Vision 2030

Indian Council of Agricultural Research
New Delhi

www.icar.org.in

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Indian Council of Agricultural Research
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PRINTED : January 2011

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Published by the Project Director, Directorate of Knowledge Management in Agriculture (formerly DIPA), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan, Pusa, New Delhi 110 012. Laser typeset and printed in India at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028.

Message

Agriculture sector is witnessing radical changes and challenges at national and global level. The demand for agricultural commodities is steeply rising; food preferences of the next-generation consumers are changing; and agriculture sector is struggling with decelerating profitability which are dragging its performance. The emerging challenges and opportunities call for a paradigm shift in the innovation-driven agricultural research system to connect inventions with all the stakeholders in the entire food supply chain.

I am delighted that the Indian Council of Agricultural Research has shown the foresightedness and prepared innovation-driven strategy. The present document *ICAR Vision 2030* provides the strategic framework for innovation-led inclusive and sustainable agricultural growth. I complement the efforts made by the Indian Council of Agricultural Research to come up with a comprehensive road-map with potential to transform Indian agriculture towards prosperity.

I am sure that the forward looking approach and proposed strategies of the Council would bring a substantial change in the national agricultural research system, and improve its efficiency and effectiveness to accelerate the growth of agriculture sector.

30 January 2011
New Delhi

(SHARAD PAWAR)
Minister of Agriculture and Food Processing Industries
Government of India
Krishi Bhavan, Dr Rajendra Prasad Road
New Delhi 110 114

Preface

The Indian Council of Agricultural Research is an apex organization in the country spearheading agricultural research, education and extension activities for productivity enhancement and diversification of Indian agriculture. The comprehensive initiatives taken by the Council have led to notable accomplishments in natural resource management, input use efficiency, climate resilience, secondary agriculture and economic transformation of farmers though technological interventions. The science-led and technology-driven agriculture is duly supported by appropriate institutional mechanisms, enabling environment and policies.

The first systematic effort to envision the challenges and opportunities, and formulate its own strategy was undertaken in the last year of the 20th century by preparing '*Vision 2020*'. The next attempt was after five years by preparing '*Perspective Plan 2025*' by all the institutes, to address the changes that had taken place. The present document, *ICAR Vision 2030* articulates the strategies to overcome the challenges and tap the opportunities by harnessing the power of science and undertaking boundary less partnership with different stakeholders in food supply chain at national and international level.

I would like to express my gratitude to Hon'ble Union Minister for Agriculture and Food Processing Industries for his invaluable guidance in preparing *ICAR Vision 2030.* I am grateful to Hon'ble Union Minister of State for Agriculture and Food Processing Industries for his keen interest. We are thankful to all the Members of the Governing Body of the ICAR for their valuable suggestions in finalizing this Document.

I appreciate the efforts of Drs P K Joshi, Ramesh Chand, N H Rao, S Maiti, M M Anwer, S Kochhar and T P Trivedi in bringing out this Document. I am sure that *ICAR Vision 2030* would provide a direction to leverage the power of science for achieving higher, sustainable and inclusive agricultural growth.

25 January, 2011
New Delhi

(S. AYYAPPAN)
Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
Krishi Bhavan, Dr Rajendra Prasad Road,
New Delhi 110 114

Preamble

Agriculture in India is the pivotal sector for ensuring food and nutritional security, sustainable development and for alleviation of poverty. It is the key sector for generating employment opportunities for the vast majority of the population. Since quite some time, agriculture sector, as a whole, has been confronted with numerous challenges linked to food and energy crisis coupled with climate change and degradation of natural resources. This sector also influences essential ecosystem services such as water and carbon sequestration.

During the first decade of the 21st century, two contrasting trends have been noticed—(i) India is being recognized as the global power in the key economic sectors with consistent high economic growth and (ii) its slow growth observed in the agriculture sector is causing concerns for the future food and nutritional security of the country. Indian agriculture contributes to 8% global agricultural gross domestic product to support 18% of world population on only 9% of world's arable land and 2.3% of geographical area. Nearly one-third of the country's population lives below poverty line, and about 80% of our land mass is highly vulnerable to drought, floods and cyclones. On the brighter side, India possesses substantial biodiversity — nearly 8 % of the world's documented animal and plant species are found in our country. Many of these are considered crucial for livelihood security of poor and vulnerable population. Therefore, conservation of natural resources, maintenance of biological wealth and acceleration of agricultural growth are considered of paramount importance in the present context as well as of the future.

The Indian Council of Agricultural Research (ICAR) is an apex body of the national agricultural research and education system of the country. It remains vigilant and responsive to changing scenario through development of novel technologies and by promoting problem-solving

knowledge products. It envisions challenges that agriculture sector is facing, especially for ensuring food, nutritional and environmental security, and is in the lookout for emerging domestic and global opportunities. The first systematic effort by the ICAR and its institutes in the last year of the 20th century was made in this direction by preparing '*Vision 2020*'; the next attempt was after five years by preparing *'Perspective Plan 2025'* to address the changes that had taken place, and to articulate new challenges that had emerged. These efforts coincided with the preparation of the XI Five-Year Plan.

It is now realized that agriculture sector would have to face several challenges and threats, along with the opportunities that are emanating from both supply and demand perspectives. An effective agricultural invention-and-innovation continuum would play a crucial role in addressing a number of supply-side obstructions and in harnessing numerous demand-side opportunities. The preconditions for making agriculture sector more remunerative and sustainable would be to evolve effective mechanisms for technology delivery and to enhance capacity of all stakeholders in the invention-innovation continuum.

'ICAR Vision 2030' document narrates key challenges and opportunities in the agriculture sector in the next two decades for developing an appropriate strategy and a roadmap to articulate role of the Indian Council of Agricultural Research in shaping the future of the Indian agricultural research for growth, development and equity.

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Contents

Agricultural Scenario

GLOBAL food demand is expected to be doubled by 2050, while production environment and natural resources are continuously shrinking and deteriorating. Across the larger part of the world, inadequate attention to agriculture has led to steep rise in food prices and increased food riots; and that has pushed an estimated 100 million more people into poverty. More than one billion people in the world already are earning less than one dollar a day, and more than 800 million are suffering from hunger. Majority of them live in rural areas, and are largely dependent on agriculture. Food crisis has aggravated further because of climate change and diversion of arable lands to urbanization, industrialization and also for producing bio-fuel. About 30% global emissions leading to climate change are attributed to agricultural activities, including land-use changes such as deforestation etc. (IAASTD, 2009). Frequent severe droughts and floods are also attributed to climate change that are making millions of people, particularly in resource-poor areas, vulnerable, when their livelihood and food security is depending on agriculture (IAASTD, 2009). To increase food production, augment income of the poor and to alleviate poverty and malnourishment, heads of the governments during the World Food Summit 2008, had reaffirmed the commitment to address challenges of high food prices, climate change and bio-energy. Role of agricultural research, policy support and institutional innovations were cited for reshaping agriculture to meet future demand for food and to eliminate hunger. Earlier, the World Development Report had also very clearly emphasized for attention on agriculture as "… agriculture has effectively served as a basis for growth and reduced poverty in many countries, but many more countries could benefit, if governments and donors were to reverse years of policy neglect and remedy their under-investment and mis-investment in agriculture…" (The World Bank, 2007).

During the recent global food crisis in 2008, Indian agriculture performed better than several of the developing countries, mainly owing to timely policy intervention, yet the agriculture sector needs special attention and emphasis to address numerous inherited and future challenges. Agriculture in India is unfolding to a new agrarian model,

represented by high dependency for livelihood by the large number of smallholders, which is contrary to the historical trajectory of the economic development. Therefore, research and development focus along with institutional framework and policy support needs to match emerging agricultural scenario of the country.

Agriculture and economy

Agriculture contribution in the gross domestic product is declining in India, which in 2008-09 touched at 15.7% from about 30% in 1990-91. During the last two decades, the average annual growth of agriculture sector was less than half (around 3%) of the overall average growth of the economy (6 - 7%) (NAAS, 2009). Industrial and service sectors have outpaced performance of agriculture sector during the last two decades. But the proportion of workforce engaged in agriculture did not commensurate with the decline of its share in the gross domestic product. At present also, agriculture sector provides employment to about 52 % of the workforce that used to be about 61% in 1990-91. These starkly different trends reveal that incomes in non-agriculture sector are growing faster than agriculture sector. And a sizable workforce from agriculture is needed to be shifted to non-agriculture sector for income and livelihood opportunities. Hence, in the country the research and development focus needs to be reoriented in a way to develop and promote those technologies that raise agricultural income and ensure employment opportunities in the agri-supply chain to a vast majority of the workforce.

Smallholders' agriculture

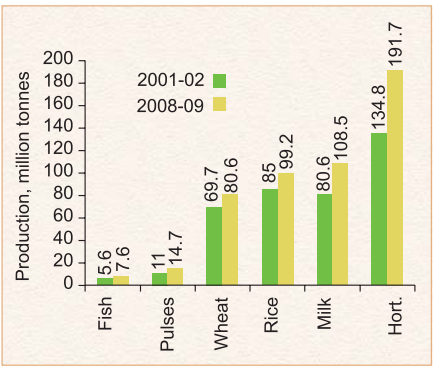
Our agriculture is dominated by small farmers, having small landholdings for cultivation. The average size of the landholding declined to 1.32 ha in 2000-01 from 2.30 ha in 1970-71, and absolute number of operational holdings increased from about 70 million to 121 million. If this trend continues, the average size of holding in India would be mere 0.68 ha in 2020, and would be further reduced to a low of 0.32 ha in 2030. This is a very complex and serious problem, when share of agriculture in gross

Average size of landholding is contracting

domestic product is declining, average size of landholding is contracting (also fragmenting), and number of operational holdings are increasing. Declining size of landholdings without any alternative income-augmenting opportunity is resulting in fall in farm income, causing agrarian distress. A large number of smallholders have to move to post-harvest and non-farm activities to augment their income. The research focus should be to evolve technologies and management options to suit needs of smallholders' agriculture, and also to involve them in agri-supply chain through institutional innovations.

Deteriorating production environment

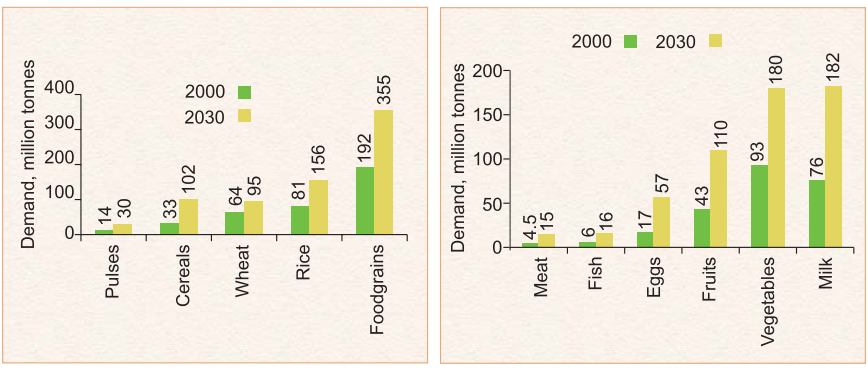
To add to smallholders' problem, the quality of production environment is worsening. The problem of land-and-water degradation is becoming a key constraint in augmenting agricultural production. Available estimates reveal that nearly 120.72 million ha of land in the country is degraded due to soil erosion and about 8.4 million ha has soil salinity and water-logging problems. Besides, huge quantities of nutrients are lost during crop-production cycle. Annually, India is losing nearly 0.8 million tonnes of nitrogen, 1.8 million tonnes of phosphorus and 26.3 million tonnes of potassium—deteriorating quality and health of soil is something to be checked. Problems are further aggravated by imbalanced application of nutrients (especially nitrogen, phosphorus and potash), and excessive mining of micronutrients, leading to deficiency of macro- and micro-nutrients in the soils. Similarly, the water-table is lowering steeply in most of the irrigated areas, and water quality is also deteriorating, due to leaching of salts and other pollutants. The green-revolution belt is exhibiting second-generation problems owing to over-exploitation and mismanagement of soil-and-water resources. These all problems can be rectified by better management options and application of amendments. The research and development challenge is to stop further degradation and go in for rehabilitation of degraded lands and water resources in cost-effective manner.



Production of important commodities

Growing food demand

The demand for food and processed commodities is increasing due to growing population and rising per capita income. There are projections that demand for foodgrains would increase from 192 million tonnes in 2000 to 345 million tonnes in 2030. Hence in the next 20 years, production of foodgrains needs to be increased at the rate of 5.5 million tonnes annually. The demand for high-value commodities (such as horticulture, dairy, livestock and fish) is increasing faster than foodgrains—for most of the high-value food commodities demand is expected to increase by more than 100% from 2000 to 2030. These



The demand for high-value commodities (such as horticulture, dairy, livestock and fish) is increasing faster than foodgrains

commodities are all perishable ones and require different infrastructure for handling, value-addition, processing and marketing. This is a challenge as well as an opportunity. The challenge is that it appears to be a difficult task for attaining mountainous targets. And the opportunities would be in augmenting farm incomes, generating employment and in involving a number of additional stakeholders in the food-supply chain. For research and development, the key challenges would be: (i) to develop promising technologies and management options to raise productivity to meet growing food demand in a situation of deteriorating production environment at the lowest cost; and (ii) to develop appropriate technologies, create required infrastructure and to evolve institutional arrangements for production, post-harvest and marketing of high-value and perishable commodities and their value-added products.

Climate change and agriculture

Inter-Governmental Panel on Climate Change has projected that by

the end of this century, global earth temperature is likely to increase by 1.8° to 4.0°C. This would lead to more frequent hot extremes, floods, droughts, cyclones, and recession of glaciers. Dynamics of pests and diseases would be significantly altered. The projected increase in these events will result in greater instability in food production and will threaten farmers' livelihood security. Producing enough food for increased demand against the background of changing climate scenario is a challenging task for agricultural research. This would require increased adaptation and mitigation research, capacity-building, changes in policies, and regional as well as global co-operation.

Technology landscape

Developments in molecular biology, biotechnology, nanotechnology, information technology and geo-spatial technology are expected to provide significant new opportunities for productivity enhancement. These developments are also posing new challenges of capacity-building and human resource development. There is a need to develop organizational policy and guidelines aimed at enhancing inventions and accelerating innovations in agriculture to harness opportunities by integrating modern and conventional research approaches. The Council is the custodian of huge *ex-situ* collection of genetic stocks of crops, animals, fishes, insects and microbes, and would facilitate their sustainable use in genetic improvement of agricultural commodities over time and space through conventional and frontier scientific techniques.

Emergence of agri-business

Conventionally, agri-marketing in India has been unorganized and inefficient; showing 18 to 25% losses in the entire supply-chain. However, the landscape of agriculture is expanding now, which includes agri-business in the supply-chain operations and management. The corporate sector is entering and investing at different levels in the supply-chain, thus linking production eco-regions with consumers in the promising domestic and global markets. A different paradigm in the food system is emerging that witnesses deteriorating and fragmenting production environment and consolidation in marketing environment in the post-harvest, processing and marketing with the entry of the corporate sector. Globalization is opening enormous opportunities for food and processed commodities while at the same time throwing challenge of competing globally. The critical issue for the future of the Indian agriculture is to evolve mechanisms for linking front-end activities of agricultural supply-chain (wholesale, processing,

logistics and retailing) with its back-end activities of farm production that would lead to enhanced efficiencies, ensured remunerative prices to producers, assured markets and reduced production and market risks (Rao, 2010). There are plenty of opportunities for strong public-private partnerships in the agricultural research and development as well as for fostering relevant agro-enterprises and technology incubators.

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National Agricultural Research System

THE Indian National Agricultural Research System is one of the largest in the world with respect to human resource engagement and infrastructure, and the Indian Council of Agricultural Research is an apex body of the National Agricultural Research System. The Council administratively is an autonomous organization under the Department of Agricultural Research and Education, Ministry of Agriculture, Government of India. The Council is for co-ordinating, guiding and managing research, education and extension in agriculture, including horticulture, fisheries and animal sciences, in the country. It has a vast network with 97 ICAR institutes, 46 state agricultural universities; five deemed universities and one Central Agricultural University and 589 KVKs spread across the country.

The research programmes under the umbrella of the ICAR are designed and undertaken for harnessing power of science that ensures food, nutrition and livelihood security for all. In the past, it played an enabling role in ushering green revolution and in the subsequent developments in agriculture in India through its research and technology development that enabled country to increase production of foodgrains by 4-fold, horticultural crops by 6-fold, fish by 9-fold (marine 5-fold and inland 17-fold), milk by 6-fold, and eggs by 27-fold since 1950-51; thus making a visible impact on the national food and nutritional security. It has also played a major role in promoting excellence in higher agricultural education. It is engaged in cutting-edge science and technology development, and is internationally acknowledged in several agriculture and allied sectors.

Mandate

- To plan, undertake, aid, promote and co-ordinate education, research and its application in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- To act as a clearing house of research and general information relating to agriculture, animal husbandry, home science and allied sciences, and fisheries through its publications and information system; and instituting and promoting transfer of technology programmes.

- To provide, undertake and promote consultancy services in the fields of education, research, training and dissemination of information in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology by developing co-operative programmes with other organizations such as the Indian Council of Social Science Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre and the universities.
- To do other things considered necessary to attain the objectives of the Society.

The past research contributions of the ICAR and its partners were exceptionally higher than any other developing countries in the world. The empirical evidence documented that investment in the agricultural research and development was a win-win option as it was the largest contributor to agricultural total factor productivity, which in turn significantly contributed in reducing rural and urban poverty (NAAS, 2009). The average internal rate of return to the investment in agricultural research was about 46% during 1980/81 and 2006/07, which is comparable to that obtained internationally (Chand, Kumar and Kumar, 2011). The growth in total factor productivity between 1980 and 2000 was estimated at 1.4 to 2.0%, which equaled to that observed for crop sector during the green revolution period. The smallholders in the unfavourable production environment shared some of these benefits (Pal *et al.*, 2005).

The Council acknowledges importance of partnerships and synergies of different stakeholders in providing technological solutions for agriculture. It has developed organization's Intellectual Property Rights (IPR) domain, and has implemented its Guidelines for Intellectual Property Management and Technology Transfer/ Commercialization (ICAR, 2006). It is expanding its reach for generating and disseminating new knowledge to its wide range of stakeholders in the production and food value-chain. It is strengthening its partnership with the national and the international organizations, various government departments, farmers and farmers' organizations, non-governmental organizations and private sector involved in agri-business. The ICAR is well prepared to meet future challenges and harness opportunities.

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ICAR 2030

THE Indian Council of Agricultural Research is marching ahead with renewed vigour to face complex challenges and to harness domestic and global opportunities for the welfare of the farmers, consumers and other stakeholders in the food-supply chain. The efforts would be to become a leading organization in the world, which is responsive, vibrant and sensitive to the needs of its stakeholders.

Vision

Ensure food and income security for all, through technological innovations and sustainable agriculture.

Mission

Harness power of science and education with a human touch for higher and sustainable agricultural production.

Focus

To accomplish the vision and the mission of the ICAR— it gives highest priority to farmers, and entire strategy is based on *'farmer first'*. It is determined to continuously strive hard to transform the existing National Agricultural Research System into a vibrant National Agricultural Innovation System. It would concentrate on the following key areas.

- Promote innovations and improve human resource capacity by involving all stakeholders in the food-supply chain.
- Strengthen institutional capacity for attaining sustainable food, nutrition, and livelihood security, and also for global competitiveness.
- Act as a catalyst in reclaiming degraded resources for agriculture, and conserve and enhance national wealth of natural resources and biodiversity.
- Promote adaptation and preparedness for meeting climate change challenge, and evolve mechanisms for effective drought and flood management.
- Foster repositories of genetic resources related to crop, livestock, fish, insects and micro-organisms for their sustainable utilization.

- Improve knowledge management system to act as an efficient clearing-house of technology, knowledge and information in agriculture and allied sectors.
- Facilitate quarantine, evolve mechanisms for sanitary and phytosanitary inspection of germplasm under exchange for research, and perform other regulatory functions.
- Develop and facilitate gradual replacement of pesticides, and execute mechanisms for bio-security of the country, especially that emerging from threat of gene piracy and cross-border vector-borne diseases.
- Reform agricultural education and extension systems, and enhance human resource befitting global competition.
- Foster linkages and collaborations with public and private, national and international organizations.

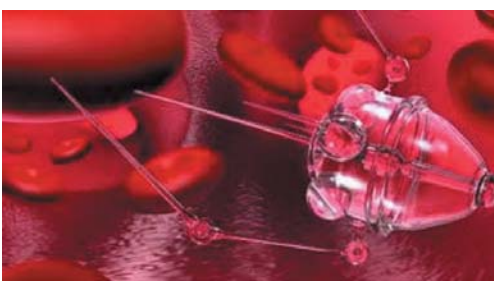
Harnessing Science

THE Indian Council of Agricultural Research would strive to harness power of science in increasing productivity, enhancing input-use efficiency, reducing cost and post-harvest losses, minimizing risks and improving quality of food commodities through conventional techniques as well as new science and tools. The Council would evolve mechanisms for accelerating innovations through institutional and policy support. It would also attempt to realize diverse interests of different stakeholders in the food-supply chains.

In the present context, technological challenges are becoming more complex than before as demand for food is increasing and supply sources are dwindling. Incidentally, the science is also changing rapidly with the emergence of new tools, methods, techniques and approaches that promise technological breakthroughs to accomplish the mission.

Potential of genetic-resource enhancement

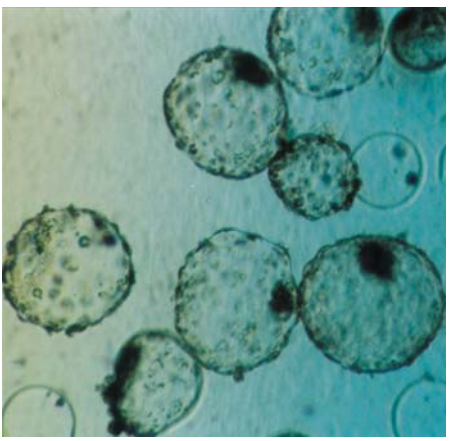
Much of the gains in the productivity of the food commodities in the past have been attributed to the genetic alterations of the crops and animals. This will continue to be the primary driver for augmenting productivity in the lesser time, space and cost. The ICAR possesses a vast variety of genetic resources of crops, animals, fishes, insects and microbes. To address future needs, research will facilitate sustainable use of available genetic resources through (i) characterization, (ii) genetic enhancement and pre-breeding, (iii) functional genomics, proteomics, phenomics etc., (iv) gene mining, (v) molecular breeding through tools like marker-aided selection and gene stacking, and (vi) customized genetic engineering (development of trait-specific transgenics).



Molecular nanosystems

Power of biotechnology

Agricultural biotechnology has a considerable potential to address many of the future challenges in the agricultural crops, horticultural crops, agriculturally important microbes, insects, birds, livestock, poultry, fisheries, aquaculture, and post-harvest processing and value-addition. The time tested and socially accepted first and second generation biotechnologies will be made use of to speed-up breeding processes and to reduce investments on research for increasing yields, minimizing production risks, for sustaining environment and for meeting consumer taste and preferences. The science part of the transgenic research would be continued and further strengthened. Priority would be given to those commodities and traits for developing transgenics that have shown low probability of research success in the past through conventional efforts.



In-vitro produced buffalo hatched blastocyst embryos at day 10 of culture

Synergies of frontier sciences

Agricultural research will leverage promises of frontier sciences — nano-technology, information and communication technology and remote sensing; and also techniques like Geographic Information System and Global Positioning System. These frontier sciences and techniques would be well integrated in the on-going and future agricultural research for improving research efficiency, better targeting of technologies and also identifying production and marketing environments.

Management of natural resources

There is a widespread concern that the stock of the natural resources is dwindling and its quality is deteriorating. Undoubtedly, the agriculture is highly dependent on the natural resources. Rainfed agriculture has huge potential if natural resources, especially soil and water, are scientifically and efficiently managed. Potential of conservation agriculture, zero tillage, precision agriculture and micro-irrigation needs

to be perfected for different agro-eco-regions. Efficient farming systems, composite farming, integrated crop management, integrated nutrient management, integrated pest management, and integrated water management would be perfected further for wider adaptability, and would be integrated with various public-sector supported programmes for holistic development. Enhanced participation of stakeholders and increased agro-ecological literacy would be given due priority in managing natural resources.

Integrated farming in Arunachal Pradesh

Next generation precision agriculture would benefit in production efficiency. This would require obtaining relevant parameters and simulation of the most complex systems with the application of increasingly powerful computers, sophisticated softwares and advance sensors. Improved long-range weather prediction technology would be required to take advantage of precision operations for crops and resource applications. This may also contribute to the better understanding of global warming and climate change, and their drivers.

Agricultural diversification

Demand for high-value commodities is increasing rapidly with the rising per capita income, growing urbanization and unfolding globalization. To meet the demand of these commodities, research focus would be further strengthened to augment their production more efficiently and competitively. Along with the development of improved genotypes (varieties and hybrids) and management practices for raising productivity of these commodities in different agro-eco-regions, consumer-preferred quality traits and food safety would be given high priority. Since these are perishables in nature, research and development focus would be on the entire value-chain from production and post-harvest to value-addition, processing and marketing. Enhancing shelf - life and improving demand-driven commodity traits (colour, size, and aroma) of these perishable commodities through different post-harvest approaches in partnership mode would be prioritized to promote agricultural diversification.

Post-harvest and value-addition

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 to unleash potential and improve market efficiency and to remain competitive simultaneously. New opportunities have emerged with the opening of the trade, therefore, issues related to sanitary and phyto-sanitary 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 sources. And these would require multi-disciplinary and multi-stakeholder research for agri-commodities, especially post-harvesting engineering, horticulture, dairy, livestock and fish. More focus would be given to primary and secondary levels of value-addition and processing.

Management of energy and agricultural waste

Growing energy crisis is a serious concern for agriculture sector and also for food security. Efficient management of energy in agriculture for various operations is the key research and development challenge. High dependence on oil and non-renewable sources of energy may make agriculture more risk-prone and less profitable. To efficiently manage energy, new sources of renewable energy need to be explored. Farm machinery that suits Indian farmers and improves efficiency of agricultural operations would be developed and promoted.

Briquetting of agro-residues

Research would be targeted to develop bio-fuels without compromising on food security and by effectively utilizing huge agri-waste (animal and crop residues). 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. New forms of machinery and equipment would also be developed for efficient use of renewable sources of energy.

Bio-risk management

Bio-risk is increasing in agriculture with climate change and owing to trans-boundary insect-pests and diseases. It is adding cost, reducing food production and is adversely affecting farm income. To overcome problem of bio-risk, efforts would be made to develop effective and integrated risk-and-disaster management production systems and institutional mechanisms, which would bear risk. Bio-risk intelligent system (such as early warning systems, drought indicators, migratory movement of bio-risk agents, etc.) would be developed for taking informed decision at the local, regional and national levels.

Institutions and policies

Growing smallholdings, rising food demand, increasing uncertainties, unfolding globalization and emerging private sector in agri-research and agribusiness call for designing policies, developing institutional mechanisms, evolving decision-making processes, mobilizing political support and improving governance of service providers in the value-chain. The added challenge is the emergence of the intellectual property rights regime, which needs to be converted into an opportunity. All these issues require effective and need-based institutions to accelerate innovations and link farmers with different stakeholders to harness growing opportunities. Innovative institutional models, pro-agricultural policies and regulatory mechanisms would be evolved for accelerating innovations, ensuring food security, enhancing livelihood opportunities of smallholders, and also for conserving natural resources.

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 agri-business and in technology development. Vertical integration of agricultural education is the key to improve quality of human resource. Efforts will be made to develop state-of-the art infrastructure and to enhance faculty competence for improving higher education in agriculture and allied disciplines. Existing

pool of talented human resource and infrastructure would be utilized to evolve globally competitive innovation agricultural university by the involvement of all the ICAR institutes.

Technology transfer systems

It is important to continuously strive to develop new and better technologies. Their effective delivery mechanism would greatly help in bridging wide gap between the potential and the realized productivity. 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.

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Strategy and Framework

A 5-point following strategy would be adopted to accomplish the vision and the goals of the Indian Council of Agricultural Research, and to enhance efficiency and effectiveness of the research resources(*see* Annexure 1).

- Improve efficiency of human and financial resources and effective utilization of infrastructure.
  - Formulate consortia-based target-oriented eco-region-wise mega-research and technology development programmes cutting-across disciplines and institutions within and outside the NARS;
  - Prioritize demand-driven and resource-based research programme with focus on smallholders and emerging market opportunities;
  - Focus more on rainfed, backward, marginal and fragile areas; and
  - Harness synergies of partners and stakeholders in developing improved technologies, systems and information.

- Facilitate accelerated dissemination of improved technologies, knowledge and information.
  - Develop and pilot effective delivery systems and evolve institutional models to link research and development system with farmers and other stakeholders in the value-chain for accelerated adoption, cost-effective post-harvest management, value-addition and processing and efficient marketing through information and communication technology and e-extension;
  - Provide state-of-the-art scientific facilities in laboratories and infrastructure;
  - Establish institutional mechanisms and governance structure for linking technology generation and dissemination system with back-end service providers; and
  - Link research and development system with society by improving science communication. Awareness and sensitization programmes would be developed addressing benefits of science and food safety concerns of the society.

- Enhance quality of human resource in agri-supply chain.
  - Regular manpower planning in agriculture sector with focus on research and development system, agri-service providing system, post-harvest processing and preservation system, and agri-business to project demand for future human resource needs;
  - Improve quality of higher agricultural education and enhance capacity of human resource in research for development through talent management for overcoming new and complex challenges;
  - Develop an accountable, professional, motivated and intellectual property rights-compatible work-culture; and
  - Facilitate in strengthening and streamlining higher agricultural education system to meet future challenges.

- Commercialization of technologies through organized intellectual property rights and benefit-sharing system.
  - In the new era of Intellectual Property Rights regime, a compatible intellectual property and technology management system needs to be strengthened for promoting science and benefiting farmers and the society; and
  - Facilitate harmonization of intellectual property domain with other parallel laws in and outside the country.

- Promote effective, efficient and decentralized governance by introducing best management practices in the Indian Council of Agricultural Research.
  - Institutionalize project-based budgeting, management information system (MIS) and priority-setting, monitoring and evaluation (PME);
  - Multi-stakeholder, multi-disciplinary, multi-institutional participatory and consortia-based research;
  - Involvement of social sciences in research prioritization, and technology development, targeting and dissemination;
  - High research priority is to be given to the needs of the rainfed, backward, fragile and marginal ecosystems and vulnerable groups; and provide gender-friendly technologies, machines and management options;
  - Evolve a lean-and-efficient administration by employing information and communication technology;

- Develop a performance-based work-culture with incentives-and-rewards system; and
- Develop a futuristic human resource development programme in cutting-edge science and technology.

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Epilogue

THE ICAR is committed to bring a demand-driven and technology-led revolution in the country to meet challenges of the rising demand for food, improving livelihood opportunities of farmers, and for ensuring sustainable farming and agricultural growth. We envision that innovations in agriculture would transform existing slow-down in agriculture sector into a vibrant and competitive sector by harnessing untapped opportunities in domestic and global markets. The Council firmly believes that agricultural research and development would augment farmers' income, generate employment opportunities, conserve natural resources, restrict imports, promote exports and increase value-addition for higher and inclusive agricultural growth. To sustain the benefits of research and development, the Council would sensitize and facilitate in creating a favourable institutional support, infrastructure and policy environment at different administrative levels.

Concerted efforts would be made to transform the Indian Council of Agricultural Research to be more sensitive to the needs of the farming community, especially of the smallholders and of the poor living in the backward, fragile and marginal areas. The Council will focus more on the commodities and the areas where private sector would be reluctant to venture. It will also develop mechanisms to regularly monitor changes occurring at the national and international level, and will develop strategies to respond to the change for the benefit of the stakeholders. It will be done in a participatory mode by becoming more vigilant and introducing institutional processes that develop a culture of responsibility, accountability and integrity in science.

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REFERENCES

Chand, Ramesh, Kumar, Praduman and Kumar, Sant (2011) *Total factor productivity and role of public sector research and education in agricultural growth during post-green revolution period*. National Center for Agricultural Economics and Policy Research, New Delhi.

IAASTD (International Assessment of Agricultural Knowledge, Science and Technology for Development). 2009. *Global Report*. Mclntyre, Baverly, D., Herren, R. Hans, Wakhungu, Judi, and Watson, Robert, T.(eds). USA, Washington, DC.

ICAR (Indian Council of Agricultural Research) (2006) *Guidelines for Intellectual Property Management and Technology Transfer/ Commercialization*. New Delhi, India.

NAAS (National Academy of Agricultural Sciences). 2009. *State of Indian Agriculture*. New Delhi, India.

Pal, S., Mathur, P. and Jha, A.K. 2005. Impact of agricultural research in India: is it decelerating? *NCAP(*National Centre for Agricultural Economics and Policy Research) *Policy Brief* **22**. New Delhi, India.

Rao, N. H. 2010. Workshop on *Agribusiness Knowledge Exchange*. 14-15 April 2010, National Academy of Agricultural Research Management, Hyderabad, India.

World Bank. 2007. *Agricultural Development Report 2008*. USA, Washington, DC.

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Annexure 1: Strategic framework

Goal	Approach	Performance measure
Improve food security	Sustained agricultural intensification for higher productivity and quality from shrinking land and water resources without impairing their quality Increase food access through improvement in storage, transport and distribution systems Improve policy through food insecurity assessment, and identification of supply and demand side drivers	Contribution of research and development in poverty alleviation and hunger reduction
Enhance opportunities for inclusive growth	Increase efficiency and profitability of production systems Improve supply-chain efficiencies of agricultural commodities Develop and introduce new products by involving farmers (bio-fuels, biopolymers, safe and organic products) Develop demand-driven high-value products (horticulture, dairy, livestock and fish) with desired traits, and their cost-effective post-harvest technologies Evolve institutional mechanisms for market linkages, market access; and supply-chain issues	Improved livelihood opportunities through higher income and better quality of life
Enhance competitiveness of Indian agriculture	Product development to adhere to sanitary and phytosanitary issues Improve market intelligence for prices, niche markets and products in domestic and global markets Develop that reduce contamination, enhance traceability, and improve food safety of products Effective policies for enhancing trade and improving regulatory mechanisms	Research and development contribution in promoting trade Research and development contribution in reducing rejections of export consignments

Goal	Approach	Performance measure
Maintain and improve the status and quality of natural resources	Conserve and promote access to genetic diversity Management options to improve soil and land quality Technological options to enhance water-use efficiencies, water quality, and increase water availability Technological solutions to improve air quality by reducing emissions Management strategies to conserve and use wastelands and marginal lands Improve policies for accounting ecosystem services; ecological economics; trade in carbon credits; virtual water trade	Improved water- and input- use efficiencies Reclaimed degraded soil, land and water resources Enhanced carbon sequestration and carbon credits gained
Improve safe production, value-addition, and processing of food commodities	Develop technologies for demand-driven, value-added products for food, energy, industrial and other purposes that satisfy demand in India and abroad Develop approaches and machines to improve efficiencies of storage and distribution Pilot research models that link production, value-addition and marketing Policies for commercialization of technologies and food processing Promote intellectual property management	Developed techniques and processed products Established public-private partnership model in agri-processing Established linkages with industry and farmers
Improve risk management	Address climate risks in agriculture (crop and livestock) Approaches for climate change adaptation and mitigation Address market risks through improved market intelligence; improved market access	Technologies and management practices developed for drought management Green House Gases reduced Insurance products developed and piloted

Goal	Approach	Performance measure
	Address issues related to bio-security Farmer-friendly insurance product to minimize risk arising owing to climate change Policies and institutional arrangements to address climate change; disaster relief, and bio-security	
Improve access to genetic material, information, knowledge and resources	Improve access to genetic resources through repository of germplasm and access to genomic resources and tools Improve access to technologies through technology transfer systems Improve access to information through effective use of Information and Communication Technology in supply chain management Access data, including geospatial data and knowledge resources Policy issues in conservation and utilization of germplasm	Shared germplasm Developed websites for sharing knowledge and information
Create adequate and quality human resources to address emerging challenges	Modernize education systems (infrastructure, faculty) Internalize problem solving approach in curricula (increase analytical skills; increase experiential learning; greater focus on science and processes) Effective co-ordination of multi-commodity, multi-disciplinary research in entire supply-chain of agricultural commodities Capacity strengthening through training at the national and international level	Improved research efficiency Qualified manpower in agriculture, agri-research and agri-business

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