INDO-US KNOWLEDGE INITIATIVE ON AGRICULTURAL RESEARCH AND EDUCATION

DRAFT INDIAN PROPOSAL

DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI BHAVAN, NEW DELHI 110001
E-Mail: mrai.icar@nic.in
Phone: ++91-11-23382629/23386711
Fax: ++91-11-23384773

ACRONYMS

APEDA	**Agricultural & Processed Food Export Development Authority**
AAU, Anand	**Anand Agricultural University**
AAU, Jorhat	**Assam Agricultural University**
AGI	**Arizona Genomics Institute**
ANGRAU	**Achryan N.G.Ranga Agricultural University**
BAU	**Birsa Agricultural University**
BCKVV	**Bidhan Chandra Krishi Viswavidyalaya**
CAU	**Central Agricultural University**
CAZRI	**Central Arid Zone Research Institutes**
CCS HAU	**Chaudhary Charan Singh Haryana Agricultural University**
CIAE	**Central Institute of Agricultural Engineering**
CICR	**Central Institutes of Cotton Research**
CRIDA	**Central Research Institutes for Dry Land Agricultural**
CRRI	**Central Rice Research Institute**
CSAUA&T	**Chandra Shekar Azad University of Agriculture & Technology**
CSKHPKV	**Ch. Sarwan Kumar Krishi Vishvavidyalaya**
CSSRI	**Central Soil Salinity Research Institute**
DMR	**Directorate of Maize Research**
DRR	**Directorate of Rice Research**
DU	**Delhi University**
DWR	**Directorate of Wheat Research**
GBPUAT	**Govind Ballabh Pant University of Agriculture & Technology**
HRD	**Human Resource Development**
IARI	**Indian Agricultural Research Institute**
ICRISAT	**International Crop Research Institute for Semi Arid Tropics**
ICT	**Information Communication Technology**
IGKV	**Indira Gandhi Krishi Vishwavidyalaya**
IIHR	**Indian Institute of Horticulture Research**
IIM	**Indian Institute of Management**
IIPR	**Indian Institute of Pulse Research**
IISc	**Indian Institute of Science**
IIT	**Indian Institute of Technology**
IIVR	**Indian Institute of Vegetable Research**
IPCC	**Inter Governmental Panel on Climatic Change**
IVRI	**Indian Veterinary Research Institute**
JNKVV	**Jawarharlal Nehru Krishi Viswavidyalaya**
KAU	**Kerala Agricultural University**
MAFSU	**Maharashtra Animal Science & Fishery University**
MAU	**Marathwada Agricultural University**
MPKV	**Mahatma Phule Krishi Vidyapeeth**
MPUAT	**Maharana Pratap University of Agriculture & Technology**
NAARM	**National Academy of Agricultural Research Management**
NBAGR	**National Bureau of Animal Genetic Resources**
NBAIM	**National Bureu of Agriculturally Important Microorganism**
NCIPM	**National Center for Integrated Pest Management**
NDDB	**National Dairy Development Board**
NDRI	**National Dairy Research Institute**
NIANP	**National Institute of Animal Nutrition and Physiology**

NSF	**National Science Foundation**
OUAT	**Orissa University of Agriculture & Technology**
PAU	**Punjab Agricultural University**
PDKV	**Panjabrao Deshmukh Krishi Vidyapeeth**
PDP	**Project Directorate Poultry**
RAU, Bikaner	**Rajasthan Agricultural University**
SAU	**State Agricultural University**
SKNAU	**Sardarkrushinagar Dantiwada Agricultural University**
TIGR	**The Genomics Research Institute**
TNVASU	**Tamil Nadu Veterinary & Animal Sciences University**
UAS, Bangalore	**University of Agricultural Sciences**
UAS, Dharwar	**University of Agricultural Sciences, Dharwar**
USDA	**United States Department of Agriculture**
WBUA&FS	**West Bengal University of Animal & Fishery Science**

CONTENTS

BACKGROUND

India-US Knowledge Initiative on Agricultural Research and Education

The contribution of US Land Grant Universities during 1960s in transforming India's National Agricultural Research and Education System has been well recognized as it helped in ushering the Green Revolution in the country. The process of technology led agricultural growth continued in the subsequent decades that enabled India to move from white, yellow and blue revolutions, thus lending a reasonable degree of self-reliance in food security.

The global agricultural scenario has been witnessing a sea change since the last two decades. An entirely new set of problems, such as global warming, new pest-disease complex, resource depletion and degradation, household nutritional security, slow growing farm profitability, and increased competition have arisen. These offer exciting challenges and also opportunities that require development and application of new knowledge and frontier technologies in agriculture that are cost and time effective. In order to ensure sustainability and profitability of agriculture a major paradigm shift is called for in HRD, research, technology generation and dissemination. .

In this endeavour the conventional research approaches need to be supplemented by the cutting edge technologies requiring multi-disciplinary and multi-institutional inputs. USA and India being leaders in different fields of science and technology, there is a tremendous scope to complement each others' capabilities by forging strategic alliance in key areas.

Based on a consideration mechanism among ICAR senior officers, select VC of SAU, Directors of National Institutes, Representations of APEDA, Private organizations and other stake holders, educational and research areas were identified for possible coverage under India-US Knowledge Initiative on Agricultural Research and Education.

A. Agricultural Education

Title: Educational Methodology and Modernization of Course Curricula for Enhancing Relevance and Utility of Teaching and Learning

a. Background

India, since independence, followed a path of science led growth of its agriculture. Agricultural education was placed in the forefront of this strategy. A comprehensive educational system has been evolved for building human resource that could undertake location and situation specific research and transfer its results to improve productivity, profitability and stability of agriculture. Not only the educational system was patterned on the Land Grants Colleges of the USA, but faculty was also trained in the US universities through a joint Indo-US programme. This initial critical mass of faculty played a key role in further preparing technically qualified human resource that set the direction and course of events leading to happening of Green Revolution.

With euphoria of Green Revolution waning due to falling productivity of principal food crops, India looks to resurgence of its declining agricultural base. Referred commonly as the occurrence of a second Green Revolution, emphasis is being placed on approaches that move from: (i) piecemeal to holistic solutions, (ii) commodity to production systems, (ii) applied to basic and strategic research, (iii) mono-disciplinary to interdisciplinary research, (iv) single institution to cross organization and trans country working and (v) home-based to consumer and market-driven agriculture. In order to meet these contemporary and futuristic challenges, a new breed of technically qualified human resource is needed. An appropriate agricultural education portfolio supportive of this requirement needs to be reengineered. Then new look agricultural education should also link with various stakeholders either depending on agriculture as a means of livelihood or pursuing economic activities dependent on agriculture. In wake of GATS, quality of agricultural education has to develop for global competitiveness and universal acceptance of the degrees awarded by the Indian agricultural universities. In pursuance of these endeavors, the first requirement would be to develop a class of highly motivated and competent faculty that in turn can churn out top quality professionals relevant and useful to sustainable development of agriculture in all its aspects – academic, economic, social and environmental. Launch of trans country joint degree programmes can also breed students reaching the level of international standards. Faculty alone will not be adequate until teaching methodologies and course curricula are modernized. Keeping these imperatives to make agricultural education better in front, the joint programme will pursue the following objectives:

b. Objectives

1. To develop processes and procedures of educational methodology and modernization of course curricula and its delivery.
2. To build faculty competence in the emerging areas of agricultural science and technology.
3. To maximize educational technology output through faculty exchange programmes.
4. To enrich the country's higher agricultural education output through joint degree programmes.

c. Concept

Agricultural education in India needs to be globally competitive and its products are internationally acceptable as a mark of academic excellence. This calls for enhancing importance and usefulness of agricultural education in terms of: (i) employability of the graduates, (ii) supporting country's developmental goals and (iii) improving environmental quality.

A critical mass of faculty in pre-identified subject domains of academic, economic and environment is required to be developed. This select faculty in turn would serve as the agent for further change and improvement. Simultaneously, efforts will be institutes to modernize course curricula and methods of delivery i.e., moving from teaching to learning. Need is, therefore, felt to bring about substantial improvement in the tools and techniques of imparting education in that teacher and taught are more interactive and learning is for up-skilling in real life situations. Affectivity of dual mode delivery of education and learning (conventional classroom and open and distance mode) would be explored and emphasized.

d. Expected Outcome

An efficient, effective and relevant system of teaching and learning in the area of higher agricultural education.

e. Probable List of Participating Institutions

Probable Indian and US Institutes : NAARM, Hyderabad; All Agricultural Universities, Utah State University, Penninsylvania State University, Mississippi State University, Illinois State University, Michigan State University, Texas A&M University, Colorado State University, Kansas State University, Cornell State University, Ohio State University

B. Natural Resource Management

B1 Adapting Agriculture and Allied Sectors to Global Climatic Change

a. Background

Global climatic change due to increased human activities is a major environmental change with significant potential implications for food security. Due to increased fossil fuel combustion and deforestation, CO_2 levels have increased to 370 ppm today and will further increase to 388-399 ppm by 2010-2015 and to 463-623 ppm by 2050/2060. The global mean annual temperature at the end of the 20th century was almost 0.7 ºC above those recorded at the end of the 19th century. The 1990s was, on an average, the warmest decade of the earth since instrumental measurement of temperature started in 1860s. The ten warmest years globally in the instrumental record have occurred after 1990s. The Inter-Governmental Panel on Climatic Change (IPCC) of the United Nations has projected that the globally averaged temperature of the air above the earth's surface would rise by 1.4-5.8ºC over the next 100 years. There is also a greater consensus now that in future climatic variability will increase leading to more frequent extremes of weather in the form of uncertain onsets of monsoon, and frequency and stages of droughts and floods.

Alarmed by the possible adverse impacts that the global environmental changes might have on the quality of life of human beings, there has been a serious concern all over the world in understanding the vulnerability of various regions and in developing and/or adapting strategies to mitigate the negative effects. These changes are expected to considerably affect the food supply through their direct and indirect effects on crops, livestock and pests, and on rural livelihoods. The vulnerability to environmental changes is expected to be much more severe in Africa and south Asian countries including India than other developing regions due to their large population, predominance in agriculture and relatively limited adaptive capacity.

Alleviating poverty and attaining food security at the sub-regional level represent major challenges to us in this century. Producing enough food for the increasing population against the background of reducing resources in adverse environmental change scenarios, while minimizing further environmental degradation, will be a challenging task. The solution to such environmental issues is closely tied to the solution of socio-economic problems. It is important to develop strategies for ensuring food security and quantify trade-offs of adaptation to global climatic change with socio-economic development.

b. Objectives

i. To quantify the vulnerability of food crops, livestock and fish to current and future climatic risks

ii. To establish early warning system for climatic risk predictions, understanding its consequences, and real-time dissemination of possible management strategies to different stakeholders

iii. To enhance our capacity to develop and use decision support systems based on dynamic simulation models and other systems research tools for quantifying the vulnerability of agricultural systems to real-time climatic risks

iv. To conduct joint research on development of high temperature tolerant varieties of cereals, natural resource management policies, modelling of vulnerabilities, carbon sequestration and increasing water productivity.

v. To examine strategies to reduce methane emissions from rice paddies and livestock

c. Conceptual Framework

For the first objective we aim to develop through this collaboration large-scale, field-based research facilities for assessing the direct impacts of increased CO_2 and emperature (e.g. FACE and FATE technologies) for crops, and similar facilities for livestock and fish. Experience for this exists in USDA, Phoenix and elsewhere. Wherever possible innovation for simultaneously studying variability in rainfall/humidity will also be considered.

For establishing early warning systems, it is conceptualized that there will be large number of automatic weather stations positioned at critical locations. The data from these together with historical databases, existing forecasting systems of climatic risks, remote sensing, international databases, and other knowledge base will be used to develop algorithms for occurrence of drought, floods, and heat waves. Expert systems will be developed for different categories of stakeholders for assessing the consequences of such climatic risks and the possible management strategies using literature review, consultancies, and simulation models.

For enhancing capacity to develop decision support systems, in country training course will be conducted. At the same time, students, and Visiting Scientist mode will also be used for this. Joint research activities will be done in the identified areas by mutual consultations on identified priorities.

d. Institutional Mechanism

The project will be operated through exchange of Visiting Scientists, Ph.D. fellowships; organisation of in country training courses, and joint research activities.

Probable Indian and US Institutes : IARI, New Delhi, CAZRI, CRIDA, CICR, UAS, Dharwar, PAU, OUAT US Massachusetts Institute of Technology, USDA at Arizona, Ohio State University, University of Florida, University of Minnesota, and Goddard Institute of Space Science, New York.

e. Expected Outcome

Better preparedness for managing increasing climatic risks through: assessment of risks to food security, identification of adaptation options, improved research infrastructure, possible strategies to reduce emissions of greenhouse gases, and policy support to the government for international negotiations

B2: Weather Based Forecasting of Pests and Diseases of Crops, Livestock and Fish

a. Background

Pests and diseases of agricultural commodities impact the economic value, quantity, and quality of food and fibre products. It is estimated that In India alone they cause an annual loss of rupees 300,000 million. Precise, quantitative estimates of yield loss due to various diseases are necessary for effective plant protection strategies. Warning of impeding pest attacks can be used by agriculturists to make timely decisions about the effective and economical application of fungicides and about other tactics to manage pests. Several models have been developed to quantify pest damage and its forecast. Most of these models are regression-based approaches, relating a measure of pest severity at a given stage to yield loss or pest loss/ population directly with some weather element. They ignore the dynamics of crop-pest interactions and also do not take in to consideration the physiological processes affected by the disease, and host-pest interactions. Their application is thus limited to the specific environmental conditions.

In recent times, crop-pest models have been developed by linking pest effects through damage mechanisms at the physiological level to dynamic simulation models. These simulation models can be used to understand the quantitative effects of the pest on the crop. The yield-infestation relations established through simulation model prove more stable and can be used for extrapolation and forecasting. In addition, a validated simulation model can also be used for various applications such as development of economic thresholds, rationalizing pesticide use and predictive pest zoning etc. Principles of aerobiology and agro-meteorology have been used together in recent times to track the spatial and temporal presence and movement of pests in different regions.

b. Objectives

i. To develop a database (including that of real-time monitoring) of critical pests presence and movement and relate this with weather elements

ii. To determine the spatial and temporal pathways of pathogens and insects using the principles of aerobiology and biometeorology

iii. To develop simulation models for forecasting pests by relating weather with pest population dynamics and host interactions.

iv. To develop simple decision support models based on above

c. Conceptual Framework

This collaboration is intended to do joint research on pests of common interests with a goal to provide forecasting support to farmers and other stakeholders by tracking the geographic presence and future spread of critical pests and diseases by relating weather to epidemic development. The work would involve developing a forecasting system using the principles of aerobiology and biometeorology to determine the spatial and temporal pathways of pathogens and insects, simple decision support models, and sophisticated simulation models. Generic pest population dynamics models will be developed based on threshold of development and thermal constants of different development stages of pests considering fecundity, sex ratio, biotic & abiotic mortality factors, migration and tolerance ranges for different physical factors.

d. Expected Outcome

Capacity to forecasts pests and disease epidemic and their prevention to avoid pest induced crop losses for enhanced productivity.

e. Institutional Mechanism

The project will be operated through exchange of Visiting Scientists, Ph.D. fellowships; organisation of in country training courses, and joint research activities.

Probable Indian and US Institutes: National Centre for Integrated Pest Management (NCIPM), New Delhi; Indian Agricultural Research Institute, New Delhi, Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, IGKVV, Raipur, AAU, Anand, UAS, Bangalore, North American Plant Disease Forecast Center at North Carolina State University, Cornell University

B3: Development of Bio-based Products

a. Background

The scarcity of fossil fuel and emphasis on sustainable industrial development will push for biofuels and chemicals derived thereof. Thus, the bio-based economy would be a key to the 21st century and new crops and new uses are central to the bio-based economy. Agriculture will be core to the bio-based economy, providing source materials for commodity items, e.g. liquid fuels and value-added products such as chemicals and materials. The public-good benefits that will accrue from the bio-based economy are compelling. They include economic advantages to farmers, industry, rural communities, and society, environmental benefits at all levels including sustainability.

The major commodity opportunity for the bio-based economy is in energy and, within the energy sector, liquid fuels. Two liquid fuels, ethanol and biodiesel are the most promising. Biodiesel contribution will be dependent on the availability of low-cost fats and oils. In long run ethanol could contribute upto 50+% of our fossil fuel consumption. Chemicals represent commodity to high-value products. The list of bio-based chemicals is long. Feedstocks and monomers include ethylene, lactate, β-OH-butyrate, 1,3-propane diol, and succinic acid. Examples of bio-based polymers include polylactate from corn starch. Other bio-based chemicals include industrial enzymes, acidulants, amino acids, vitamins, food conditioners, nutraceuticals, pharmaceuticals, and cosmeceuticals. Edible vaccines are in efficacy/safety testing for human and domesticated animal diseases. Oils and lubricants are another major area. Other products include cleaners, solvents, adhesives, industrial gums, and paints.

The initial biosources will be unused crop residues, waste and add-on uses for existing crops, e.g. starch and oil crops, and some relatively unexplored plants such as Jatropha. The intermediate-term sources will be easily domesticated native crops. In the longer term, there will be dedicated biosources for energy, chemicals, and materials. These dedicated biosources will be combinations of established, transgenic, and new polysaccharide, oil, fibre, and high-value chemical crops. Domestication of new crops is often very high risk, and can take a long time. Public-sector leadership will be necessary for domestication of new crops.

b. Objectives

i. To develop an efficient and economical process for conversion of agri-residues to ethanol using suitable microbes/enzymes

ii. To identify new crops/plants for bio-based economy and utilisation of crop produce, residues and grasses for conversion to useful chemicals for industry.

iii. To conduct environmental impact analysis of the land use designed to enhance recovery of bio-based products

c. Conceptual Framework

The following components are generally involved in bio-based economy and they will be the key elements of this project as well:

i. Modifying plants to produce desired chemicals with higher productivity and less inputs
ii. Developing profitable and sustainable land use systems around these crops.
iii. Development of more efficient harvesting, pre-processing, processing, value-addition, transportation and storage
iv. Economic processing of diverse raw materials
v. New chemistry and separation technology
vi. Material end use application technology

The collaboration will be mutually beneficial since Indian has rich experience in unexplored crop plants, large human resource, whereas there is considerable expertise in USA for chemical processes.

d. Institutional Mechanisms

This project will operate through exchange of Visiting Scientists, focused training courses in India, and establishment of research infrastructure and joint research activities.

Probable Indian and US Institutes: IARI, New Delhi, NBAIM, Mau; CIAE, Bhopal, CAZRI, Jodhpur, MPUA&T, GBPUA&T, CCS HAU, Hisar, RAU, Bikaner Michigan State University, University of California-Davis, Pittsburgh State University, Pacific Northwest National Laboratory, Richland, WA 99352, Purdue University, University of Florida, National Renewable Energy Laboratory, ANL, BC International, NTEC-Versol, Goodrich Corporation, SolviGen LLC, Vogelbusch U.S.A., Cold Spring Harbor Lab

e. Expected Outcome

Since it uses the carbon cycle, it is inherently sustainable whereas the fossil-based economy is inherently unsustainable. The bio-based economy will mitigate global climate change by the major greenhouse gas, CO2. There will be reduced local, regional, and global environmental pollution. Most “bio-based” crops will be perennial with low inputs, will be harvested annually, will produce minimum environmental impact and is wildlife friendly, and will not be grown on prime food-producing crop land.

B4: Recycling Waste Water and Solid Wastes in Agriculture

a. Background

Agriculture today accounts for more than 80 percent of the water use in India. The requirement of irrigation water for agriculture may increase in future due to higher demand for food, and uncertainties associated with expected disturbances in hydrological cycle, in turn, affecting crop production in irrigated as well as rainfed areas. By contrast, we can expect in future a scenario of reduced water supply for agriculture due to the effects of global climatic changes on hydrological cycle, increasing competition from industry/urban areas, and currently declining trends of groundwater tables at many places. Production of increased quantity of food with decreasing availability of quality irrigation water would, therefore, be a big challenge for the agricultural community.

Increasing industrialization and urbanization is leading to the generation of untreated wastewater, which is often disposed-off as such in rivers, canals, and lakes causing pollution of water bodies and associated health problems. Agricultural utilization of wastewaters offers a low cost alternative. Similarly, solid wastes generated from urban areas can be composted and utilized in agriculture. This will ensure safe disposal of pollutants as well as reduce costs in agriculture. In doing so the manurial and irrigational potential of various types of wastewaters which invariably have a considerable economic value in context of present energy and nutrient crisis and lately felt need for water conservation need to be primarily considered. However, it is equally important that potential toxicants present in the wastewater are identified. Such waters are rich in salts and heavy metals. Repeated application of these waters in agricultural soils may cause heavy metal toxicity and build up of salinity. Irrigation with untreated wastewater may cause intestinal infections in crop consumers and field workers particularly with hookworms.

b. Objectives

Quantification of the extent of poor quality waters and solid wastes available in different regions and their current use practices.

i. Assessment of short-term and long-term impacts of poor quality water applications on agriculture land in terms of pollutant dynamics, ground water pollution, salinization, microbial dynamics

ii. Defining the safe, critical and dangerous threshold limits for various heavy metals and other pollutants in different soil types, irrigation water, and food systems

iii. Developing suitable bioremediation practices for the various pollutants

iv. Developing practices and guidelines, which will minimise contamination of soil, ground water and environment due to continuous use of sewage and industrial waters for agricultural use.

c. Conceptual Framework

This project will involve surveys, chemical and biological characterisation of the available waste waters and solid wastes. Efforts will be made to utilise modern tools such as remote sensing for spatial and temporal characterisation. Laboratory and field studies will be conducted to determine the critical limits. Long-term impact studies will be done by designing suitable field experiments. Simulation models will also be developed to quantify short and long-term impacts in different regions.

d. Expected Outputs

Guidelines and strategies for safe use of poor quality waters and solid wastes in agriculture; pollution control in expanding urban areas, exploitation of the manurial potential of urban wastes

e. Institutional mechanism

This project will operate through exchange of Visiting Scientists, focused training courses in India, and establishment of research infrastructure and joint research activities.

Probable Indian and US Institutes: CSSRI, Karnal, IARI New Delhi, GBPUAT, Pantnagar, ANGRAU, Hyderabad, BCKVV, Mohanpur, CSAUA&T, Kanpur, Ohio State University, University of California, Davis; Texas A and M

B5: Mitigation of Methanogenesis in Ruminants by Novel Feeding Practices like Herbs

a. Background

India had 282.1 million cattle and buffaloes besides large population of goats, sheep and other ruminants (excluding young stock less than three months of age) in 1994 which are being maintained mainly on crop residues and as per an estimate these animals emitted 10 Tg methane per annum as a result of enteric fermentation. The increase in livestock population is expected to increase the methane emission. Keeping in view the role of methane in global warming as green house gas, efforts have to be made to reduce the methane emission from livestock by employing novel feeding practices.

b. Objectives

Dietary incorporation of the herbs for reducing the methane emission and improving the productivity of cattle and buffaloes

c. Conceptual Framework

Certain herbs containing secondary metabolites such as saponins, tannins etc. which not only improve the productivity of animals following their inclusion in the diet at low level but reduce methane emission.

d. Institutional Mechanism

Probable Indian and US Institutes: NDRI. Karnal, IVRI, NIANP, NDDB, CSK HPKV, Palampur, TNVASU, Chennai, School of Environment North Dakota USA, Utah State University, Logan, Utah

e. Expected Outcome

Increase in the productivity of farm animals and reduction of the global warming

B6: Power Generation through Gasification of Crop Residues

a. Background

It is estimated that about 125 MT / year of surplus biomass from agriculture, forestry and plantation having a power generation potential of 12,500 MW is available in the country. Besides, 3,500 MW potential is available through co-generation of bagasse in 500 sugar mills. Apart from combustion, technologies for gasification, fast pyrolysis, alcoholic fermentation and anaerobic digestion of biomass are now either available or being developed to derive gaseous and liquid fuels from biomass.

b. Objectives

Development of crop residue based gasifiers for power generation [100 - 250 kWe] in rural production catchments.

c. Conceptual Framework

Biomass gasifier based decentralized power plants appear most promising for rural sector in near future. Multi-fuel gasification systems which may use free flowing agro-processing residues, like groundnut shells, have been developed for thermal applications under the All India Coordinated Research Project on Renewable Energy Sources. The gasifier designs needs to be developed for capacity of 100 / 150 / 200 / 250 kWe capacity. Low cost, technically sound gas cleaning systems will have to be developed for IC engine operation.

d. Institutional Mechanism

The programme will be implemented through training of scientists from the lead centre as well as participating institutions in India by sending them to leading US Universities, exchange of faculty, medium term visits of US scientists to India for conducting training programmes and development of laboratories. The programme will also entail joint research projects to be undertaken.

Probable Indian and US Institutes: CIAE, Bhopal, IIM, Ahmedabad, MPUA&T, Udaipur, SKNAU, Dantiwada, University of Florida, Gainesville; Stanford University, Institute of Gas Technology, Illinois , National Renewable Energy Laboratory, Colorado & University of California, Davis.

e. Expected Outcome

Technology for gasification of crop residues for power generation in rural areas.

C. Biotechnology

C1: Genomics of Grain Legumes, Oilseeds, Animals and Fishes

a. Background

Recent advances in the area of genomics have provided us with means to understand the structure and function of large number of genes that constitute the genomes of higher plant and animals. Advances have been made in applications emerging out of these tools in precision breeding of plant and animals. There are several recalcitrant problems in agriculture which can be tackled using information and technologies generated through genomics that will make the agricultural science more rewarding and economically viable. The genomics research has already made an impact in the fields of human medicine and nutraceuticals, and more recently it has led to the discovery of several genes of agronomic importance in rice e.g. earliness, grain number, dwarf ness, disease resistance and so on. There is a compelling need to develop partnerships among established laboratories and critical work sites in US and India for making agriculture a scientific, predictable and remunerative industry.

b. Objectives

i Infrastructure and capacity building for comprehensive research on genomics
ii Structural genomics of pigeon pea
iii Functional genomics in the identified crops, animals and fish, Chick pea (plant type, drought, Ascochyta blight, pod borer, quality)
  Pigeon pea (plant type, excessive moisture, pod borer, sterility, quality)
  Ground nut (Drought, Aflotoxin)
  Rapeseed Mustard (Alterneria blight, drought, salinity)
  Cotton (Leaf curl virus)
  Cattle/BufalowLivestock genomics (production and resistance traits)
  Genomics of probiotic organisms
  Functional genomics in Rohu fish

c. Conceptual Framework

The genomics research has already made an impact in the fields of human medicine and nutraceuticals, and more recently has led to discovery of several genes of agronomic importance in rice. There is compelling need to develop genomic tools to address the production constraints in grain legumes and oilseeds, particularly in India. The potential of Genomics for improving legume and oilseed production has already been recognized and significant investment has been made in US and Europe. The NSF, USA has provided over $11 million for genomics research in soybean and *Medicago truncatula*. The institutional capabilities, expertise, tools and technologies expected to develope through the proposed Indo-US collaborative research will help discover new genes and mine the biodiversity that is available in our germplasm collections for better versions of these genes. This will help breed superior varieties of grain legumes and oilseeds for increased production and quality of these crops.

d. Institutional Mechanism

Probable Indian and US Institutes: Indian Agricultural Research Institute, New Delhi, Indian Veterinary Research Institute, Bareili, National Dairy Research Institute, Karnal, Indian Institute of Pulse Research, Kanpur, MAU, Parbhani, CCS HAU, Hisar, PAU. Ludhiana, AAU, Anand, University of Agricultural Sciences , Dharwad, TNVASU, Chennai, ICRISAT, The Genomics Research institute (TIGR), Maryland, Arizoana Genomics Institute (AGI), Arizona, University of Minnessota, University of California, Davis, Cornell University, New York, SR Noble Foundation, Texas A & M, Texas

e. Expected Outcome

i. Establishment of an internationally accreditable genomics infrastructure in India to cater to genome sequencing needs of crops, animals, fishes and microbes.
ii. Complete sequence of the pigeonpea genome with gene annotation
iii. Cloned genes for the listed agronomic traits in grain legumes and oilseeds.
iv. Genes for nutraceutical and pharmaceutical compound
v. Gene mapping of indigenous probiotics dairy cultures

C 2: Host-Pathogen Interaction- Genetics and Molecular Signaling

a. Background

The pathogens interact with the host systems on the basis of molecular signal exchanges that determine the ability of the pathogen in infecting, establishing and causing damage to the host tissue. The genes and their products involved are crucial factors that determine the type of host-pathogen interaction. In addition, the pathogens produce **toxins** and the host plants produce chemical defenses to protect themselves against all sorts of pests and stress, such as in plants, **phytoanticipins** (constitutive) and **phytoalexins** (inducible). Probing the interactive mechanisms will enable in breeding of host plants and animals for durable resistance on one hand and discovery novel genes and molecules having herbicidal and fungicidal activities.

b. Objectives

i. To understand the host-pathogen molecular signaling during infectivity and spread in:
   - Leaf blights (spot and blotch) disease complex in wheat
   - Fusarium wilts in pulses (pea, chick pea and pigeon pea)
   - Mosaic complex in soybean, urd and mung bean
   - Ascochyta blight in chickpea
   - Fusarium head blight in wheat and barley
   - Molecular identification of high risk food pathogens like *Listeria monocytogenes, E. coli O157:H7*
   - Cellular and Molecular studies on Prions in farm animals
   - Immunogenetics for histocompatibility complex for diseases resistance and susceptibility in farm animals

ii. Application of the information generated in strategies for breeding

c. Conceptual Framework

The host pathogen interaction inducing protein products and other biomolecules involved indirectly will be the factors to be analysed in the selected plant and animal species. This requires indepth analysis of the infection process to be characterized and studied under simulated conditions to monitor the expression and related changes in the expressing regions in the genomes of the pathogen and the host. It would be possible to also decifer the differential regulation that distinguishes the resistant and susceptible host challenged by the same pathogen. This is expected to provide leads that can assist in enabling selection or synthesis of such host genotypes carrying the genetic sequence that either minimize or limit the completion of the interaction between the host and pathogen which results in the expression of tolerance or resistance to the diseases.

d . Expected Outcome

Signaling pathway elucidating the successful infectivity across the host systems
Designing specific ESTs or SNPs for genotyping sources of resistance
Varieties/ breeds/ genotypes with resistance to the listed diseases

Characterization of emerging pathogens and their virulence expression mechanisms
Greater understanding of disease resistance

d. Institutional Mechanism

Probable Indian and US Institutes: IARI, New Delhi (Lead Centre); IIPR, Kanpur, ; ANGRAU, Hyderabad ; PDKV, Akola ; DWR, Karnal ; ICRISAT ; IIHR, Bangalore ; DU, Delhi, NDRI, Karnal ; IVRI, Izatnagar ; TNVASU, Chennai, Kansas State University, Kansas, University of Minnesota, Purdue University, North Carolina State University, University of Wisconsin, University of Georgia.

C 3 : Molecular Breeding for Stress Tolerance (water, salinity, heat stress) in Crops and Diseases in Animals using Biodiversity

a. Background

Durable resistance or tolerance to stresses in crops and animals is known to be provided by quantitatively inherited genes or multiple genes due to the complexity of the mechanism of tolerance or resistance. These genomic regions known as quantitative trait loci are detectable through molecular polymorphism based tagging of the loci which possess genes that contribute to the tolerance or resistance to a large extent out of the available variability in the whole genome. These QTLs when identified enable the breeding for these traits to be done with a precision that is not possible through environment labile selection for the desirable phenotype. The identification of QTLs and their tagging is most effective when the experiments are carried out under varying environments. A collaborative approach involving environments backed with molecular technology infrastructure would be essential for successful achievement of the objectives.

b. Objectives

i. QTL mapping and identification of markers for yield related traits, salinity, drought and heat tolerance in crops
i. Allele mining using the sequence data from above in the germplasm and wild relatives of the crops and animals for utilization of biodiversity
ii. Use of the markers in mobilizing the QTLs for the listed traits
iii. Identification of markers linked to economic traits of farm animals
iv. Identification of markers linked to mastitis, brucellosis and bovine tuberculosis

c. Conceptual Framework

Emphasis will be placed on two most important grain legumes *viz.* pigeonpea and chickpea and two most important oilseed crops *viz.* groundnut and mustard for India. The knowledge generated on Genomics of these crops will be applied to improve tolerance to abiotic and biotic stresses including various diseases and pests, and to enhance the nutritional quality. Among the environmental stress factors, drought affects crop productivity most severely. The grain legumes in India are mostly grown under rain-fed conditions and so is the case with the oils seed crops. It is imperative therefore to develop genotypes which can withstand harsh environmental conditions to further improve the productivity vis-a-vis production. The plant types of these crops have hardly changed over the years despite continuous breeding efforts. It is necessary to increase the harvest index and introduce synchronized fruiting in these crops. The proposed major areas comprise objectives that can complementarily worked upon at identified institutions in the two countries according the expertise, material and functional feasibility. The traits and the genes are of importance for farming communities in both the countries, consequently generating information and valuable material.

d. Institutional Mechanism

Probable Indian and US Institutes: RRI, Cuttack; DRR, Hyderabad, IARI, New Delhi, DWR, Karnal; PAU, Ludhiana; HAU, Hissar; RAU, Pusa; UAS, Dharwad; UAS, Bangalore, IIVR, Varanasi; DMR, New Delhi; ANGRAU, Hyderabad; NDRI & NBAGR, Karnal; IVRI, Izatnagar; TNVASU, Chennai, University of California, Davis, University of Colorado, Fort Collins, University of Florida, Cornell University , Texas A & M

d. Expected Outcome

Focused improvement of the crops for tolerance to abiotic stress.
Molecular maps linked to gene/genes for yield related traits, tolerance to the stress
Common donors effective under different ecologies (relevant to India)
Advanced lines for yield testing and/or genetic stocks packaged with molecular markers linked to the identified genes for MAS
Markers tagged for MAS in livestock

C4: Marker-free and Site-targeted Integration of Transgenes in Crop Plants and Livestocks

a. Background

India has now started harnessing the benefits of transgenic crops for improved yield, quality and better economic returns to the farmers. In view of this, it is important to ensure the safety of the environment, animals and human beings. The need is to be armed with appropriate technologies to monitor and detect any possible expression of the assessed risk at the time of releasing the transgenic in a given environment. The areas of vertical and horizontal spread of the transgene and related impact of the escape in terms of populations in a given ecology need to be evaluated to ensure safety against long-term effects on the ecology on which no data are available. A collaboration in the area at least on those crops which are of mutual interest like the cotton and rice need to be established to take benefit of this frontier technology for the economic well being of the farmers.

The need for site targeted integration and marker free development of transgenic crop plants will enable minimization of the risks involved while the transgenic is in cultivation. The possibility of site targeted integration has been explored in mice and it is therefore a potential researchable area on plants. The markers used in selection of the trangenes during the development of transgenics have come to face criticism from both ecologists and health activists with implied risks to both environment and human beings. If a perfected technology is developed in both these areas, there would be good amount of risks minimized while the material is released in an environment. Any lead from such a strategy could also be of immense value for providing insights into this globally important aspect of the transgenics.

b. Objectives

i. Development of protocols and methods for reliable marker free transformation
ii. Development of protocols and methods for site-targeted integration of transgenes in crops
iii. Development of protocols and methods for site-targeted integration of transgenes in animals

c. Conceptual Framework

It is possible to breed out the antibiotic and herbicide tolerance selectable markers from the transgenic plants provided if care is taken during production of transgenics by using co transformation with separate DNA molecules that will integrate at different positions in the genome. The targeted integration can be achieved by homologous recombination for which there are preliminary reports but the methodology needs to be refined for routine application.

d. Institutional Mechanism

Probable Indian and US Institutes: Collaborating Institutions: NDRI, IVRI, IARI, GBPUA&T, Pantnagar, CCS HAU, Hisar,
New Initiative,

e. Expected Outcome

A protocol for the biosafe transgenics with predictable gene expression

C5: Identification for Nutrient Use Efficient Genotypes from Germplasm and Allele Mining of Identified Genes in the Wild Relatives of Major Crops

a. Background

The nutrient composition of soils in the intensive cropping areas of Indo-Gangetic plains are showing signs of significant imbalance due to indiscriminate use of chemical fertilizers and exhaustive mining of micronutrients from the field by the crops without proper replacements. A micronutrient deficiency has now become a key factor limiting crops production in these areas. The crops now show significant response to the micronutrient application.

b. Objectives

i. Identification of genotypes for efficient usage of micronutrients like Iron, Boron, Zinc and macro nutrient usage like Nitrogen, Phosphorus

ii Allele mining for genes with efficient micronutrient utilizations

iii. Identification of micronutrient toxicity tolerant (Fe, Al, Cu) genotypes

c. Conceptual Framework

Crop genotypes do possess significant variability in their capacity to utilize the micronutrients that may present in the soil but are not easily available. The wild relatives of the cultivated crops are likely to be rich source of genes for micronutrient utilization as they thrive in the deficient soils without much nutritional supplements.

d. Institutional Mechanism

Probable Indian and US Institutes: UAS, Dharwad, OUA&T, Bhubaneshwar, BSKKV, Dapoli, MPKV, Rahuri, RAU, Bikaner

e. Expected outcome

Identification of genotypes with efficient nutrient utilization.

D. Livestock and Poultry

D1: Livestock and Poultry: Areas of Priority Research

a. Background

The livestock productivity in India does not match with the strong 400 million population. This is primarily due to infectious and metabolic diseases, poor nutrition and their genetic make-up. Besides direct production losses, the prevalence of infectious diseases of animals and poultry precludes India's entry into the lucrative international market of dairy, meat and poultry products. Many diseases are endemic in the country. Ineffective or non-availability of sensitive diagnostics and vaccines are the major impediments in disease control and/or eradication. To tackle these disease problems; a multi-pronged approach such as employing advanced immuno-pathological and biotechnological interventions to develop newer generation diagnostics (including pen-side tests for use at farmers' door and more sensitive and high throughput assays like microarray-based diagnostics) and vaccines on one hand, and improving feed efficiency and producing disease-resistant/tolerant animals and poultry on other hand seem logistically plausible and sustainable strategies in Indian context. The ruminants in India mainly sustain on lignocellulosic crop residues, which are poorly utilized in the rumen. Improvement in their nutritive values by manipulation of rumen microbial eco-system appears to be a promising practical solution. Selective inhibition of methanogenic *Archaea* helps in improving the feed conversion efficiency and in the protection of environment against green house effect gases like methane and nitrous oxide. The newer cutting edge scientific approaches like genomics, proteomics and stem cell research have great potential. Buffalo is the major contributor to Indian livestock economy and needs special attention mainly in the areas of structural genomics and stem cell research.

b. Objectives

Elucidation of mechanisms of molecular pathogenesis of infectious diseases (brucellosis, tuberculosis, parartuberculosis, salmonellosis, blue tongue, classical swine fever, rabies, infectious bursal disease, avian influenza, chicken infectious anemia for their control

c. Conceptual Framework

i. The molecular pathogenesis of mycobacterial infections (JD & TB) is poorly understood. The currently available diagnostics have poor sensitivity and specificity, and effective vaccines are not available. Macrophage–pathogen interaction with regard to up-and down regulation of genes for survival/resistance against the organisms, novel specific peptide based diagnostics for subclinical diagnosis and new generation vaccine especially augmenting Th1 cell immunity against paratuberculosis and tuberculosis are the researchable areas for collaboration. Molecular differentiation of organisms of

M.tuberculosis complex will be another area of joint efforts as tuberculosis is a worldwide problem.

ii. Salmonellosis: Development of deletion mutant vaccine using signature tagged mutagenesis against important salmonella infections.

iii. Brucellosis is a problem in India for which the conventional diagnostics and vaccine have been found ineffective. Development of recombinant antigen based diagnostics and DNA/marker vaccine (DIVa) for differentiation between infected and vaccinated animals are the most challenging areas where both countries can collaborate for control and eradication of brucellosis.

   a. Blue tongue (BT): Development of Mab-based sandwich ELISA for group/genus specific detection of BTV.
   b. Development of recombinant protein based competitive ELISA for detection of BTV antibodies.
   c. Development of Mab &/or nucleic acid based diagnostic tests for serotype specific diagnosis of BT and development of multivalent live or killed vaccine.

iv. Classical swine fever (CSF): Development of DIVa vaccine and companion diagnostic test (Mab-or recombinant protein based ELISA).

v. Rabies: DNA vaccine and antiviral therapy using RNA interference.

vi. Infectious bursal disease: Understanding mechanism of immune suppression in relation to vaccination of immune complex harbouring birds, gene vaccines using bicistronic messenger vector coding immunogenic genes (VP1 & VP2) and cytkine (chicken gamma interferon), understanding the molecular pathogenesis (virus-host interaction) of virulent, very virulent and variant isolates of IBD.

vii. Avian influenza: Development of diagnostic test and marker vaccine (DIVa) for our preparedness to meet the challenge if disease comes to India.

viii. Chicken infectious anaemia: Development of diagnostics and vaccine using VP1 and VP2 genes, use of VP3 genes for apoptosis for cancer therapy.

ix. Development of improved delivery of drugs/vaccine using liposomes, esceriosomes and nanoparticle based delivery systems.

d. Institutional Mechanisms

Probable Indian and US Institutes: IVRI, TANUVAS, Chennai; Indian Institute of Science, Bangalore; CCA HAU, Hisar, IIT, UAS, Bangalore, PDP, Hyderabad, JNKVV, Jabalpur, BAU, Ranchi, Iowa State University; University of Minnesota; University of Wisconsin; Cornell University; USDA-ARS-NADC Plum Island Animal Disease Center; Auburn State University; Ohio State University; National Center for Infectious Diseases, CDC, Atlanta; University of Maryland; University of Illinois; Washington State University; NIH, Bethesda.

e. Expected Outcome

Understanding the disease process, management and control of diseases using new generation diagnostics, vaccines and therapeutics that would significantly reduce the economic losses due to infectious diseases augmenting the productivity of livestock and poultry. DNA/ marker vaccines are useful in monitoring national surveillance programme for any disease listed above.

D2: Genetic Resistance of Host Against Infectious Diseases

a. Background

The occurrence of disease due to infectious agents is a complex phenomenon and various strategies like use of pharmaceutical compounds, improved management practices and use of newer generation of vaccines have been employed to control it in livestock and poultry. Although these efforts have significantly reduced the incidences of several infectious diseases yet these measures are expensive as well as less sustainable due to ever-increasing awareness of drug residues in livestock products. Besides many species have developed microbial resistance, which has limited the benefits of vaccination. Therefore, there is a strong need to develop an alternative strategy that should be based on integrated disease control systems as well as be sustainable. India offers a large and diversified genetic resources, many of which are known to be resistant to some of the infectious diseases. However, not much is known about genetic mechanism of host-pathogen interaction in these animals. Integrated studies in these directions and subsequent application of host genomics can be an important component in such programs which will not only be economical in the long run but also remain sustainable.

b. Objectives

i. To delineate molecular mechanism of genetic resistance/ susceptibility of indigenous livestock and poultry against infectious diseases.

ii. To identify molecular markers for genetic resistance/ susceptibility to different infectious diseases.

c. Conceptual Framework

It is known, since long, that host-resistance/ susceptibility to different infectious diseases is under genetic control, and as such there is a vast potential of host-genomics in reducing the impact of these diseases. However, the first step of any such endeavor would be to understand the underlying molecular-mechanisms that determine resistance/ susceptibility to a given pathogen. A second step will be to identify molecular markers for resistance/ susceptibility to infectious diseases. Considering the fact that there is no single gene that could confer resistance against all the diseases, independent study should be conducted for diseases that have similar pathogenesis using both candidate gene as well as linkage strategy. Finally, improvement of host-resistance will lead to less reliance on antibiotics and vaccines and will result in an improvement of animal well-being and reduction of disease associated stress towards increased productivity.

d. Institutional Mechanisms

Probable Indian and US Institutes: IVRI, Izatnagar, Collaborating Centers: TANUVAS, Chennai; NDRI, Karnal, NBAGR, Karnal, CARI, Izatnagar, PAU, Ludhiana, MAFSU, Nagpur, University of Texas (A&M), University of Wisconsin, USDA-ARS, Beltsville, University of California; San Fransisco; University of Illinois; University of California, Washington State University.

e. Expected Outcome

i. Establishment of an internationally-accreditable genomics infrastructure in India to cater to needs of genomic sequencing and mapping of livestock species including buffalo.
ii. Identification of genes important to disease resistance.
iii. Mapping of loci that encode genes, which are important to disease resistance/ susceptibility.
iv. Isolation and use of protein products encoded by the host genes responsible for the inhibition of multiplication of organisms.

D3: Development of Embryonic Stem Cell Lines in Farm Animals to Use it as Transgenic Vehicle and Cloning

a. Background

Derivation of Embryonic stem cells in farm animals has major goals like (1) to clone larger numbers of animals from founder embryos; and (2) to introduce precise genetic modifications into the genome of livestock species via gene targeting. The ES cells might be easier to reprogramme than somatic cells and prove extremely valuable for animal cloning. In this light under the proposed programme efforts will be made to first establish, characterize and propagate the stem cell lines from the cells of early differentiated preimplantation embryos from farm animal species. Simultaneous effort to work out an alternative cloning strategy for large scale cloning and a gene targeting strategy for transgenesis using pleoripotent blastomere derived stem cells would naturally fulfill the ultimate purpose of establishing an embryonic stem cell line in farm animals. NDRI has already taken lead in terms of initial studies on stem cell establishment and nuclear transfer studies.

b. Objectives

i. To establish, characterize and propagate the stem cell lines established from the farm animal species.

ii. To work out alternative cloning and gene targeting strategy for transgenesis.

c. Conceptual Framework

Early precompaction preimplantation embryos (16 cell to morulla) produced by IVF will constitute the starting material for blastomere isolation and stem cell generation. To optimize the functional normalcy of IVF produced embryos and their developmental competence a battery of developmentally important genes will be evaluated for their expression profile and transcriptional modification pattern and genomic imprinting status under the given in vitro condition. Although a feeder layer based system is most commonly being used for maintaining the cells at undifferentiated state an alternative strategy of LIF based in vitro culture system will be experimented. Selected embryos produced by reconstitution of blastocysts will be re-cloned to potentially generate more embryos. Unfortunately, to date, re-cloning has resulted in progressively lower efficiencies with each round of NT using both blastomeres and somatic cell donor nuclei. So, in this context the researchable issues would be to qualify the phenomenon of pre-activation of cytoplasm, which limits the reprogramming potential. Re-cloning will become even more useful once reliable assays are available to screen for a set of molecular ‘reprogramming markers’ in biopsies from cloned embryos. The colonies obtained for the first instance will be re-passaged again under either the feeder cell environment or under more chemically defined medium. The nuclear transfer protocols will be optimized using enucleated oocytes after synchronization. Development rate of reconstituted embryos using cultured blastomere stem cells will be assessed by progression of growth and stage specific gene expression based makers.

d. Institutional Mechanisms

Probable Indian and US Institutes: NDRI, Indian Veterinary Research Instititure, Izatnagar, The National Centre for Biological Sciences (NCBS), Bangalore, Indian Institute of Reproduction, Mumbai, TANUVAS, Chennai, CCS HAU, Hisar, WBUA&FS, Kolkata, University of Pennsylvania, Utah State University, USDA, Beltsville, Madison, University of New Orleans

e. Expected Outcome

An embryonic stem cell derived embryo cloning strategy will ultimately be more useful than somatic cloning for agricultural applications. These strategies may provide a substantial one-off genetic lift of 15 times the annual genetic gain from conventional breeding schemes. A small numbers of genetically superior animals could also be created for natural breeding. This would involve cloned sires of progeny-tested males used for transmission of their elite genetics following natural mating or, alternatively, increased semen production for artificial insemination (AI). ES cell based cloning could be useful in multiplying outstanding F1 crossbred animals, to maximize the benefits of both heterosis and greater uniformity within the clonal family. Establishment of ES cells could also be used to counter loss of biodiversity, and has been integrated into the conservation of rare breeds.

D4: To manipulate Rumen Microbial Ecosystem for Enhancing Release of Energy from Lignocellulosic Crop Residues by use of Biotechnological Techniques

a. Background

The Indian livestock mainly thrives upon lignocellulosic agricultural by-products and its bioconversion in the rumen is an essential pre-requisite for utilization of nutrients of these by-products by the animals. There is no report until now indicating the involvement of any enzyme of animal origin in the hydrolysis of lignocellulosic polysaccharides. Therefore, the animals have to depend upon the microorganisms for the bioconversion of these feeds into such forms (like volatile fatty acids) as are utilizable by the animals. Hence the rumen microbial ecosystem, a very complex consortium of different types of microorganisms, plays an important role in the digestion of lignocellulosic feed and availability of nutrients to the animals. The extent to which the nutrients can be extracted from the lignocellulosic feeds depends upon the efficiency of microbial eco-system. In the recent experiments conducted at Microbiology Section, Animal Nutrition Division, Indian Veterinary Research Institute, Izatnagar have indicated that rumen microbes (fungi and bacteria) isolated from the faeces/ rumen liquor of wild ruminants and some of the superior strains isolated from buffalo are better equipped to degrade lignocellulosic feeds. When these elite strains from wild or some domestic ruminants were inoculated in the rumen of buffalo, the utilization of various nutrients is significantly improved. Therefore, it is essential to study the rumen microbial dynamics quantitatively and qualitatively in relation to different types of feeds in different species of animals.

b. Objectives

i. 1.To study the microbial diversity of domestic animals by using molecular biotechnological techniques.
ii. 2.To select of elite group of microbes with desired characteristics. Maintenance and proliferation of selected elite microbes in laboratory conditions to be used as direct fed microbials.
iii. To create a nitch in the rumen for the newly introduced microbes so that they can be established in the rumen to express their biological activity.

c. Conceptual Framework

The rumen microbial eco-system represents all the three domains of life (prokarya, eukarya and archaea). A large number of bacteria present in the rumen are non-culturable as the number of total viable bacteria on a particular medium is much lower than the microscopic count of bacteria. Therefore, whatever information is available on the culturable bacteria of the rumen is incomplete. The classification of rumen bacteria based on phenotypic characteristics and biochemical tests is not sufficient to study the diversity among the culturable organisms. Therefore to understand the complexity and interactions of rumen bacteria involved in lignocellulosic degradation, work on microbial diversity of animals using latest molecular biological techniques is needed to achieve the goal of rumen manipulation to enhance the utilization of poor quality lignocellulosic feeds by the livestock.

d. Institutional Mechanism

The scientists of the Rumen Microbiology section of Animal Nutrition Division, IVRI have expertise on rumen microbes. The scientists of the laboratory are working on rumen microbes its isolation, characterization and quantification using RT-PCR and other related techniques. The work will be done in collaboration with other institute of ICAR and the US laboratories listed below working in same area.

Collaborating Institutes

Probable Indian and US Institutes: IVRI, Collaborating Centres: NDRI, Karnal, NIANP, Bangalore; TANUVAS, Chennai; CARI, Izatnagar, MAFS&U, Nagpur, GBPUA&T, Pantangar, University of Wisconsin, University of California; University of Illinois

e. Expected Outcome

The productive potential of the livestock thriving on poor quality lignocellulosic feed can be improved by improving the utlization of nutrient by the introduction of elite microbial cultures in the rumen.

D5: Development of Crop Residue and Bypass Nutrient Based Technology to Reduce Methane Production and to Increase Milk Production from Bovines

a. Background

In India, there is a severe shortage of proteinous feeds as well as energy rich feeds. The major feeds available are crop residues, which are not only inferior in quality in terms of palatability, digestibility and nutrient supply, but also possess a negative attribute of producing methane gas in rumen, which on emission to the environment causes green house effect. Recently, block making of straws is emerging as a favourable technology for meeting the protein and energy requirement of high yielding animals as supplements in the block using bypass nutrients. Their supplementation in the straw based complete feed blocks, can also reduce the amount of methane produced in the rumen, than when straw is fed alone.

Straw based complete feed blocks produced commercially, have the potential to become popular among farmers, not only as a ready made feed, but nutritious enough to meet the requirement of at least medium producing animals, while simultaneously reducing the methane production from ruminants, as farmers will be left with little choice but to feed concentrate along with straws.

b. Objectives

Increasing the productivity of dairy animals along with the reduction in methane production using newer feed technologies

c. Conceptual Framework

By and large the feeds fed to ruminants in India, which are mostly straw based are such shat it is difficult to meet the protein and energy requirement of medium and high yielding animals. Fortification of straw based block with nutritious supplements including bypass proteins, bypass fat, legume hay, mineral mixture and some feed additives makes it a complete feed for ruminants, aimed at increasing their productivity. Bypass nutrients technology can be called as the passive rumen manipulation, in which, the protein and energy supplements remain inert in rumen i.e. these nutrients bypass rumen fermentation and are passed on to the lower tract, where these are digested and absorbed.

Thus, the Complete Feed Block Technology with bypass nutrients appears to be a good solution to the multiple problems associated with feeding of bovines in India. It is a sort of complete package to the farmer to feed dairy animals, especially in areas where green fodder is hardly available.

d. Institutional Mechanisms

Probable Indian and US Institutes: NDRI, Collaborating Indian Institutes/ Universities, Farm Engineering Division of IARI, New Delhi, PAR Division of IGFRI, Jhansi (UP), CCS HAU, Hissar, PAU, Ludhiana, ANGRAU, Hyderabad, WBUA&FS, Kolkata, Dr. B. Harris, Jr., Extension dairy specialist, Dairy Science Dept. Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611. USA, Dr. D. L. Palmquist, The Ohio State University, Wooster, OH 44591, USA, Dr. T. C. Jenkins
Dept. of Animal & Veterinary Sciences, Clemens, SC 29634, USA

e. Expected Outcome

Straw based feed block technology is certainly a future technology for most of the tropical countries, where there is an acute shortage of green fodder and sufficient of cereal crop residues. The technology has the potential to increase the productivity from ruminants and at the same time to bring about some reduction in methane production from these animals. In India, the technology has already been initiated and the successful completion of the proposed project, using modifications and supplementations with rich nutrients can make it a still better technology.

E. Value-addition, Quality Assurance and Safety of Agri and Food Products

E1: Food Safety and Quality

a. Background

In the wake of liberalized trade under WTO, the quality and safety standards have become more stringent. In fact these will be increasingly used by the countries to promote their own export and restrict the imports. Further, there has been increasing consciousness of consumers about what they eat and are prepared to pay for high quality at competitive rates. There are concerns about food borne diseases, residue levels, microbial levels of raw and processed produce. India apart from its huge internal market should enter the world market especially the US market but that would entail developing quality detection equipment, kits as well as software for analysis to ensure that our products are absolutely safe and of high quality.

b. Objectives

i. Development of instruments, rapid detection kits and software for quality assurance and safety
ii. Risk assessment, management and communication encompassing pathogens, environmental pollutants and residues
iii. Application of the existing and development of new codes and standards for food safety and quality

d. Conceptual Framework

Quality and safety aspects have assumed great importance in view of the WTO agreement requiring strict adherence to the norms in order to remain competitive. Although, the work on developing and implementing quality and safety standards through development of equipment and diagnostic kits have been initiated, much more work has to be done to cope up with the emerging competition. Apart from the global ramifications, the increasing purchasing power of the domestic consumer has raised the quality and safety consciousness considerably.

d. Institutional Mechanism

The programme will be implemented through training of scientists from the lead centre as well as participating institutions in India by sending them to leading US Universities, exchange of faculty, medium term visits of US scientists to India for conducting training programmes and development of laboratories.

Probable Indian and US Institutes: CIPHET, Ludhiana, Other participating institutions: NDRI, Karnal; CIFT, Cochin; IVRI, Bareilly; TNAU, Coimbatore; YSPUH&F, Solan; IIT, Kharagpur; NIN, Hyderabad, MPUA&T, Udaipur, MAU, Parbhani, University of California, University of Minnesota, University of Wisconsin, Cornell University, Iowa State University, USFDA

e. Expected Outcome

i. State of art instruments, kits and software for assured quality and safety of food.
ii. Risk assessment and management algorithms for prediction of food borne diseases, food poisoning outbreaks, allergens, pathogens, residue levels and traceability.
iii. Human resource development on food quality and safety.

E2 : Processing, Product Development and Packaging

a. Background

The need for higher levels of processing and value addition of raw produce from plant and livestock-fish sources has been highlighted due to its potential for increasing income and employment opportunities in production catchments and also giving a boost for food processing industries for secondary and tertiary processing. This will help in increasing our food trade. Although efforts are on but tremendous amount of R&D, development and transfer of technologies for economic scale processing and value addition which will ensure top quality produce at competitive price and reasonable shelf life to consumers in India and world is required involving all stakeholders.

b. Objectives

i. Development of innovative products including traditional, functional, health, GM foods and natural food colourants
ii. Utilization of by-products from processing industries for food, feed and industrial purposes
iii. Mechanized processing and packaging of indigenous products including pulses, fruits and vegetables, dairy, medicinal and aromatic plant products and natural fibres

c. Conceptual Framework

Low levels of processing and value addition have to be lifted to considerable extent in order to increase profitability of agriculture, creating employment in the production catchments, fighting the gluts of perishable produce and offering year round high quality processed food at competitive price for domestic and also global consumption. The appropriate packaging of raw and processed produce has also become very important for not only attracting the consumers but also keeping them safe from ingress of moisture, heat, pests and microorganism.

d. Institutional Mechanism

The programme will be implemented through training of scientists from the lead centre as well as participating institutions in India by sending them to leading US Universities, exchange of faculty, medium term visits of US scientists to India for conducting training programmes and development of laboratories. The programme will also entail joint research projects to be undertaken.

Probable Indian and US Institutes: CIPHET, Ludhiana, Other participating institutions: NDRI, Karnal; CIFT, Cochin; CIRCOT,Mumbai; NIRJAFT, Kolkata; UAS, Bangalore, GBPUA&T, Pantnagar; TNAU, Coimbatore; IIP, Mumbai, CCS HAU, Hisar, KAU, Trichur, University of California, University of Minnesota, University of Wisconsin, Cornell University, Ohio State University, Michigan State University, Uniersity of Washington, Seattle, Auburn University, University of Tennessee, Knoxville

e. Expected Outcome:

i. Processes, equipment, and pilot plants for commercial exploitation and manufacturing of high quality innovative food and fibre products.
ii. Natural food colourants from plant and microbial sources.
iii. Cost effective utilization of processing waste and by-products.

E3 : Loss-free harvest and storage

a. Background

In India, there has been tremendous increase in the agricultural production. But on the other hand, there are huge losses during harvest and post-production stages which need to be reduced. Further, the good production practices play a very important role in ensuring high quality raw material and combined with picking/harvesting at right time with right tools/practices, the losses could be minimized. Besides loss free storage, there is a strong need to ensure safe storage of produce which require development of cost effective preservation methods/devices and storage environment.

b. Objectives

i. Development and promotion of good agricultural practices including precision farming
ii. Safe harvesting at appropriate stage, transport and handling for ensuring high quality raw produce
iii. To develop and promote preservation technologies for enhancing shelf life of processed produce using thermal and non-thermal approaches
iv. Modified and controlled atmosphere storage for perishable commodities

c. Conceptual Framework

There are huge losses due to absence of good agricultural practices and inadequate indices for optimum stage of harvest, tools and equipment for harvesting, transport, handling and storage. ICAR is involved in developing technologies for safe harvest handling and storage of agri-horti produce. This offers a big potential for collaboration with some of US Universities, which have been engaged in R&D in these areas. The losses in the US are very low and sometimes negligible. In order to gain on the lost time, a concerted effort on loss assessment and prevention at different stages by developing/adopting cost, time and energy saving technologies has to be put in place.

d. Institutional Mechanism

The programme will be implemented through training of scientists from the lead centre as well as participating institutions in India by sending them to leading US Universities, exchange of faculty, medium term visits of US scientists to India for conducting training programmes and development of laboratories. The programme will also entail joint research projects to be undertaken.

Probable Indian and US Institutes: CIPHET, Ludhiana, Other participating institutions: CIAE, Bhopal, PAU, Ludhiana, IIHR, Bangalore, GBPUA&T, Pantnagar, KAU, Trichur, Cornell University, University of Florida, University of California, Davis; University of Illinois; Texas A&M University

e. Expected Outcome:

i. Good agricultural practices for production of high quality raw material.
ii. Safe, damage free harvest, transport and handling practices and devices
iii. Maintenance of high quality during storage

E4 : Enhancing Biosecurity Capabilities for Diagnostics, Risk Assessment and Risk Mitigation of India in relation to International Standards of Phytosanitation

a. Background

Exchange of agricultural commodities/ planting material carries the risk of introducing harmful organisms/ unwanted transgenes into any country. The development of international standards on phytosanitary measures under the Agreement on Sanitary and Phytosanitary (SPS) Measures has promoted international trade. The pest risk analysis (PRA)/ detection capabilities of transgenes provides science-based reasoning for the implementation of measures that are technically justified and are not just based on protectionist barrier to trade. The combination of these analysis/ activities often leads to a trade decisions during exchange of agricultural commodities.

b. Objectives:

i. Capacity building for detection and identification of pests/ transgenes, risk assessment methodology as per the international standards including development of disinfestations protocols through research.

ii. Generating data through research on biology of pest/ vector/ host and interpreting them through modelling to support accurate assessment of risk involved.

d. Conceptual Framework:

The PRA is a resource demanding exercise particularly in instances where the available scientific and technical information is insufficient to reach a sound decision on the exchange of commodities.

Exchange of information on aspects like biology of pests (which can accompany the exchanged commodity), economic losses due the pest concerned in the country, distribution areas, detection techniques/ race/ transgene identification protocols and phytosanitary measures is very important for safe trade. The analysis looks into the sequence of events under which pests can survive and establish in the importing country for which the data has to be generated through research.

India needs to upgrade its infrastructure and expertise on diagnosis on variability in pests, transgene detection in bulk consignments, climate modeling and disinfestations techniques in collaboration with US, which is leading the world in these areas.

Activities:

Evaluation of risk through qualitative and quantitative procedures requires data on following aspects

(a) Pest information : pest identity, pest distribution, host range

(b) Likelihood of entry and establishment: distribution and host range of pest, availability of vectors, survival during transit and under existing pest management practices, detection at the port of entry and phytosanitary measures available for eradication of the pest

(c) Likelihood of spread after establishment: reproductive patterns, dispersal mechanisms, natural factors for dispersal (wind, water etc.), potential rate of spread, presence of natural barriers.

(d) Economic and environmental consequences of introduction of new pest species, management options and costs

(e) Detection of transgenes in bulk imports of plants/ planting material

Methodologies:

- Detection/ identification of pests/ vectors with special reference to biotypes/ strains/ races through molecular techniques, conventional identification through reference collections and digitized keys

- Probability of spread and establishment potential of pests and vectors using climate models

- Risk management through fumigation, thermal treatments, controlled atmospheres and combinations thereof for developing disinfestations protocols for commodities of mutual interest with special focus of research on alternative chemicals to methyl bromide

- Developing serological/ molecular kits for detection of transgenes in bulk lots

d. Institutional Mechanism:

Probable Indian and US Institutes: National Bureau of Plant Genetic Resources, New Delhi and Hyderabad, National Research Centre on Weeds, Jabalpur, Regional Plant Quarantine Station, Chennai, ANGRAU, Hyderabad, NDRI, Karnal, Plant Epidemiology and Risk Assessment Laboratory (PERAL) Raleigh, North Carolina (Risk analysis), USDA, Beltsville, MD (Taxonomy), Department of Biological Science, Northern Arizona University, Flagstaff, Arizona State, USA (Taxonomy), National Museum of Natural History, Smithsonian Institute, Washington, USA (Taxonomy), University of Florida, Gainesville, FL 32611-0620 (Molecular techniques for identification, Fumigation, alternatives to Methyl Bromide), University of California, Davis/ Riverside, CA 93905 (Alternatives to Methyl Bromide, Taxonomy), Monsanto, Missorie, St Louis, USA (Detection of transgenes), Cornell University, Cornell, USA (Detection of transgenes), US-Pacific Basin Agricultural Research Centre, Hilo, Hawaii (Irradiation), University of Hawaii, Honolulu, HI 96822 (Irradiation, Detection)

e. Expected Outcome

Information gaps in conducting pest risk analysis (PRA) for reaching to a decision-based research findings on quarantine pests/ vectors/ transgenes and availability of appropriate pest mitigation protocols would facilitate smooth trade of agricultural commodities of mutual interest.

E5 : Enhancing Capabilities for Mapping of Endemic Pests/ Weeds including Invasive Alien Species, Establishment of Pest-free Areas as per International Regulations and Development of Database

a. Background

Under the WTO- Agreement on application of sanitary and phytosanitary (SPS) measures countries allow imports from regions that had been declared pest free and each country has the burden of developing and certifying procedures to declare its region(s) free from certain pests. To boost India's exports, establishment and recognition of pest free areas (PFAs), as per the international norms, has assumed great importance under the Agreement. The country is not considered as one unit for determining PFA and determination of such areas, within a country through extensive survey and surveillance is the key point here. Also, the Convention on Biological Diversity under its Article 8 (h) calls for action to be taken to protect the native biodiversity from the threats posed by the invasive alien species (IAS) to prevent introduction, control and eradicate IAS which threaten ecosystems, habitats or species.

b. Objectives

i. Methodology for establishment of pest-free areas as per international norms

ii. Distribution map of pests of quarantine significance and IAS of weeds using remote sensing techniques, etc. and development of models for preventive measures.

iii. Standardization of survey methodologies to certify freedom from pests.

e. Conceptual Framework

The identification of pest free areas (PFAs) as per international norms requires immediate attention for boosting our exports. To get a realistic picture of the country, extensive surveys and surveillance are a must for authentic mapping of endemic pests. Early detection of pests/ weeds require mapping of both new and existing infestations. Remotely sensed data and geographic information systems (GIS) are being used to classify and map land surface cover types based on the spectral reflectance characteristics of electromagnetic spectrum.

In this regard, USA is equipped with the requisite information on endemic pests and India could benefit from collaboration for developing a database on IAS and pests of quarantine significance.

Activities:

Short-listing of pests including weeds through mapping, standardization of GIS and remote sensing methodologies for identifying PFAs. To develop new models integrating the available quantitative knowledge for pest/ weed management.

Development of survey methodologies, monitoring systems and phytosanitary measures to maintain areas free from specific pests.

Development of a database of identified PFAs, IAS including prediction of spread of IAS based on mathematical models and past meteorological data of areas.

Methodologies:

Survey and surveillance for detection and monitoring for identification of PFAs. Mathematical models would be used to predict spread of IAS, design preventive measures and develop strategies for pest/ weed management.Development of survey methodologies, monitoring systems and phytosanitary measures for establishment and maintenance of certified PFAs. A database of identified PFAs for endemic pests and IAS.

d. Institutional Mechanism

Probable Indian and US Institutes: National Bureau of Plant Genetic Resources, New Delhi and Hyderabad, National Research Centre on Weeds, Jabalpur, Regional Plant Quarantine Station, Chennai, BCKVV, Mohanpur, AAU, Jorhat, CAU, Imphal, Depts. Botany/ Plant Pathology and IPPC (Integrated Plant Protection Center) Oregon State University, Corvallis Oregon, USA 97331-2907, Department of. Soil, Water, and Climate, Borlaug Hall, University of Minnesota, Upper Buford Circle, St Paul, MN 55108-6028, USA, ESRI Corporate HQ, 380, New York Street, Red lands, California, 92373-8100,USA, Natural Resources and Development Program, Division of Water, Environment and Forestry, Pretoria, South Africa. Corvallis, OR 97331-2915, USA, Natural Resources and Development Program, Division of Water, Environment and Forestry, Integrated Plant Protection Center, 2040 Cordley Hall, Oregon State University, Plant Epidemiology and Risk Analysis Laboratory (PERAL), 1017 Main Campus Drive, Suite 1550, Raleigh, North Carolina USA 27606-5202 (risk analysis), USDA, Beltsville, MD (Taxonomy), Department of Biological Science, Northern Arizona University, Flagstaff, Arizona State, USA (Taxonomy), National Museum of Natural History, Smithsonian Institute, Washington, USA (Taxonomy)

e. Expected Outcome

Identification of pest free areas to facilitate export as per international norms.

Development of national distribution map/ database of pests of quarantine significance and of invasive alien weed species to for targeting specific preventive measures.

F. Agri-business Strategies

F1: Evolving Agricultural Markets, Trade and Outlook

a. Background

Increased commercialization of agriculture, emergence of surpluses, shifts in demand pattern and pressure of global competition are asserting significant influence on agricultural markets. Public and private sector decision-makers now require more information on how markets operate and the implications of various reform options. In addition, reliable and timely information on the market outlook for Indian agricultural commodities is needed for efficient functioning of agricultural markets and trade. There is also a growing concern about WTO issues and their implication on Indian agriculture. The debate often lacks empirical and dispassionate analysis. There is an urgency to study evolving agricultural markets and emerging domestic and global trade scenario. Further, India does not have any institutional mechanism to present "Agriculture and Food Outlook" which is required for efficient marketing and for planning commodity management, inflation, and trade activities.

b. Objectives

i. To suggest policies to improve competitiveness in agricultural markets
ii. To analyse impact of developed and developing country policies on global prices.
iii. To develop capacity for preparing Agriculture and Food Outlook at national and regional level
iv To undertake studies on fish market structure, conduct and performance and trade

c. Conceptual Framework

The proposal aims at high quality analysis of agricultural markets and impact of reforms and global changes on domestic prices, producers and consumers. It is also intended to analyse impact of developed and developing country policies on global commodity prices. The study would attempt to present future scenario of production and trade in selected commodities. In particular it would focus on Supply, demand and policy analysis of oilseeds/oil, grains, sugar and cotton. The study would develop Agriculture and Food Outlook Model for India and to present half yearly outlook at country level and at state level. This would be done on the pattern of Outlook exercise undertaken by ERS/USDA and FAPRI, Iowa State University. Three researchers from NCAP and one each from collaborating Indian institutes would spend about three months in USA to work with ERS/USDA and FAPRI to acquire expertise in market analysis (tools like CGE) and in Agricultural Outlook. It is also proposed to have one expert each from USDA/ERS in NCAP for one month to deliver seminars/lectures on techniques for market analysis and outlook. The study on fish would anlyse tools for analysis of fish market and analyse prospects for improving fishery exports from India.

d. Institutional Mechanism

NCAP has initiated modest activities to understand nuances of agricultural market, market reforms, WTO and trade and to come out with "Ägriculture and Food Outlook". ERS/USDA has a very long experience in this direction and has strong team working on a variety of commodity markets, policy topics and Outlook for U.S. and global agriculture and Indian agriculture. FAPRI (Food and Policy Research Institute) at Iowa State University is another major organisation working in this area and also focusing on Indian agriculture. NCAP would undertake collaborative work ERS/USDA and FAPRI on topics related to liberalization of Indian commodity markets and trade, and to increase the exposure of our researchers to the programs, perspectives and tools employed by countries with more open, market-oriented agricultural economies. In the second stage this collaboration in India would be extended to regional/state level where some strength is available in the proposed area. This would include UAS Bangalore, TNAU, PAU, OUAT, HPKV. In fisheries, CIBA and CMFRI would participate from India and University of Memphis and Ag. Economics Research Center, Oregon State University are proposed to be the collaborating Institutes from USA.

e. Expected Outcome

The proposed collaboration would help understand functioning of domestic and global market for various agricultural commodities and their implications for future of Indian agriculture. Agriculture and Food Outlook at national and regional level would meet the long felt need of planners and private sector for planning commodity management, domestic and international trade and safeguarding against supply shocks and price risk. The study on fish would help in understanding analytics of fish markets.

F2: Commercialization and Impacts of Agricultural Biotechnology in India

a. Background

Yield losses to the tune of 50 percent or more are quite common in the years of severe stress, and the level is alarmingly high for a country expected to experience high population growth. These yield losses could be successfully controlled with the applications of modern molecular biology tools. In addition, plant improvement programs could be targeted to enhance product quality and value to meet market demand. While genetic engineering methods can help control yield losses and enhance product quality, micro propagation methods can help rapid multiplication of disease free planting material, particularly for horticultural crops. These advantages of agricultural biotechnology are well established, but spread of these technologies and their impacts are restricted by policy and regulatory measures. While IPR and bio-safety issues are more important for genetically engineered products, institutional issues are more important for tissue culture technologies. The proposed program aims address these issues.

b. Objectives

i. To assess the status of agricultural biotech research in India and changing roles of the public and private sectors.
ii. To assess the impacts of strengthened IPR regime on agricultural biotech industry in India.
iii. To assess policy and institutional constraints in commercialization of biotechnologies.
iv. To study technical and economic feasibility of bio-safety regulations in commercialization and use of biotechnologies.
v. To study socio-economic impacts of agricultural biotechnologies, especially on small holders.

c. Conceptual Framework

The study will survey biotech research organizations to assess the investments, research priorities and changing roles of the public and private sector. In the second phase, impacts of IPR regime on the biotech industry and institutional constraints in commercialization of technologies will be examined on research investments and technology transfers. Cost associated with compliance with IPR and bio-safety regulations will also be assessed. Finally, two case studies will be conducted to assess the institutional constraints in technology dissemination and their socio-economic impacts. The case study on cotton and one major pulse crop will focus on genetically engineered products, while on grape will focus on micro-propagation and other associated technologies.

A training program will be organized to strengthen the capacity in this area, and inputs from the case studies will be used. Primary responsibility of conducting the study will rest with the NCAP scientists. They will plan the study in consultation with the US experts during their visit to USA. They will also attend courses on science and technology policies, and other courses of interest. Scientists from the collaborating ICAR institutes and SAUs will work on the case studies during their visit to US. The US experts will help plan the study, provide input during the study, and help conduct a training course on research evaluation during their visit to India.

d. Institutional Mechanism

Probable Indian and US Institutes: National Centre for Agricultural Economics and Policy Research, SAUs/ICAR institutes to be identified later, USDA, University of Minnesota, University of California (D), IFPRI.

e. Expected Outcome

The study would help suggest suitable policy and institutional measures to use biotechnologies for sustainable and pro-poor agricultural development in the country. The suggestions on IPR and bio-safety issues will be useful in evolving scientifically sound and economically viable regulations for biotechnologies.

F3: Strengthening Information and Communication Technology (ICT) for Growth and Efficiency of Indian Agriculture

a. Background

Owing to new challenges and increased global competition in agriculture, the farmholders tend to venture in diversification, value addition, and integrated farm approaches with risk minimization. This increases their demand for acquiring diversified and up-to-date agricultural technical knowledge. But information inadequacy at the grass roots level constrains wider technology uptake and marketability of commodities in globally competitive markets. The use of Information and Communication Technology (ICT) has emerged as an important option for the farmers and stakeholders in National Agricultural Research System (NARS). ICT offers tremendous potentialities in information delivery and sharing. World Bank in its report launched on June 28, 2005 entitled “India and the Knowledge Economy: Leveraging Strengths and Opportunities” recommends that the government should promote the application and use of ICTs throughout the economy to raise productivity and growth. This view has been emphasized by National Knowledge Commission of India constituted on August 2, 2005 also. National Farmers Commission has suggested establishment of rural knowledge centers. In India, various public and private and NGOs organizations have initiated ICT-based initiatives but these are isolated efforts at a low level. India requires expertise support for evolving sound policy and strategy in deploying ICT in agriculture especially from countries like USA having considerable experience.

b. Objectives

i. To study the ICT enabled Agricultural knowledge management systems prevailing in USA and draw lessons for India
ii. To study the ongoing ICT initiatives in India and to identify community needs, challenges and opportunities in ICT applications
iii. To suggest policies and models for greater and efficient use of ICT in agriculture in India
iv. To develop capacity within NARS for deploying ICT enabled Agricultural Knowledge management systems at national and regional level.

c. Conceptual Framework

The proposal aims at evolving ICT Policy in Agriculture which comprise developing toolkit for Information needs analysis of communities, stakeholders’ analysis for building ICT based networking, prioritization and determining appropriateness of use of ICT in terms of target groups/regions/crops/sector, developing models for content/knowledge convergence and sharing, designing index for monitoring and evaluating ICT enabled agricultural knowledge system, ICT enabled vertical integration of value chain for export potential commodities, development of online platform which can serve as consortium of various stakeholders, pilot testing of village information centres which can help bottom up evolving of ICT models and interactive policy formulation.

Couple of US institutions, having high level expertise, have exhibited interest in ICT in Indian agriculture. These are DOT. ORG , Academy for Educational Development (AED), USA and USAID, Program in Science, Technology and Society, Massachusetts Institute of Technology, USA, Department of communication Cornell University, USA and University of Maryland. The researchers from India would visit Cornell and MIT/University of Maryland to undergo courses/training and to understand the ICT policies/ strategies and institutional aspects of ICT enabled Agricultural Knowledge management prevailing in USA. The collaborative researchers from Cornell and MIT/University of Maryland would visit India and have interactions with the different stakeholders at highest level in NARS and would undertake capacity building exercises for the Indian researchers in framing ICT policy for Indian Agriculture.

Online consortium of stakeholders in NARS would be developed. The NGO- MSSRF would help in evolving bottom up ICT policy for agriculture by testing though village knowledge centre.

d. Institutional Mechanism

Probable Indian and US Institutes: NCAP, Other Centres: TNAU, UAS Bangalore, APAU, PAU, NGO like MSSRF, CCS HAU, Hisar, MPUA&T, Udaipur, USAID, Cornell University (Cornell), Massachusetts Institute of Technology (MIT), University of Maryland.

e. Expected Outcome

ICT policy for Indian Agriculture

- Evolving toolkit for Information needs analysis of communities
- Stakeholders’ analysis for building ICT based networking
- Developing models for content development/ index for monitoring ICT enables agricultural knowledge system.
- Online platform which can serve as consortium of various stakeholders
- Pilot testing of village information centers which can help bottom up evolving of ICT models and interactive policy formulation.