagnostic kits is the key issues to be considered in these aspects.

In the present scenario, mithuns are being reared in pockets confined with natural barriers. Otherwise when reared in comparatively accessible jungle, mithun comes out to cultivated crop area igniting social conflict. Rearing mithun in small groups in isolated places makes them more prone to inbreeding. Farmers do not have the knowledge about the deleterious effect of uncontrolled breeding under free-range condition, which might lead to a mithun population with lethal genes and inbreeding depression. Open nucleus breeding herd will be developed for production of elite animal with farmers' participatory approach. Male animals from it will be used for breeding for overall genetic improvement of mithun herds.

Presently mithuns are reared in 34 out of 44 districts of Arunachal Pradesh, Manipur, Mizoram and Nagaland in a very scattered way, in an altitude between 300 to 3000 MSL by resource poor famers with inadequate exposure towards modern scientific knowledge technologies makes proper implementation of scientific mithun rearing is a challenging job. The recent experience of non-mithun rearing Wokha district of Nagaland will be helpful for further propagation of this animal in non-rearing districts. By 2050 we are expecting to make all the non-mithun rearing districts as mithun rearing ones.

In nutshell the major challenges are

1. To standardize sustainable mithun production system without affecting the ecology in some designated forest area of mithun rearing states.
2. To enhance the reproductive efficiencies of mithun to get a calf each year from a mithun cow
3. To increase the birth weight to about 25-35 kg, average growth rate to maturity about 700-900 g/day, reduction of age at puberty to about 25 months and age at first calving about 34 months.

4. To construct the draft genomic assembly through NGS technologies in comparison with other available bovine genome sequences to understand the molecular mechanisms underlying the biological processes and the functional aspects of economic traits of mithun.
5. To replace about 15-20% of mithun population by 2030 and about 30-40% by 2050 by genetically upgraded elite animals and increasing the population to about 0.40 million by 2030 and about 0.50 million by 2050 and feeding them with cent percent utilization of lignocellulosic biomass through manipulation of rumen microbs using genetic and non-genetic techniques.
6. To make the mithun rearing system more remunerative through
   i value added designer milk and meat production with high functional attributes and leather production; and increasing sacrifice rate to about 15% by 2030 and about 20% by 2050 with appropriate turnover rate.
   ii certification of existing free range mithun rearing system, for organic meat production with proper consideration of maintenance of biodiversity.
7. To reduce the calf mortality to the level of about 5% in the organized farms by 2050.
8. To develop animals with higher disease resistance capacity against various diseases by 2045.
9. To develop strategies for better management for improved productivity of mithun under climate change scenario.
10. To develop animals through selection having capacity to tolerate higher abiotic stress.
11. To develop rapid and cheap diagnostic kits for controlling diseases like FMD, Haemorrhagic Septisemia and other emerging diseases under climate change scenario.
12. To develop open nucleus breeding hard for production of elite animals with farmers participatory approach.
13. To transform all the non-mithun rearing districts in all the four states to mithun-rearing ones.

Operating Environment

The people of the region are predominantly non-vegetarian and the production of meat is inadequate to meet the demand. The Demand Intensity Measure (DIM) (the consumption share of a particular product with respect to the all-India consumption share) for non-vegetarian commodities (meat, milk and eggs) was observed to be 136.8, 104.68 and 240.54 for Arunachal Pradesh, Manipur and Mizoram, respectively. The dependency index for meat in Arunachal Pradesh and Mizoram is 5.68 and 18.80, respectively (Statistical abstract of India, 2003). The requirement of meat in 2003 in NEH region was observed to be 0.44 million metric tonnes whereas production was only 0.22 million metric tonnes (NE Vision, 2020). Thus, the NER has to import major chunk of its requirement. The Department of Animal Husbandry of Nagaland reported that meat consumption in the State is higher as compared to other States of the country, while production is low. Import of meat and meat products not only increases the cost of food but also results in outflow of resources.

In India, the annual mean temperature of the country as whole for the period 1901-2009, has risen by 0.56°C and by 2050s the temperature may rise by 2-4°C. Further, a recent report by MoEF, GOI (INCCA, 2010) projects that even by 2030, our annual mean surface air temperature may rise by 1.7°C to 2°C with respect to current climate base line (1960-1990).

Maximum temperature in Arunachal Pradesh is projected to increase by 2.2°C to 2.8°C during 2030s as compared to baseline and towards 2080s the increase is projected by 3.4°C to 5°C. Minimum temperature is projected to increase by 1°C to 2.6°C during 2030s and by 2.8°C to 5°C during 2080s (Govt. of Arunachal Pradesh, 2011).

However, in the mid century (2020-2050), Nagaland State is projected to experience an increase in annual average temperature between 1.6°C and 1.8°C (Govt. of Nagaland, 2011). Similarly, increase in annual average temperature has also been reported from Manipur and Mizoram.

In case of livestock, global warming and climate change are likely to impact negatively on production and health. Alteration in physiological reactions at high temperatures will cause heat stress resulting into a decline in productivity of meat, wool, milk and draught power (Upadhya

et al., 2008). Higher temperatures and changing rainfall patterns can enhance the spread of existing vector borne diseases (Bhattacharya *et al*, 2006) and macro parasites, accompanied by the emergence and circulation of new livestock diseases. Humidity variations could also have a significant increase in helminth infections, protozoan diseases such as Trypanosomiasis and Babesiasis. Increase in temperature favours bacteria to grow fast in the milk and spoil the milk quickly causing economic loss to farming community. Rising temperatures will have an additional impact on the digestibility of plant matter. Raised temperatures increase the lignifications of plant tissues and thus reduce the digestibility and the rate of degradation of plant species. This not only affects the health of an animal but also results in the reduction in livestock production which in turn has an effect on food security and incomes of small livestock keepers. Infertility cases are likely to increase in cattle mainly due to mineral deficiency possibly due to high soil erosion trace minerals leach out.

In some recent development, it was observed that common farmers associated with *Jhum* cultivation formed Self-help groups (SHGs) in Nagaland and Manipur and preferred mithun rearing over *Jhum* cultivation, transforming their *Jhum* land into forest, which is considered to be more remunerative in long term.

The harness fabricated for mithun bulls for pulling load/cart

Opportunities

As a recent development, mithun rearing is observed to be more remunerative on long-term basis compared to *Jhum* cultivation and some farmers forming SHGs are voluntarily opting for the same. Besides mithun rearing, it may be beneficial for increasing the forest cover, maintaining the biodiversity and sequestration of more carbon. The SHGs can have additional monetary benefit in the form of carbon credit under Clean Development Mechanism (CDM).

It is a common belief that mithun is comparatively less affected by some diseases compared to cattle. It may or may not be correct. As mithun is reared in jungles and does not come in contact with different types of diseases, might be the reason of showing less disease incidences. Otherwise, if it is true, comparative genetic studies on disease incidence between mithun and cattle be helpful for having some insight and eradicate many diseases. Genetic studies in mithun will also help us to identify the desirable genetic quality in terms of production parameters, which in turn will be helpful for the genetic improvement of other species under genus *Bos*.

As this animal is reared exclusively in jungle, their products are organic by default. Little efforts in terms of management and certification may bring good remuneration to the mithun rearers by selling their products in international market.

Mithun is a large ruminant depends mostly on forest based forages and therefore is not a competitor to human and other livestock species for consumption of cereals, oil seeds and other related ingredients. This animal can be incorporated as a viable component in integrated hill farming system and propagated under forest based framing system with almost zero investment.

Milk yield of this animal can be increased through better nutrient management and selective breeding.

In situ conservation of individual strain will help us to understand the capability of individual strain in respect of production and other traits which in turn can be amplified with proper breeding policy.

The identification and evaluation of locally available feed resources preferred by mithun will be helpful to identify promising feed and fodder resources. Farmers can be motivated for conserving both the animal as well as their feed and fodder resources. It will open an avenue

for propagation and cultivation of suitable grasses and tree fodders at different altitude.

Traditional testified knowledge of the farmers will be very handy for incorporation in the semi-intensive scientific mithun management.

As mithun (*Bos frontalis*) and gaur (*Bos gaurus*) are genetically identical, any research information generated in mithun will also be helpful for implementing any effective conservation programme for gaur, which is currently identified as an vulnerable species since 1986 (Duckworth et al., 2008).

Above all, the National Research Centre on mithun (NRCM) functioning from its main centre at Jharnapani, Medziphema with state-of-art infrastructural facilities for various disciplines with skilled manpower. So, we will definitely be able to capitalize opportunities for generating appropriate technologies for making the mithun production system a remunerative one.

Technology Injection Programme under TSP at Mani, Doimukh, Arunachal Pradesh

Goals and Targets

Sl No.	Goal/Target	Activities	Expected Outcome
1	Identification and characterization of mithun germplasm available in the country	Morphometric, cytogenetic and molecular characterization of mithuns will be studied to identify the genetic variations and unique attributes.	New mithun strains to be specified, if any.
2	Genomic selection of mithun by evaluation and identification of important economic traits and genes related to unique attributes of mithun	Genome wide association studies taking multiple traits will be taken up for genomic selection of elite mithun in respect of meat, milk and other important traits.	Mithun with high genetic worth for economically important traits will be available including better efficiency, reduced externalities and better adaptation.
3	Draft whole genome sequences (including RNA-seq data) of mithun through NGS approach	Assembly of de novo entire genome sequence of mithun and comparison with other bovine sequences available	Facilitates research in identifying genetic features in the mithun genome that are related to economically important traits like growth, meat quality and genetic basis for disease resistance and expecting for developing animals with disease resistance capacity for certain diseases by 2045
4	Development of an integrated growth promotion protocol of mithun (IGPPM)	Interdisciplinary approach will be emphasized through amalgamation of recent advances in the field of breeding, nutrition, reproduction, genetics, health to enhance the growth of mithun in terms of quantity and quality.	IGPPM will be achieved as targeted. Elite animals with higher birth weight of about 25-35 kg and higher growth rate to maturity for about 900 g/day will be developed and expected to replace about 20% mithun population by 2030 ad about 40% by 2040 with elite stock.
5	Somatic cell cloning, stem cell research and transgenic in view of conservation and propagation of mithun population	Efforts will be made to clone the quality mithun germplasm, both male and female, to conserve and propagate the same. In addition, special emphasis will be given to stem cell research for its application towards reproduction enhancement and, diagnosing and treating diseases. Transgenic mithun for production of targeted pharmaceuticals through mithun produces will also be targeted if requires	Cloned and transgenic mithuns will be produced for economically viable mithun farming. Stem cell therapy will be an alternate for faster diagnosis and effective treatment of any kind of ailment in mithun.

Sl No.	Goal/Target	Activities	Expected Outcome
6	Assessment of performance of mithun under different climatic conditions	In-house assessment for performance of mithun under different simulated climatic changes under the present climatic change scenario will be conducted in psychometric chamber. Water economy for production of per kg boneless mithun meat has to be estimated both for free range as well as intensive system. Selection and breeding studies will be conducted for development of heat/cold tolerant mithun, if climatic parameters significantly affect production performances.	Performance of mithun under different climatic conditions will be assessed. Strategies for better management for improved productivity of mithun under climate-change scenario will be developed.
7	Nutritional evaluation and propagation of locally available feeds and fodders	Nutritive evaluation of locally available feeds and fodders for selecting the best ones for their incorporation in daily ration to make mithun rearing a viable proposition. Best selected ones will be propagated by standardizing propagation techniques. Efforts will be made to restore the habitat with high quality nutritive fodder trees.	Feeding strategy of mithun both in intensive and semi-intensive system will be developed Maintenance and availability of nutritious fodder plants will be ensured, thereby habitat will be restored.
8	Applications of neutraceuticals for better nutrient utilization	Exploiting rich biodiversity in terms of flora and fauna of this region, identification and characterization of neutraceuticals will be done for better nutrient utilization.	Efficiency of utilization of nutrient will be increased
9	Development of protocol for feed and fodder bank establishment	Methodologies will be developed for establishment of feed and fodder banks for increasing availability of feeds and fodders for mithuns reared in semi-intensive as well as in intensive system	It will be helpful in mitigating feed and fodder scarcity during scarcity period.
10	Manipulation of rumen microbial ecosystem.	Rumen microbes of mithun will be isolated and characterized and rumen microbial ecosystem will be manipulated through genetic/non-genetic techniques to improve nutrient utilization and reduce methane production.	Feeding strategy with higher nutrient utilization and lower methane production will be developed

Sl No.	Goal/Target	Activities	Expected Outcome
11	Determination of carrying capacity of forests in terms of mithun rearing	Studies will be conducted to determine the carrying capacity of forests in terms of mithun rearing with taking care of ecological balances.	Number of mithuns that can be reared per unit area will be determined, will also be helpful in production of certified organic meat taking care of ecological balances.
12	Evaluation of mithun rearing as an alternative livelihood proposition to traditional *jhumias* (shifting cultivators)	Earnings of the farmers and impact on ecology from *jhum* cultivation as well as mithun rearing in forests will be compared	mithun rearing might be recommended as an alternate way of livelihood
13	*In-situ* conservation with superior mithun germplasm for different strains	Animals from different strains will be maintained separately under nominated mating scheme in two altitudes (low and mid) as practiced presently for conservation of pure stock of individual strains of mithun.	A group of genetically elite mithun of specified strains will be available for future use.
14	Development of an Integrated Fertility Enhancement Protocol of Mithun (IFEPM*)*	Details studies in regard to breeding behaviour, oestrus cycle, gestation parturition, dystokia, involution of uterus shall be taken up. Programmes will also be taken up to augment fertility using modern reproductive, diagnostic and therapeutic tools. Every effort will be made on semen collection, evaluation and preservation including the feasibility of A.I. in domesticated population of confined mithuns with an emphasis on estrous synchronization and TAI. In order to increase the population of superior mithun, artificial insemination (AI), embryo transfer, SOET/MOET, IVM/IVF shall be standardized to study the feasibility and economic viability of these programmes for propagation of elite mithuns. Practices of all above-mentioned technologies will help for development of an IFEPM. Semen and embryo bank will be developed to support the programme.	Elite animals with reduced age at first puberty with about 25 months and age at first calving about 34 months will be produced. Conservation, preservation and propagation of these elite animals for future growth.
15	Development pregnancy diagnosis kit.	Pregnancy diagnosis kit will be developed using biotechnological techniques	Help in early diagnosis of pregnancy in mithun

Sl No.	Goal/Target	Activities	Expected Outcome
16	Identification/development of suitable biomarkers, kits and protocols for determination of male fertility/infertility	Biomarkers will be developed through proteomics and genomics studies	Fertility will be enhanced through using biomarkers/kits/ protocols.
17	Epidemiological studies of diseases	Epidemiological investigation of various viral, bacterial and parasitic diseases prevailing in the mithun population will be conducted. Various pathogen including bacterial, viral and parasites responsible for different diseases will be identified and characterized. Monitoring and surveillance of different diseases will be conducted.	Status of disease scenario will be documented in different seasons and altitudes. Special attention will be given on trans boundary diseases. Calf mortality will be reduced to the level of about 5% by 2050
18	Studies on disease pattern of animal in changing climate scenario in different altitude and seasonal variation.	Efforts will be made for studies on disease prevalence with respect to variation in environmental temperature, precipitation pattern and relative humidity round the year with respect to changing climatic scenario.	Disease forecasting model will be developed
19	Development of economic, sensitive and rapid diagnostic tools for different viral and bacterial diseases of mithun for field level application using advanced biotechnological tools	Efforts will be made for competence building for OIE prescribed and alternate diagnostics, targeting nano-particles (using the advance state-of-art in the field of Nano-biotechnology) for important diseases that are known to and likely to make impact on mithun in future	Battery of immuno-biologicals/ reagents specific for immuno-diagnosis of the mithun pathogens/diseases (bacterial/viral) will be developed.
20	Control of parasitic diseases of mithun	Efforts will be made for prevention and control of parasitic diseases by formulating deworming schedule. Efficacy of various drugs including drugs of herbal origin will be tried for prevention and control of diseases. While doing so efforts will be made to have collaboration with institutes of reputation like IVRI, PDADMAS, ICAR-RC NER, AAU and CAU.	Reduction of detrimental effects of parasites thereby increased productivity in mithun
21	Evaluation of meat quality and processing.	Carcass characteristics as well meat quality of mithun will be as assessed. Protocols for making value added products from meat will be standardized.	Value added products from mithun meat will be developed for national and international market.

Sl No.	Goal/Target	Activities	Expected Outcome
22	Evaluation of milk quality and processing.	Quality of mithun milk will be assessed in relation to human nutrition as wholesome milk as well as preparing certain value added products.	Value added products from mithun milk will be developed
23	Development of functional/designer meat products	Functional/designer meat products will be developed by modification of carcass composition or manipulation of meat raw materials.	Meat products will have tertiary health benefit
24	Evaluation of hide and skin quality and processing.	Efforts will be made to study the hide and skin for preparing finished leather products. This will be done in collaboration with the institutions deals with leather technology.	Value added products from mithun leather will be developed
25	Development of nucleus herd of mithun for enhancing their genetic worth.	ONBS will be followed to develop genetically superior herds of mithuns in their native tracts.	This will help to create the nucleus stock of mithun and will help in conservation and propagation of superior mithun germplasam
26	Development of suitable housing system under the climate change scenario	As there is no specific housing system for mithun rearing, efforts will be made to standardize proper housing of mithun with locally available materials.	Housing system for rearing mithun both in semi-intensive as well as intensive system will be developed
27	Development of sustainable mithun based Farming system in the fields.	Mithun will be assessed as a component of integrated agro-forestry based farming system.	Integrated forestry farming system with mithun as an important component will be developed for sustainable income to mithun rearers.
28	Determination of economics of mithun production	Economics of mithun rearing system and its impact on socio-economic condition of the local people will be studied. This will be done in collaboration with economists of ICAR and SAU	Viability of mithun production from economical point of view will be apparent
29	Development of repository of information related to mithun husbandry	Digitization of data related to various aspects of mithun rearing to develop an authentic source of information	Data bank will help scientists, students, farmers and policy makers to have access to reliable information.
30	Extension activities	Transfer of technology	Dissemination of appropriate technologies for benefit of mithun owners and farmers.

Time Schedule

Sl. No.	Goal/Target	2013-20	2020-30	2030-40	2040-50
1	Identification and characterization of mithun germplasm available in the country				
2	Genomic selection of mithun by evaluation and identification of important economic traits and genes related to unique attributes of mithun				
3	Draft whole genome sequences (including RNA-seq data) of mithun through NGS approach				
4	Development of an integrated growth promotion protocol of mithun (IGPPM)				
5	Somatic cell cloning, stem cell research and transgenic in view of conservation and propagation of mithun population				
6	Assessment of performance of mithun under different climatic conditions				
7	Nutritional evaluation and propagation of locally available feeds and fodders				
8	Applications of neutraceuticals for better nutrient utilization				
9	Development of protocol for feed and fodder bank establishment				
10	Manipulation of rumen microbial ecosystem.				
11	Determination of carrying capacity of forests in terms of mithun rearing				
12	Evaluation of mithun rearing as an alternative livelihood proposition to traditional *jhumias* (shifting cultivators)				
13	*In-situ* conservation with superior mithun germplasm for different strains				
14	Development of an integrated fertility enhancement protocol of mithun (IFEPM)				
15	Development pregnancy diagnosis kit.				
16	Identification/development of suitable biomarkers, kits and protocols for determination of male fertility/infertility				
17	Epidemiological survey of diseases				
18	Studies on disease pattern of animal in changing climate scenario in different altitude and seasonal variation.				

19	Development of economic, sensitive and rapid diagnostic tools for different viral and bacterial diseases of mithun for field level application using advanced biotechnological tools	
20	Control of parasitic diseases of mithun	
21	Evaluation of meat quality and processing.	
22	Evaluation of milk quality and processing.	
23	Development of functional/designer meat products	
24	Evaluation of hide and skin quality and processing.	
25	Development of nucleus herd of mithun for enhancing their genetic worth.	
26	Development of housing system	
27	Development of sustainable mithun based farming system in the fields.	
28	Determination of economics of mithun production	
29	Development of repository of information related to mithun husbandry	
30	Extension activities	

Parasites of mithun

Way Forward

The NRCM is committed for development of mithun rearing as an economically viable and ecologically sustainable component of the agro-economic practices for the tribal communities of the NEHR. We foresee that this species will act as one of the most important driving forces for conserving the agro-ecological balances, economic development and preservation of the cultural uniqueness of this hotspot zone of the country. The NRCM family believes that research on mithun as well as its ecological environment would augment profoundly the farmers' income, generate employment opportunities, conserve natural resources and increase value addition for overall socioeconomic development of the tribal population of the NEHR in general and mithun rearers in particular. To sustain the benefits of research and development, the NRCM would strive for a continuous effort to disseminate the technologies in the farmers' field with consorted effort with State Governments, Private Sectors, NGOs and other Governmental and Non-Governmental developmental agencies. Consorted efforts would also be made to transform the research, development and extension activities of the Institute using state-of-art technologies to be more target-oriented and need-based programmes depending on the need of the farming communities and the ecological environment. The Institute will be more focused on research and development issues, always updating the recent development both at national and international levels in the related fields. The NRC on mithun will serve as an exclusive solution centre for all kind of problems related to mithun husbandry in the world.

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NOTES

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