Vision 2050

National Research Centre on Mithun
Indian Council of Agricultural Research
Jharnapani, Medziphema, Nagaland - 797106

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शरद पवार
SHARAD PAWAR

कृषि एवं खाघ भसंस्करण उघोग मंत्री
ाारत सरकार

MINISTER OF
AGRICULTURE
& FOOD PROCESSING
INDUSTRIES
GOVERNMENT OF INDIA

Dated the 13th June, 2013

MESSAGE

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

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

I wish NRC Mithun all success in realisation of the Vision – 2050.

(SHARAD PAWAR)

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सचिव एवं महानिदेशक

Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL

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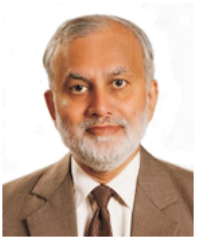

Foreword

The Indian Council of Agricultural Research, since inception in the year 1929, is spearheading science and technology led development in agriculture in the country. This is being accomplished through agricultural research, higher education and frontline extension undertaken by a network of research institutes, agricultural universities and Krishi Vigyan Kendras. Besides developing and disseminating new technologies, ICAR has also been developing competent human resources to address the present and future requirements of agriculture in the country. Committed and dedicated efforts of ICAR have led to appreciable enhancement in productivity and production of different crops and commodities, which has enabled the country to raise food production at a faster rate than the growth in demand. This has enabled the country to become self-sufficient in food and emerge as a net food exporter. However, agriculture is now facing several challenges that are expected to become even more diverse and stiffer. Natural resources (both physical and biological) are deteriorating and getting depleted; risks associated with climate change are rising, new forms of biotic and abiotic stress are emerging, production is becoming more energy intensive, and biosafety concerns are growing. Intellectual property rights and trade regulations impacting technology acquisition and transfer, declining preference for farm work, shrinking farm size and changes in dietary preferences are formidable challenges.

These challenges call for a paradigm shift in our research approach to harness the potential of modern science, innovations in technology generation and

delivery, and enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy efficiency, agri-incubators 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.

It is an opportune time that the formulation of "Vision-2050" by ICAR institutions coincides with the launch of the national 12th Five Year Plan. In this Plan period, the ICAR has proposed to take several new initiatives in research, education and frontline extension. These include creation of consortia research platforms in key areas, wherein besides the ICAR institutions, other science and development organizations would be participating; short term and focused research project through scheme of extramural grants; Agri-Innovation fund; Agri-incubation fund and Agri-tech Foresight Centres (ATFC) for research and technology generation. The innovative programme of the Council, 'Farmer FIRST' (Farmer's farm, Innovations, Resources, Science and Technology) will focus on enriching knowledge and integrating technologies in the farmer's conditions through enhanced farmer-scientist interface. The 'Student READY' (Rural Entrepreneurship and Awareness Development Yojana) and 'ARYA' (Attracting and Retaining Youth in Agriculture) are aimed to make agricultural education comprehensive for enhanced entrepreneurial skills of the agricultural graduates.

I am happy to note that the Vision-2050 document of National Research Centre on Mithun (NRCM), Jharnapani has been prepared, based on the assessment of present situation, trends in various factors and changes in operating environment around agriculture to visualise the agricultural scenario about 40 years hence and chalk out a demand-driven research agenda for science-led development of agriculture for food, nutrition, livelihood and environmental security, with a human touch.

I am sure that the 'Vision-2050' would be valuable in guiding our efforts in agricultural R&D to provide food and nutritional security to the billion plus population of the country for all times to come.

Dated the 30th May, 2013
New Delhi

(S. AYYAPPAN)

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Preface

Mithun *(Bos frontalis)*, a unique livestock species reared by the farmers of four different States of North-Eastern-hilly region viz., Arunachal Pradesh, Nagaland, Manipur and Mizoram. Mithun plays a important role in the socio-economic status of poor farmers, thereby contributing in overall economy of tribal people of mithun inhabited States. According to 2007 Census, there is 0.26 million of mithun population in our country and mithun population showed a declining trend in all the States except in Arunachal Pradesh. In the State of Mizoram, the population has been reduced to an alarmingly low level.

There is ample scope for improving the productive and reproductive status of this animal. Apart from knowing the facts about the rumen microbes and also to study the processing of meat, milk and hide, there are several challenges in the field of research in various aspects in mithun. The animals in the field are facing inbreeding, inter-species breeding with cattle and habitual destruction of habitat due to faulty cultivation and thereby threatening the existence of this animal.

The National Research Centre on Mithun being an institution exclusively dedicated to this species has a great role to play 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 this diverse ecological environment.

This institution has already prepared Vision 2030 to address the challenges that have already in place. The present document 2050 is prepared to articulate the challenges which will be encountered by mithun and mithun rearers due to fragile ecology in their traditional tract along with climate change scenario and to capitalize the opportunities for developing strategies through various appropriate technologies. This will help to prepare a road map by the Institute for sustainable growth and development.

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

I want to express my deep sense of gratitude and indebtedness to Dr. S. Ayyappan, Honourable Secy (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, Honourable 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. N. Haque and Dr. Sabyasachi Mukherjee who took all initiatives and pain to bring out this document. I also express my sincere thanks to all the Scientists working in this Institute for their inputs, suggestions and tireless efforts to prepare this valuable vision document.

01 June, 2013
Medziphema

(Chandan Rajkhowa)
Director

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Context

Mithun *(Bos frontalis)* being a socio-cultural emblem of mithun rearing States, viz., Arunachal Pradesh, Manipur, Mizoram and Nagaland, it 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 their 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 way 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 high 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. However, mithuns are having sufficient genetic variations in terms of their physical and productive genetic characters. It seems to be a unique animal in terms of vulnerability / resistance point of view against different diseases compared to that of cattle. This animal is also very much special in their feeding behaviour and maintaining themselves complete independent without material inputs from mithun rearers except salt in free range system. Considering the existing socio-ecological condition and above mentioned characters of this animal that make it a unique one with ample avenues for improvement in their productive characters, searching for specialty in disease resistance, reproductive traits, rumen microbes, and meat, milk and hide products, needs 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) as well as 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, climate change, etc 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 for sustainable growth and development of mithun and its rearers.

It is noteworthy to mention here that out of 25 areas qualified as Biodiversity Hotspot globally, the Northeastern region of India is one of them. 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 Northeastern region.

The normal annual rainfall ranges from 200-300 cm. The Northeastern region of India by virtue of receipt of heavy rainfall, falls in low-rainfall-variability category and it ranges from 8-15%. However of late, the 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, the naturally dominated tree species in mid-altitudes are encroached upon by another tree species Schema wallichii, climatic consequences of which needs to be thoroughly evaluated (Das et al., 2009). It indicates some changes in vegetation pattern which is a great cause of concern for mithun rearing in its natural habitat.

Studies on rainfall and temperature regimes of Northeastern region indicate that there is no significant trend in rainfall for the region as a whole i.e. rainfall is within increasing or decreasing appreciably for the region as a whole (Das and Goswami, 2003; Das 2004). However for a part of the region that the meteorologists of the country officially refer to as the " 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. The summer monsoon rainfall is found to be decreasing over this region significantly during the past century at an approximate rate of 11mm per decade (Das 2004, Mirza et al, 1998).

Analysis of long term temperature data for the region points to a distinctly rising trend in surface temperatures. The annual mean maximum temperature in the region is rising at a rate of $+0.11^{0}$C per decade. The annual mean temperature is also increasing at a rate of 0.04^{0}C per decade in the region (Das, 2004).

Extreme precipitation events (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 and jhum (shifting) cultivation with shorter duration may 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 besides many issues, 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 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 1998 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 could achieve a remarkable progress during the period 2000 to 2012 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, National Research Centre on Mithun 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 predict the body weight of Mithuns based on the morphological traits
- Developed the technique for age determination of mithun by dentition pattern
- Genetic polymorphism in CSN3 gene of Mithun was identified using PCR-RFLP technique. Phylogenetic tree was constructed with the Mithun kappa casein gene and homologous species.
- A PCR based technique was developed to select Mithuns for favourable genotypes of kappa casein which is suitable for cheese making. This will be useful for genetic improvement in terms of better cheese production.
- Developed superovulation and ETT protocol for 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 thirty fibre - degrading and two tannin - degrading bacteria from rumen of mithun using the technique of serial

dilutions and repeated tubing and characterized by isolating DNA and DNA fragments amplified by universal/specific primer for bacteria. The PCR product was also purified, sequenced and compared with NCBI Blast database.

- 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 associate 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 from hides and mithun milk 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 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.

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 thereby, 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 population of mithun in 1997 during 16th Livestock Census was 124, 17, 3 and 33 thousand (GoI, 1997) and in 2003 during 17th Livestock Census 192, 20, 2 and 40 thousand in Arunachal Pradesh, Manipur, Mizoram and Nagaland, respectively with an increase of 43.50% in population (GOI, 2003), 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 in animals reared in free range system is not available. However, the same in animals reared 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 from a mithun cow two calves are available in three years in semi-intensive condition that has to be targeted to be one calf in each year. This needs to increase the birth weight to 25 - 30 kg, average growth rate up to maturity 900 g/day and reduction of age at puberty to 25 months and age at first calving 34 months.

The challenges to achieve the target is to develop animals with high genetic worth for economically important traits, assured availability of feed in its natural habitat through propagation of fodder trees and supplementation of feeds during scarcity period

particularly winter season and development of integrated fertility enhancement protocol of mithun.

Genomics refers to the comprehensive study of genes and their function. 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 underlying the biological processes and the functional aspects of economic traits of animals. 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 animls. 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 the targets, at least 20% of mithun population by 2030 and 40% by 2050 will be replaced with genetically upgraded elite animals and population to be increased to 0.40 million by 2030

and 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 States. 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 have to be developed and sacrifice rate to be increased to 15% by 2030 and 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 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 in forests. 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 special 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 will 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 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 in many places 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

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

- To replace 20% of mithun population by 2030 and 40% by 2050 by genetically upgraded elite animals and increasing the population to 0.40 million by 2030 and 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.
- To make the mithun rearing system more remunerative through
  - value added designer milk and meat production with high functional attributes and leather production; and increasing sacrifice rate to 15% by 2030 and 20% by 2050 with appropriate turnover rate.
  - certification of existing free range mithun rearing system, for organic meat production with proper consideration of maintenance of biodiversity.
- To reduce the calf mortality to the level of 5% in the organized farms by 2050.
- To develop animals with higher disease resistance capacity against various diseases by 2045.
- To develop strategies for better management for improved productivity of mithun under climate change scenario.
- To develop animals through selection having capacity to tolerate higher abiotic stress.
- To develop rapid and cheap diagnostic kits for controlling diseases like FMD, Haemorrhagic Septisemia and other emerging diseases under climate change scenario.
- To develop open nucleus breeding hard for production of elite animals with farmers participatory approach.

- 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, production of meat is low in the State. 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 brought out by the 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 the 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 elevate heat loads of animals 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 rates 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 SHG groups 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.

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 Self-Help Groups (SHGs) are voluntarily opting for that the same. Besides mithun rearing it may be beneficial in the form increasing the forest cover, maintaining the biodiversity and sequestration of more carbon. The SHGs can have additional monetary benefit in the form 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 selection 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.

Goals / Targets

Sl No.	Goals / 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 25-35 kg and higher growth rate to maturity for 900gm/day will be developed and expected to replace 20% mithun population by 2030 ad 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.

6	Assessment of performanc e 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

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 integrated fertility enhancement protocol of mithun (IFEPM). Semen and embryo bank will be developed to support the programme.	Elite animals with reduced age at first puberty with 25 months and age at first calving 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
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 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 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.
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 socioeconomic 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				

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 threatened 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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