



# Vision 2030



**Central Institute of Agricultural Engineering**  
Bhopal

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# Vision 2030

**Central Institute of Agricultural Engineering**  
Nabi Bagh, Berasia Road, Bhopal - 462 038  
Madhya Pradesh  
India

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डा. एस. अय्यप्पन

सचिव एवं महानिदेशक

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SECRETARY & DIRECTOR-GENERAL

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## FOREWORD

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

Engineering interventions in agriculture have become highly critical for reducing the cost of production and drudgery while improving the livelihood opportunities, income and environmental sustainability through appropriate mechanization, post-production technologies and energy management. Central Institute of Agricultural Engineering (CIAE), Bhopal needs to focus on R&D efforts in frontier areas of engineering applications in agriculture to enhance the competitiveness of Indian agriculture. Besides, the institute must effectively liaise with the industry to undertake joint programmes of mutual interest with a view to ensure mass multiplication of appropriate technologies having requisite quality. The institute with its modern infrastructure and expertise has the responsibility of developing appropriate human resource to address the agricultural engineering challenges of tomorrow.

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

8 July, 2011  
New Delhi

  
(S. AYYAPPAN)

# Preface

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Indian agriculture during the past six decades has gone through various stages of modernization. Production has increased manifold to sustain the increasing population through improved input supply system. High yielding varieties, fertilizers, agro-chemicals and irrigation were the forerunners in the input supply management system. Role of engineering interventions in Indian agriculture for further improvements in production, productivity, and profitability along with post harvest management, processing and value addition has been well recognized in the recent past. Farm mechanization is moving towards a level of maturity pushing the annual sales of machinery to over ₹ 50,000 crore. The efforts in mechanization have led to improvement in farm power availability with increased share of mechanical and electrical power. Today India is the largest tractor manufacturer in the world. Engineering interventions in the field of post harvest management, processing and value addition of produce in production catchments are being perceived to enhance farm income through reducing the loss of precious produce, adding value to the raw produce, and utilizing the byproducts.

Central Institute of Agricultural Engineering, Bhopal during the past three decades has come to be recognized as the pioneer research institute in the field of agricultural engineering. The institute has developed technologies for farm mechanization, post harvest management and value addition, efficient energy management in agriculture and harnessing the potential of natural resources. Improvement in profitability of agricultural enterprise along with reduced human and animal drudgery and gender specificity have been shown to be the much-needed incentive for farmers and farm workers of tomorrow. Recent

surveys have amply established the fact that low or no profitability of present day agriculture coupled with human drudgery and uncertainty are the reasons that are discouraging the younger generation to go for farming. Through engineering interventions, an increase of 15% in productivity and a reduction of 20% in cost of cultivation can be achieved. Currently interventions are limited to a few crops, farm operations and post harvest activities. There is an urgent need to extend them to various crops, cropping systems and agro-climatic zones in the country.

The Vision-2030 is an attempt to conceptualize the role that CIAE, Bhopal is prepared to play for the growth of Indian agriculture during the next two decades. It takes the ground realities, emerging challenges and recent developments in science and engineering into account so as to carve out its strategy and programmes. The institute seeks to develop and demonstrate appropriate technology for various farming situations incorporating modern tools and methods. Precision farming, conservation agriculture, mechanization of horticultural crops, developing techno-entrepreneurship, modern methods of manufacturing and food processing are proposed to be taken up. To address the issue of farm power availability, harnessing potential of agro-residue and renewable sources of energy are envisaged.

I would like to place on record my gratitude to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR for his inspiration and guidance in the formulation and preparation of this document. Dr. M. M. Pandey, DDG (Engg), Dr. NPS Sirohi, ADG(Engg) and Dr. KK Singh, ADG (PE) have been very kind in shaping and finalizing the document for which I am grateful to them. Dr. Gyanendra Singh, Ex-VC Mahatma Gandhi Chitrakoot Gramodaya Viswavidyalaya and Chairman, RAC of CIAE has kindly gone through the Vision document and has made valuable suggestions. The contributions of PD (APPD), PCs of AICRPs and Heads of Division are duly acknowledged. Dr. Nachiket Kotwaliwale, Pr. Scientist, Dr. K N Agrawal, Dr. KVR Rao, Dr. Sandip Gangil, Sr. Scientists and Shri K. Shankar deserve special appreciation for their efforts to bring out this document.

30 June, 2011  
Bhopal

  
**PITAM CHANDRA**  
Director CIAE

# Preamble

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Modernization of Indian agriculture began in mid sixties. The major emphasis during this period was to increase the application of inputs such as high yielding varieties, agro-chemicals and irrigation for agricultural development. Research efforts were made to generate technologies in the field of varietal development, soil and water management, improvement in fertilizer application, pesticides and modern methods of their application. These efforts led to higher agricultural production to meet gross demand of the country. However, the inclusivity could not be achieved, disparities remained and migration from farm to non-farm activities is continuing. The hardships, uncertainties, and low profitability are some of the reasons that, if not corrected, may lead to acute shortage of food, feed and fiber.

Lack of concern on post harvest management including processing and value addition have led to unacceptably high post harvest losses and absence of processing industries in production catchments. Agricultural residues and processing by-products have been environmental liabilities instead of being the raw materials for more valuable products and generation of wealth. It is, therefore, essential that Indian agricultural development is viewed with a different perspective where the inputs continue to be important but engineering interventions for efficient utilization of the inputs and post harvest processing lead to higher profitability in addition to environmental sustainability. It is in this context that technology led agricultural development in the country is envisaged. The experiences in the past two decades convincingly prove the impact of engineering interventions on making agriculture and other rural based industries competitive and profitable. The need is for up scaling the experiences and

taking this strategy for agriculture development to every nook and corner.

Agricultural engineering education, research and related industries at this turning point in Indian agriculture need a considerable course correction, up-gradation and spread to meet the needs of the country. The model of this technology led agricultural development is also expected to be relevant to the developing countries in the world. The Vision 2030 of the Central Institute of Agricultural Engineering, Bhopal is an effort towards developing a framework for achieving profitability and sustainability of Indian agriculture through engineering applications, which may have relevance to the developing world as well.

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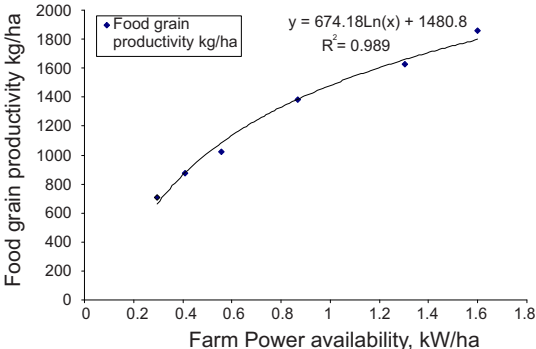
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# Engineering Inputs in Agriculture Sector

Engineering and technological inputs in agriculture have made significant contributions in increasing production and productivity through timely farm operations, accurate metering and better placement of inputs, conserving soil and water resources, increasing irrigation potential and efficiencies, reducing losses of produce by providing improved storage structures and technologies, and value addition. In future, Indian agriculture will face more challenges. It has to increase its production substantially from almost the same cultivated land to feed its growing population, reduce the cost of production, reduce losses, add value to the farm produce and maintain the quality of raw and processed products to a high standard to compete with foreign goods, both for the domestic and export markets. The biggest challenge is to make agriculture profitable. This will be possible only by reducing cost of cultivation through enhanced input use efficiency and by higher returns to the farmers through value addition in production catchments and adopting loss prevention measures.

Concerted agricultural mechanization efforts in India began after independence. Energy intensive operations like land development, irrigation, tillage, sowing, threshing and cleaning, harvesting, and transport were mechanized first. However, spread of farm mechanization has not been uniform throughout the country. It has not adequately penetrated particularly in East and North-East India, hills and mountain regions, and tribal areas and generally amongst marginal and small farms. Average farm



Relation of farm power availability and food grain productivity

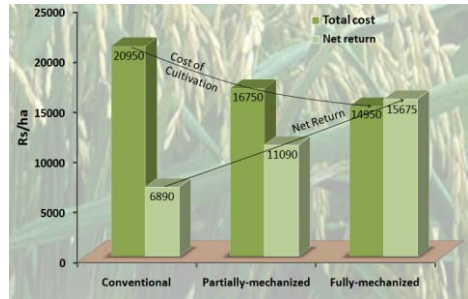
power availability is about 1.7 kW/ha. Total energy use in production of principal crops in India has increased 4-5 times between 1970 and 2005 during which average productivity increased from 837 to 1583 kg/ha and the average food grain productivity has now reached the level of about 2000 kg/ha.

Share of animal energy in agriculture has decreased significantly from 43.9% to 5.8% and that of human energy from 36.7% to 7.9%. Commercial energy use increased significantly - electrical energy from 0.19% to 38.1%, diesel from 2.4% to 18.3%, and chemical fertilizers from 16.4% to 29.7%. The demand for energy in agriculture, in future, will increase considerably with the shifting trend from use of animate sources of energy to electro-mechanical energy in agricultural production and increased on-farm and off-farm agro processing activities for value addition, better storage, packaging and transport. It would be necessary to adopt energy conservation practices and high capacity energy efficient equipment and processes for optimizing the energy intensiveness of the production and post-production operations. The huge amount of surplus biomass available as crop residue, growths from energy plantations, road side and waste land plantations and animal waste need to be processed and used to convert into solid, liquid and gaseous fuels for thermal application and to generate electricity to meet the energy requirements of agro-industries and rural areas.

Since its inception in 1976, the institute along with its associated AICRPs (having centers across the country) has led the development of improved farm implements and machinery. Indigenous R&D on farm implements and machines led to development and adaptation of vertical conveyor reapers, improved serrated sickles, power threshers, winnowers, rice transplanters, weeding and interculture equipment, power weeders, grain combines, laser land levellers, scrapers and graders, zero-till drill, raised-bed planter, vegetable trans-planters and diggers for some of the vegetable crops. Today farm mechanization industry has annual sales of more than ₹ 50000 crore.

The case of benefits derived from the use of zero-till drill, now covering more than 3 million ha, in terms of 40 l/ha diesel saving and about ₹ 3000/ha

reduction in the cost of cultivation has been well appreciated all over the country. Mechanized harvesting by combine harvesters is cost-effective to the extent of up to 36% over reaper-thresher combination (cost of harvesting and threshing, ₹ 2311/ha) and up to 67% over manual harvesting and threshing (cost of ₹ 4500/ha); besides ensuring timeliness with reduced losses to the late matured crops. Laser land leveling is another equipment getting popular for precise leveling of the field. Laser leveling of 2 million ha can save 1.5 million ha-m water, 200 million litres of diesel, improve crop yields amounting to ₹ 6750 crore and reduce GHG emission equivalent to 500 million kg.



Effect of level of mechanization on profitability of paddy cultivation

The drainage technology in vertisols in conjunction with appropriate mechanical weeding tools has made it possible to take a kharif crop of soybean on an additional area of about 2.5 million ha in Madhya Pradesh. Impact analysis of drainage technologies' adoption for soybean cultivation in temporary waterlogged vertisols of the country has indicated that the overall impact is in terms of additional soybean yield of about 3.0 million t/annum. Introduction of appropriate greenhouse technology in the country has permitted the export of flowers (about ₹ 400 crore annually), cultivation of off season vegetables, extension of growing season in cold deserts, and production of high quality planting material. A farmer's income from a 500 m<sup>2</sup> greenhouse would be several times more than that from the use of traditional growing practices. Establishment of mini dal mills in production catchments has enhanced rural incomes through value addition to the raw material and additional employment. There are a number of such specific and general experiences all over the country indicating that benefits through engineering interventions in agriculture are indeed high.

Small land holding pattern has a very complex set of challenges for mechanization. With the number of operational holdings increasing,

alternative sources of income will be needed to sustain farm distress. Research, development and management options need to be evolved to meet requirement of small landholders. Unlike other advanced countries, which have greatly reduced the human intervention in agriculture through mechanization, India would continue to depend on large labour force. The small farm mechanization, precision farming and post harvest technology will have to play a major role in future to increase production and productivity, to lower the cost of production and in generating more income and employment opportunities in rural areas. These developments must address the comfort and occupational health of farm workers. The need is to transform rural India from only producer of agricultural goods to producer-cum-primary processor.

Areas under Green Revolution are now facing second-generation problems of over exploitation of resources, higher input use leading to higher cost of cultivation and environmental degradation. These problems would need better management options such as conservation agriculture, efficient water management practices and site-specific application of inputs. The research and development challenges are to sustain production levels and manage available resources in cost-effective manner.

There has been a growing concern among various quarters on climate change and its effect on agriculture. Farmers would need adjustments in cropping patterns and management of resources including engineering inputs. The adaptation and mitigation research, capacity building and changes in policies will certainly need greater attention.

The Vision 2030 document of CIAE highlights the present and future challenges in Agricultural Engineering Research in terms of developing appropriate technologies for timeliness, precision, maximizing input utilization efficiencies, reducing losses, value addition and conserving energy and natural resources. It also lays greater emphasis on mechanization of hill agriculture, horticulture, value addition, nutritional security, greater use of renewable sources of energy, human comfort and safety and gender issues to reduce drudgery in farm operations and agro-processing.

# Central Institute of Agricultural Engineering

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The Central Institute of Agricultural Engineering (CIAE), Bhopal was established on 15<sup>th</sup> February, 1976 during the V Five Year Plan to develop and popularize technologies for mechanization of production and post-production agriculture using conventional and non-conventional energy sources. Subsequently, irrigation and drainage related activities were included. CIAE is now the premier institute in India devoted to Agricultural Engineering which helps in enhancing agricultural productivity by achieving timeliness in agricultural operations and proper placement of inputs; reducing drudgery of agricultural workers; efficient energy and water use, converting plant and animal wastes into different forms of energy, minimizing post-harvest losses, producing value added quality products and employment and income generation in the rural sector.

The Institute has a 93 ha (225 acres) farm with six open wells, eight tube wells and four farm ponds of total 23.5 ha-m capacity. All water resources have been connected through underground pipeline system to irrigate 40 ha area. CIAE has five buildings accommodating five Divisions, Krishi Vigyan Kendra (KVK), a research workshop, a Prototype Production Centre, an Agricultural Technology Information Centre and six laboratory sheds besides a model Agro-Processing Centre, Feed Processing Plant and a threshing floor. The Institute has a well-furnished Hostel and Guest House facility to accommodate 80 persons. Air-conditioned Conference Hall with 400 seating capacity, three Committee Rooms (seating capacity of 20 each), seven Lecture/ Seminar Halls with seating capacity of 40 to 60 each are located in different buildings. Residential quarters (153) are located on the campus and in the city. It also has a well-equipped dispensary. One IEP (Industrial Extension Project) Centre of the Institute is located at Coimbatore.

Various activities of the Institute are organized through five Divisions; four Centres; KVK, including one Industrial Extension Centre at Coimbatore and Coordinating Cells of four AICRPs.

<b>Laboratory Facilities at CIAE</b>	
<i>Discipline</i>	<i>Laboratory Facilities</i>
Agricultural Mechanization	Tillage and soil dynamics, Seeding and Planting, Plant Protection, Precision Farming, Ergonomics, Animal Energy, Material Testing, Computer Aided Design Cell, Research Workshop
Agro Produce Processing	Dehydration; Cleaning, Grading and Storage; Bio-material Properties; Milling, Soy Dairy Analog Processing, Oil Extraction; Handling and Packaging; Extrusion cooking; and Membrane separation; Chemical Analysis and Quality Control, Fermentation, Baking, Product Development and Pilot Plant
Irrigation and Drainage	Automatic Pumpset and Dripper Testing Lab, Drainage Engineering
Agricultural Energy and Power	Biomass densification; Gasification; Biogas Technology; Liquid bio-fuels, Solar Thermal Applications

## **Mandate**

The mandate of CIAE is:

- To undertake adaptive, applied and basic research leading to development / improvement of equipment, technology, process for production, post harvest technology and processing and energy-use in agriculture and rural industries.
- To develop hardware and technology in cooperation with other ICAR Institutes in the area of crops, horticulture, aquaculture and animal husbandry for production and processing.
- To provide leadership and co-ordinate network of research with state agricultural universities for generating location-specific technology and value addition.

- To provide input to ICAR for policy intervention with respect to agricultural mechanization, energy management in agriculture, irrigation and drainage and post harvest management.
- To provide consultancy and undertake sponsored research for agriculture machinery industry and other organizations.
- To act as a repository of information on agricultural engineering.
- To act as a centre for training in research methodologies and technology and conduct graduate, post graduate and doctoral research programme.
- To collaborate with relevant national and international agencies in achieving the above objectives.

# CIAE 2030

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## **Vision**

To integrate engineering with agriculture for higher productivity, profitability and sustainability.

## **Mission**

To make Indian agriculture profitable, sustainable and globally competitive enterprise through engineering interventions in farm mechanization, agro-produce processing and value addition, irrigation and drainage, and energy management for production and post harvest activities.

## **Objectives**

- To increase mechanization of farm operations for production agriculture through precision farming, adoption of efficient water management practices, mechanization of farm operations using machines with low drudgery, high safety and comfort and empowerment of women through suitable gender-specific technologies.
- To increase energy use efficiency in production and post production operations.
- To reduce dependence on conventional energy sources through enhanced use of renewable sources.
- To reduce post harvest losses in food grains and perishables, value addition and processing of farm produce in production catchments for higher returns and employment in rural sector.
- Reduction in malnutrition in rural areas through fortification of conventional foods with nutrient rich produce such as soybean and coarse cereals.

- To strengthen the process of transfer of engineering technologies and promote technopreneurship in proactive mode through capacity building, demonstration, exhibition and strengthening of forward and backward linkages with stakeholders.

### **Functions**

- To undertake adaptive, applied and basic research leading to development/ improvement of equipment, technology, process for production, post-harvest technology and processing and energy-use in agriculture and rural industries.
- To develop and manufacture hardware and technology in cooperation with other ICAR Institutes and manufacturers in the area of field crops, horticulture, aquaculture and animal husbandry for production and processing.
- To provide leadership and coordinate network of research with state agricultural universities for generating location-specific technology and value addition.
- To disseminate knowledge and technology related to energy management in agriculture, irrigation and drainage and post harvest processing and value addition; to act as a centre for training in research methodologies, technology transfer and conduct post graduate research programme leading to Master's and Doctoral degrees in Agricultural Engineering and collaborate with relevant national and international agencies.

# Integrating Engineering with Agriculture for Profitability and Sustainability

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A scientific principle or invention is interfaced with engineering to make it usable and beneficial to the society. The spurt in the growth in various sectors could be correlated to the engineering inputs. Developed countries have taken advantage of engineering interventions for the progress of their agriculture sector. India, therefore, must also take due advantage of engineering for the growth of its agriculture. As the frontiers of agriculture expand, there is greater potential for engineering interventions.

## **Agricultural Mechanization leading to Precision Farming**

Agricultural mechanization is inevitable in a growing economy. Developed nations have succeeded mechanizing most of the unit operations of agriculture. They are using high capacity machines that can prepare seedbed, apply seed and fertilizers, pesticides in a single pass. Rising labor wages have forced them to develop radio controlled machines for automatic dispensing of feed and fodder to the livestock. Intensive modern agriculture in India is practised only on 55 million hectare out of 143 million hectare of net cultivated area. Use of inputs in irrigated agriculture has resulted in higher crop production. However, 60% of cultivated land, which is under rainfed agriculture, is contributing only 45% to total crop production.

With inputs becoming costlier, development and adoption of precision farming techniques on large scale would have to be taken up for improving input use efficiency and checking environmental degradation caused by non-judicious and excessive use of inputs. Precision farming is a holistic farm management strategy where farmers can adjust input use and cultivation methods including seed, fertilizer, pesticide, and water application, planting, tillage, harvesting to match varying soil, crop and



Pneumatic planter

other field characteristics through the use of appropriate machinery. Most of the seeding and planting devices available in the country are suitable for field crops. Such machinery for precision planting of tiny, expensive and irregular seeds is lacking. Effective application of chemicals with presently available sprayers/ dusters is inadequate and penetration is poor. About 80% of the total pesticide applied is wasted. Therefore, farmers are putting chemicals more than the requirement, causing loss of input and environmental pollution. Farm machinery that suits Indian farmers and improves efficiency of agricultural operations would need to be developed.

It is usually presumed that precision farming is only applicable to large holdings as seen in the developed countries. Flexibility is an inherent feature of precision farming and hence type and size of farms are no hindrances in the adoption of a well-designed precision farming system. It offers the opportunity to improve agricultural productivity and product quality. Timeliness is one of the built-in advantages of precision farming and helps to maintain punctuality despite local and farm level variability in sowing, application of fertilizers and pesticides and harvesting. Irrigation and drainage are critical components of a successful production system. Enhancing water productivity is a goal that is becoming increasingly important. Holistic approach in on-farm management of rainfall, harvested water, irrigation and drainage and selected machinery needs attention for efficiency and economy.

### **Climate Resilient Agriculture**

Climatic change is now considered a reality and a continuously evolving process, which may have potential adverse effects on food systems. It must be taken seriously even though there are large uncertainties in its spatial and temporal dimensions. Strategies and tools need to be evolved to develop a comprehensive understanding of all drivers of change in agricultural land use, food production and societal well being. Such an understanding requires an innovative multidisciplinary approach. To facilitate our

preparedness for climatic change, it is important to identify the key information needs and research issues from the perspective of various stakeholders such as farmers, policy makers, scientific research community, trade and industry, and donors. Engineering interventions to insulate agricultural production from the abiotic and biotic stresses on account of climate change need to be worked out.

### **Conservation Agriculture**

Conservation agriculture has shown the potential acceptance in rice-wheat system with an increase of 25-30% in net income returns resulting from savings in fuel and irrigation water as well as increased yield of wheat. Conservation agriculture is not only the minimization of inputs but it is the output/input ratio that needs to be



Sowing under no tillage condition

maximized in space and time. Livestock and fisheries sectors should also be brought under the umbrella of conservation agriculture. As a result, mechanization should address not only cropping systems but also the farming systems. Anticipating 5% increase in adoption of conservation agriculture practices for targeted food requirement by 2030 a large number of efficient farm equipment will be required to reduce cost of operation and achieve timeliness. Conservation machinery requires urgent and intensive efforts for a sustainable agriculture.

### **Mechatronics**

In order to take farm mechanization to a higher level, greater use of electronics and IT is called for. Diminishing availability of human labour, especially for agriculture, and to ensure human safety in agricultural operations, machineries and equipment need to have artificial intelligence and accompanying maneuverability to accomplish the intended tasks. Mechatronics makes use of the principles of mechanical design, controls,

electronics, artificial intelligence, and information technology to achieve the targeted objectives. Future mechanization efforts requiring precision, automation, and remote functionality would make increasing use of mechatronics.

### **Specialty Agriculture**

Certain biotic and abiotic stress situations require intensive engineering inputs for agricultural production. These include production under near-hostile terrestrial agro-climatic conditions, oceanic production systems, advanced life support systems, algal production, etc. With the growth in economy and the need for specific bio-produces, agricultural engineers are required to envision, plan and implement R&D programmes in specialty agriculture in collaboration with agricultural scientists.

### **Secondary Agriculture**

An average farming family in India has less than 1.25 ha land to cultivate. For the majority of the 115 million farming families, the income from agricultural production is far less than the family income based on per capita income of US\$ 580 for an average family of five persons. With the cost of living increasing all the time, this income is not adequate to permit the farmers' families to lead a decent life including good education to their children. Obviously, farmers need to supplement their incomes through other farm and non-farm activities.

Creation of non-farm job opportunities in production catchments through post harvest activities is being considered as one of the most powerful mechanisms of transferring the benefits of economic growth to rural sector. Agricultural produce from production catchments is taken to processing industries, storages and wholesale markets located largely in the urban areas so far since the required skills and infrastructure have not been available in the production catchments. It also needs to be realized that since 70 % of the consumers live in the rural sector, the processed food is transported back to

where it was produced at much higher prices and after incurring substantial losses. Had the produce been processed in the production catchments, the consumers there would have accessed the food at lower prices; post harvest losses would have been reduced and byproducts would have been utilized effectively.

Agri-marketing in India is unorganized and inefficient; as high as 18 to 25% losses occur in the entire food supply-chain from production to consumption. Markets for value-added and processed commodities are consistently increasing with increasing demands by consumers of these products. Low-cost improved technologies are required for value added products including ethnic foods



Pilot plant for soy dairy analogs

to unleash potential and improve market efficiency and to remain competitive simultaneously. New opportunities have emerged with the opening of the global trade; therefore, issues related to sanitary and phytosanitary measures would need to be appropriately addressed. A three-pronged strategy is needed to reduce post-harvest losses; (i) compress supply chain by linking producers and markets; (ii) promote processing of food commodities in production catchments to add value before being marketed; and (iii) develop small-scale processing refrigerated chambers or cold storages using conventional and non-conventional energy sources. And these would require multi-disciplinary and multi-stakeholder research for agri-commodities, especially post-harvest engineering. More focus would be given to primary and secondary levels of value-addition and processing in production catchments.

### **Management of energy and agricultural waste**

Even before alternatives to meet the additional requirements are sought, there is a need for inducing greater energy efficiency in agricultural production to consumption systems. Intensive agriculture is leading to greater intensity of energy use on farm and the energy input to output ratio

has been increasing. A close scrutiny of each of the operations in the production to consumption value chain in the context of the latest technologies and their optimization individually and collectively is essential. Efficient energy management should lead to greater competitiveness of Indian agriculture.

Growing energy crisis is a serious concern for agriculture sector and also for food security. High dependence on oil and non-renewable sources of energy may make agriculture more risk prone and less profitable. To efficiently manage energy, sources of renewable energy such as wind, solar, surplus crop residues, processing byproducts, and other specially cultivated biomass need to be explored. Research would be targeted to develop bio-fuels without compromising on food security.

Of all the 1000 M t of biomass that is harvested through agriculture at present, only about one-third is utilized as food, feed and fibre. A fraction of the remaining biomass is utilized as roughage for animal feeding; some for domestic and industrial fuel. It is estimated that about 150 million tonnes of surplus biomass would still be available for conversion into fuel. There has been renewed interest in biomass as a source of energy since it is renewable, widely available, carbon neutral and has other socio-economic benefits. Biofuels, have begun to be very attractive with all the associated environmental advantages after the crude prices crossed the US\$ 100 per barrel level.

Biofuels research for and from agriculture is going to be increasingly important in the near future. More stringent emission norms may incapacitate the farm sector in the absence of biofuels. While looking for augmenting the energy supply through biofuels, one can not overlook the essentiality of reducing the energy wastages through efficient application technologies. Keeping the diversity of fuels in view, development of multi-fuel prime movers may be a norm than an exception.

A multi-pronged strategy would be adopted to: (i) explore new biological sources of ethanol, especially from non-food stocks; (ii) develop processes for maximizing ethanol extraction, (iii) explore management practices and opportunities to grow bio-fuel stocks in low-productive areas, and (iv) process high-quality animal feeds from crop residues and waste from food-processing industries. Utilization of renewable energy sources for agriculture would require modifications in the existing machinery for greater efficiency.

### **Education and human-resource development**

Enhancing quality of human resource is a pre-requisite for implementing and upgrading research programmes, developing technologies, evolving institutional arrangements to face challenges and harness opportunities. Maintaining global standards and enhancing competitiveness are equally important in agricultural engineering technology development, and agri-business enterprises. Vertical integration of agricultural education is the key to improve quality of human resource. Agricultural Engineering education at under graduate level is offered in over 35 colleges in India. However, the availability of qualified human resources at postgraduate level commensurate with the advances and challenges of Indian agriculture is inadequate. Efforts will be made to develop state-of-the art infrastructure and to enhance faculty competence for improving higher education in agricultural engineering and allied disciplines. Existing pool of talented human resource and infrastructure would be utilized to evolve globally competitive and innovative programmes for postgraduate education and research.

### **Technopreneurship**

Apart from continuously striving to develop new and better technologies; an effective delivery mechanism would greatly help in bridging wide gap between the real potential and the realized potential of mechanization and processing of farm produce. More far-reaching, participatory information

and communication technology would be evolved by optimizing print and electronic delivery systems and by showcasing research products for effectively linking research accomplishments with the stakeholders. There is a need for an efficient agro-service sector to provide backward and forward linkages to growers. Custom hiring services, farm inputs and farm output management, agro-processing centres in production catchments, agro-advisories, machinery banks are some of the forms of agro-services which would transform the agricultural scenario of tomorrow. It is equally important to prepare the right kind of human resource to sustain the entrepreneurial growth through appropriate certificate, diploma and degree programmes in agri-business and related areas.

# Strategy and Framework

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A 6-point strategic framework will be pursued by the Central Institute of Agricultural Engineering (CIAE), Bhopal to develop innovative technology for ensuring higher returns to stakeholders with sustainable agricultural development. Details of research goals, approach and strategic performance indicators are presented in Annexure.

- Farm equipment for increasing productivity and production by reducing cost of cultivation, timeliness of farm operations, and efficient use of inputs.
  - Adoption/ development of precision farming technologies for fixed rate and variable rate application of inputs (seed, water, fertilizer, power and plant protection chemicals) to reduce cost of cultivation and environmental degradation.
  - Development of region and commodity specific technology packages especially for arid, hilly and other agro-climatically difficult areas to improve profitability of farming community.
- Mechanization of horticultural crop production and processing in plains and hills for higher growth rate, reduced losses, greater nutritional security and employment opportunities.
  - Mechanization of farm operations for horticultural crops and centralized system for nursery raising, planting of light vegetable seeds and transplanting of seedlings, pruning and canopy management, efficient spraying and harvesting equipment for fruits, vegetables, plantation, medicinal and spices crops.
  - Application of environment control techniques to enhance the quality and yield of high value crops, including flowers, under covered and protected cultivation in the form of mulching, low tunnels and green houses.
- Development of region and commodity specific technology packages for post harvest loss reduction, processing and value addition for agricultural produce with a view to promote agro-processing in production catchments and enhanced returns to the growers.

- Equipment and technologies for reducing losses, value addition and primary and secondary processing in production catchments through agro-processing centres for higher returns to farmers.
  - Process and equipment for functional and ready-to-eat foods based on optimized parameters from plain and fortified cereals, pulses and oilseed.
  - Development of suitable technologies for long distance transport and handling of fruits and vegetables.
  - Development of processes and equipment for soy based/coarse cereals and millets fortified food products with improved nutritional quality to alleviate malnutrition in the country.
  - Development/ adaptation of processes to utilize byproducts of soy based industries.
- Harnessing and efficient utilization of energy sources (both conventional and renewable) along with pragmatic and innovative utilization of by-products and residues in agricultural production catchments for agricultural production and post production activities
    - Ensuring efficient harnessing of energy from agricultural residues in production catchments through physical, biological, bio-chemical and thermal conversion methods and technological options for utilization of generated power in most effective manner.
    - Development of processes and technology for cost effective biofuel and alcohol production from agro residues.
    - Thermal and photovoltaic application of solar energy for cold chain and other uses in rural sector.
    - Development of technological options for farm machinery management to enhance energy use efficiency.
    - Development of energy efficient farm power machinery packages and management practices which reduce dependence on commercial energies, supplementing and substituting with alternate energy sources in production agriculture at different levels of productivity with least energy input cost, post-harvest activities and rural living.

- Water harvesting, management and utilization of natural resources for sustainable farming systems
  - Development and demonstration of package of systems for rainwater harvesting, drainage, and utilisation of harvested water for sustainable cultivation of high value crops using micro-irrigation systems.
  - Development of micro irrigation based fertigation system.
  - Improvements in design and selection of irrigation pumps for energy efficient operation.
  
- Technopreneurship development through organized intellectual property rights and benefit-sharing system
  - Develop and pilot effective delivery systems and evolve institutional models to link research and development system with farmers, manufacturers and other stakeholders in the value-chain for accelerated adoption of improved farm machinery and equipment, post-harvest management practices, processes of value-addition through information and communication technology and e-extension.
  - Capacity building of extension functionaries, scientists, faculties of the SAUs, manufacturers, potential entrepreneurs, farmers, and rural women on agricultural engineering machines and technologies
  - To extend information and technical know how, guidance, training, services, resources, and logical support to the potential and upcoming entrepreneurs willing to set-up their business based on agricultural engineering technologies through business and technology incubators, technology innovation centre, technology display park, business models, pilot plants, hands-on training, custom hiring etc. to facilitate setting up of successful agri-business enterprises at national level and thereby generating employment and income.
  - To protect the Intellectual Property Rights on the knowledge, technologies, publications and other assets developed by CIAE and other partners through timely filing of patents at national and international levels.

## Epilogue

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Central Institute of Agricultural Engineering is one of the pioneering institutions for research and development in the field of agricultural engineering in India. The institute has consistently worked its way up by developing and introducing appropriate machinery and technologies to transform the agricultural scenario in the State of Madhya Pradesh where it is located and else where in the country. It was due to appropriate and timely intervention of CIAE that kharif crop of soybean could become feasible and profitable in vertisol-dominated regions of MP. The institute has spearheaded the development of suitable technologies for use of soybean for human nutrition. A large number of farm tools, implements and machines have been developed and commercialized so far. The institute has worked with its sister institutes and other partners in the National Agricultural Research System to identify and solve the commodity and region specific problems related to engineering interventions. Development and dissemination of agricultural engineering technologies have brought recognition to the institute. The institute has been facilitating the academic institutions in providing hands-on experiences to the prospective professionals at undergraduate as well as post graduate levels.

The Institute will be striving to develop demand driven engineering technologies to accelerate the pace of farm mechanization in the country and enable the stakeholders to meet the challenges of improving production and reducing post-production losses. It is envisaged that innovations in the field of engineering technologies to enhance agricultural productivity would go a long way in transforming the socio-economic landscape of the rural India. This would be possible by achieving timeliness in agricultural operations and proper placement of inputs; reducing drudgery of agricultural workers; efficient energy and water use; converting plant and animal wastes into different forms of energy; minimizing post-harvest losses; producing value added quality products; and generating employment and income in the rural sector. The institute will keep the needs of contemporary and future agrarian sector in view to envisage the strategies and programmes.

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## ANNEXURE : Strategy and Framework

Goal	Approach	Performance measure
Improvement in crop productivity through agricultural mechanization	<ul style="list-style-type: none"> <li>• Improved farm equipment with better timeliness of operation, higher input use efficiency and comfort to operators.</li> <li>• Precision input applicators</li> <li>• Mechanization of horticultural crops</li> <li>• Technology for conservation agriculture</li> <li>• Specialty agriculture</li> <li>• Gender specificity in machine design</li> <li>• Occupational safety and health</li> </ul>	<ul style="list-style-type: none"> <li>• Development/adaption of commodity specific farm equipment for irrigated and rainfed farming system for different agro-climatic zones.</li> <li>• Precision farming approach for better input use efficiency of critical inputs like seed, fertilizer, water and chemicals.</li> <li>• Mechanization of commodity specific farm operations of fruit and vegetable crops.</li> <li>• Mechanization of controlled environment agriculture.</li> <li>• Mechanization of farm operations in medicinal plants and spice cultivation</li> <li>• Equipment and Technology for residue incorporated conventional and minimum tillage cultivation.</li> <li>• Equipment and technology for controlled traffic cultivation of crops.</li> <li>• Technology for deep placement of nutrient.</li> <li>• Adaptability of conservation agriculture technologies under varying agro-ecosystems such as rainfed, semi-arid, hilly and agro-forestry systems.</li> </ul>
Reduction in post harvest losses	Post harvest practices/equipment for coarse cereals, oilseeds, pulses and horticultural crops	<ul style="list-style-type: none"> <li>• Technology and equipment suitable for rural level processing, value addition and production at pilot plant level for various products.</li> <li>• Package of practices for processing of byproducts from coarse cereals, oilseeds, pulses, and horticultural produce.</li> <li>• Nutraceutical, functional and RTE food development suiting to needs of various target groups.</li> <li>• Ensuring quality standards and food safety with appropriate protocols.</li> </ul>
Ensuring production and productivity under changing climatic conditions	<ul style="list-style-type: none"> <li>• Development of climate resilient engineering technologies</li> <li>• Management of resources</li> </ul>	<ul style="list-style-type: none"> <li>• Engineering technologies for farm operations to minimize the impact on climatic change.</li> </ul>

Goal	Approach	Performance measure
Efficient energy harnessing from renewable energy sources	<ul style="list-style-type: none"> <li>• Harnessing the potential of biomass energy through thermo-chemical, biological and other conversion methods.</li> <li>• Development/adoption of energy gadgets for effective utilization of solar, wind and other renewable energy sources.</li> <li>• Management &amp; farm energy and power</li> </ul>	<ul style="list-style-type: none"> <li>• Technologies for handling, storage and transportation of biomass.</li> <li>• Decentralized renewable energy based power generation systems for production catchments and rural areas</li> <li>• Energy audits and development of efficient energy utilization systems.</li> </ul>
Efficient Management of irrigation water	<ul style="list-style-type: none"> <li>• Improvement in on-farm water management practices</li> <li>• Efficient utilization and recycling of water</li> </ul>	<ul style="list-style-type: none"> <li>• Technologies for improving the water application efficiency in various water application systems</li> <li>• Decision support systems for irrigation water management in different production system.</li> <li>• Technology for fertigation with drip irrigation system for different crops.</li> </ul>
Skilled manpower for agricultural engineering research and techno-preneurship	<ul style="list-style-type: none"> <li>• Capacity building – Human resource development</li> <li>• Strengthening the postgraduate education and research in the field of agricultural engineering and techno-preneurship</li> </ul>	<ul style="list-style-type: none"> <li>• Trainings to SMSs,, students, researchers, planners and other agricultural engineering stakeholders.</li> <li>• Deemed University with postgraduate education and research in field of agricultural engineering.</li> </ul>
Efficient mechanism for transfer of agricultural engineering technologies to end users	<ul style="list-style-type: none"> <li>• Demonstration of agricultural engineering technology to various stakeholders</li> <li>• Entrepreneurship development.</li> <li>• Ensuring quality product to users.</li> <li>• Protecting Intellectual property right.</li> <li>• Business incubation</li> </ul>	<ul style="list-style-type: none"> <li>• Demonstration/Exhibition/Promotional Production and supply of agricultural engineering technology to various stakeholders.</li> <li>• Models for custom hiring of agricultural engineering technologies.</li> <li>• Management of Intellectual property right and commercialization of engineering technology</li> <li>• Industrial liasioning for standardization of material, safety, quality promotion and material upgradation.</li> <li>• Testing of commercial prototypes to ensure minimum standards of the product.</li> </ul>

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# CIAE

*Modernizing Agriculture  
through Engineering Interventions*

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