भाकृअनुप
ICAR

Vision 2030

DRR

Directorate of Rice Research

Rajendranagar, Hyderabad - 500 030

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S. AYYAPPAN

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Foreword

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. In tune with the document, ICAR Vision 2030, which 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, DRR Vision 2030, is the blue print of strategies planned to address the future challenges in meeting the country's food security, enhancing & sustaining the rice productivity, ensuring economic viability of rice production systems and preserving the environment.

Future challenges for rice production are formidable with uncertainty of magnitude of impacts due to climate change, declining water and labor availability, falling margin of profitability. Opportunities are also opening up with advancement in science and availability of modern technologies. Therefore, there is an urgent need for our preparedness with concrete action plan to face these challenges.

I am happy to note that the Director and staff of the Directorate of Rice Research, Hyderabad have carefully evaluated the future demand and production constraints to meet this demand and projected realistic requirement of human and other resources to execute the plan of work outlined in this document.

I hope this Vision 2030 for DRR will also integrate other action plans of related activities under the purview of allied organizations of ICAR.

I compliment the efforts made by the staff and Director of the DRR.

(S. AYYAPPAN)

Preface

Directorate of Rice Research has twin major mandates of coordinating the multi-location, multi-disciplinary testing of varietal and management technologies under the All India Coordinated. Rice Improvement Programme (AICRIP) and conducting strategic and applied research on irrigated rice aimed at enhancing production, productivity and profitability while preserving environmental quality.

Taking this new opportunity to revisit our earlier document, Vision 2020 – A Perspective Plan for DRR, we have done a mid-course evaluation of the above document vis-a-vis our perfomance. Since the publication of this document, India has posted another all time high rice production of 99.2 million tonnes during 2008-09. Number of rice varieties released for commercial cultivation has now crossed 900 mark. Over 46 rice hybrids are now aggressively marketed by the private sector. First batch products of marker technology has arrived and are becoming popular. System of Rice Intensification (SRI), aerobic rice and AWD methods of cultivation are effectively addressing production constraints like water and labour shortages.

On the contrary, production scenario is unstable and tend to depend heavily on monsoon patterns. Cost of cultivation is proving deterrent to farmers. Climate change is likely to affect rice production. DRR is poised to look ahead to these challenges and opportunities and prepare itself to shoulder the responsibilities of meeting the future goals and expectations of the nation towards achieving food and nutritional security. I sincerely hope the current document will serve as a guiding principle towards meeting the future challenges in more meaningful ways.

We are grateful to Dr. S. Ayyappan, Secretary, Department of Agricultural Research and Education and Director General, Indian Council of Agricultural Research for being the constant source of inspiration and driving force for the present initiative.

We are also exteremly thankful to Dr. Swapan Datta, Deputy Director General (Crop Science), ICAR, for his keen interest in rice and his constant endeavor to improve the progamme at different levels. We place on record our sincere thanks to Dr. R.P. Dua ADG (FFC) for his keen interest and support in preparing this important document.

This document is the product of long stretches of brain storming, incisive discussions argumentative points of view of my senior colleagues from time to time. I appreciate the efforts of Drs. K.V. Rao, J.S. Bentur, T. Ram and Mangal Sain in the preparation of draft. Participation of several of my colleagues in the Council in shaping the document and bringing uniformity across those being prepared by other Institutes is also acknowledged.

(B.C. Viraktamath)

Preamble

Rice is the corner stone of national food security. It Occupies 44 M. ha (22%) of cropped area with annual production of 96 Mt; is a source of livelihood for millions of Indians and also earns foreign exchange of 12,000 crores. Over the last six decades rice production trend has kept in pace with growing population and the demand for food to feed it. However, recent trends of declining growth rates coupled with increasing shortage in inputs like water, labour and land are causing concerns. Additional developments of recent times like globalization, advances in biotechnology, climate change and forging public private sector partnership have thrown open challenges and opportunities alike.

The Directorate of Rice Research has twin mandate of coordinating research under the unbrella of All India Coordinated Research Project on Rice (AICRIP) with 47 funded and over 50 voluntary centres covering all rice ecologies, and conducting lead research addressing specific problems of irrigated rice ecology. It is provided with infrastructure and human resources to organise country-wide technology validation activity and generate information and technology to face the present and future challenges.

We had earlier examined these challenges and opportunities and framed Vision 2020 and Perspective Plan 2025 some time back that had set priorities and road map to achieve the goals. This call by the Indian Council of Agricultural Research to revisit the document on the eve of XII five year plan has given us another opportunity to re-examine the document. 'DRR Vision 2030' document enumerates key challenges and opportunities to meet the goal of enhanced and sustained rice production to meet the national food and nutritinal security keeping in view the environmental concerns and threats of climate change and has attempted to develop an appropriate strategy and a roadmap for the next two decades for research for growth, development and equity.

Contents

Rice Scenario

Globally rice is planted to about 160 million ha and 685 million tonnes of produced harvested annually (FAO, 2009). Of this, Asia accounts for 90% of the production and consumption of rice. Only about 35 million tonnes of rice is traded through international market. Leading rice exporting countries are Thailand, Vietnam, USA, India and Pakistan. Thus it is imperative that rice production and supply for domestic consumption is entirely the national responsibility. In recent past ban on export by some of the above mentioned countries led to food riots in importing countries like Haiti and Egypt.

India has the world's largest area under rice with 44.0 million ha and is the second largest producer (96.0 million tones - 2010) next only to China. It contributes 21.5 percent of global rice production. Within the country, rice occupies one-quarter of the total cropped area, contributes about 40 to 43 percent of total food grain production and continues to play a vital role in the national food and livelihood security system. During 2007-08 India exported a record 6.5 million tonnes of rice worth Rs. 12,000 crores and was second only to Thailand. Rice export contributes nearly 25% of total agriculture export from the country. However, productivity of rice is only 2.1 tonnes/ha (milled rice) which is lower than worlds average productivity of 2.9 tonnes/ha (FAO, 2009).

The main reason for low productivity of rice in India is that rice is grown in the country under various production ecologies mainly grouped as irrigated and rainfed systems. While former is considered most favourable, rainfed system has again a wide range of subsystems like shallow, mid and deep water rainfed lowlands and rainfed uplands. Productivity in these systems vary widely. Based on available figures for 2004-04 the states of Andhra Pradesh, Karnataka, Tamil Nadu, Punjab and Haryana have predominantly irrigated rice and average productivity of these states for 2009-10 is 3.136 t/ha (Rani *et al.* 2010). Total irrigated area in the country, including that in rabi/boro season is about 25 million ha (58%). Likewise states of Utaar Pradesh, Bihar, west Bengal, Orissa, Jharkhan, Chattisgarh and Assam represent predominantly rainfed shallow lowland system that can be considred fovourable rainfed ecology. These states have registered an average productivity of 1.658 t/ha. Total area under rainfed lowlands is is about 11.0 million ha. Rainfed uplands which form the least productive system cover about 5 million ha with a productivity of 0.8 t/ha. Rest of the 2 million ha land is deep and semi-deep water with low productivity of 0.5 t/ha. Relative area and productivity of these different ecologies is given in Fig. 1.

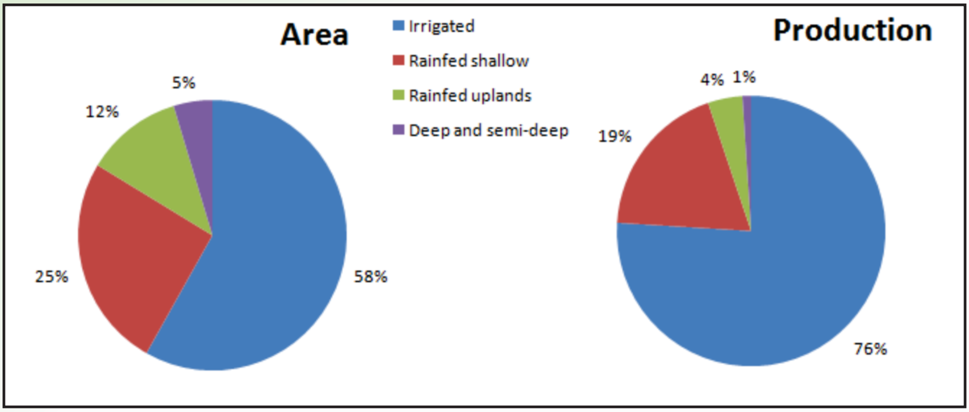


Fig. 1 Relative contribution (%) of different rice ecologies in terms of area and production

Constraints for rice production enhancement

Water, labour and land are the main constraints in productivity enhancement. Water availability for rice cultivation is declining at an alarming rate. It is estimated that for each kg of rice production under normal transplanted rice system require about 2,500 to 3000 litres of water. Rice alone has more than 50% of the share of water for agriculture purpose and feasibility of water saving in other crops are less. Hence rice cultivation will be under pressure to save water.

Labour shortage is another major limitation in view of migration of rural poor to urban areas. Further fragmentation of land will limit effective management. It is estimated that 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 (ICAR 2010). Rice cultivation is also becoming less and less remunerative to the cultivators. The returns over paid-out costs for rice farmers have been estimated to have declined at 1.15% per annum in real terms over the last 20 years (Mahendra Dev and Rao, 2011). Timely availability of inputs like improved seeds, fertilizers and credit and lack of awareness of modern cultivation practices are also contributing to the poor production environment. To compound the situation, changing climate has been posing threats of uncertain dimensions.

Demand and supply of rice

Rice being the staple food for the majority of the Indians, demand for rice in the future is bound to increase with the growing population. Considering the annual decline of 0.05% in population growth rate, India's population is projected to be 1.301 and 1.378 billion by 2020 and 2030 (Goyal and Singh 2002). There have been several projection of demand of rice made based on per capita consumption of rice and projected population.

Recent trend has been a marginal decline in the per capita consumption of cereals including rice (Mittal, 2008). This study has considered rice per capita consumption of 72.9 kg per annum and the demand for domestic consumption is projected to be about 102.3 million tonnes (Mt) during 2026 accounting also the demand for seed, feed, industrial use and wastage (12.5%). This figure can be further extrapolated to 107 (Mt) for the year 2030. Earlier study had projected demand of rice by 2020 at 122.1 Mt (Kumar 1998) that can be extended to 142.2 Mt for 2030. Goyal and Singh (2002) estimated a demand of 136 and 146 Mt of rice (taken as 50% of total cereals) for the year 2020 and 2030, respectively. On the other end of the scale, third projection puts rice demand to be 156 Mt by 2030 (ICAR, 2010).

Similar variations are obvious in estimates of rice supply for the years to come. Annual growth rate in production has been the criterion for such estimates. The growth rate in rice production was found to be much higher during 1970s and 1980s over the previous decade mainly due to larger increase in yield growth despite of marginal decline in area growth rate during 1980s over previous decade. The production growth declined during 1990s over 1980s mainly due to decline in yield growth (Goyal and Singh 2002). This study projected supply of rice (taken as 50% of the cereals) for the years to 2020 and 2030 to be 136 and 159 Mt, respectively. Averaged over the past 25 years rice production has posted a satisfactory annual growth rate of 2.4%, but during the last decade the figure is only 0.1% (Mittal 2008). Supply projections in this study based on the growth rate of the past decade for rice for the year 2025 is 111.2 Mt that can be projected to 116 Mt for 2030. Linked to the growth of total factor productivity (TFP) the rice supply for the year 2020 is projected to be 134 Mt with the present growth rate in TFP but would fall by 10% to 120.5 Mt if deceleration in TFP is encoutered (Kumar and Jha 2005). Based on linear trend noted for the decade 2000s the projected figures for rice production and productivity are shown in Figure 2. This also shows the expected trend in the next two decades keeping in view the demand position. It is very clear that demands of rice can only be met with empahsis on productivity enhancement and sustainenece.

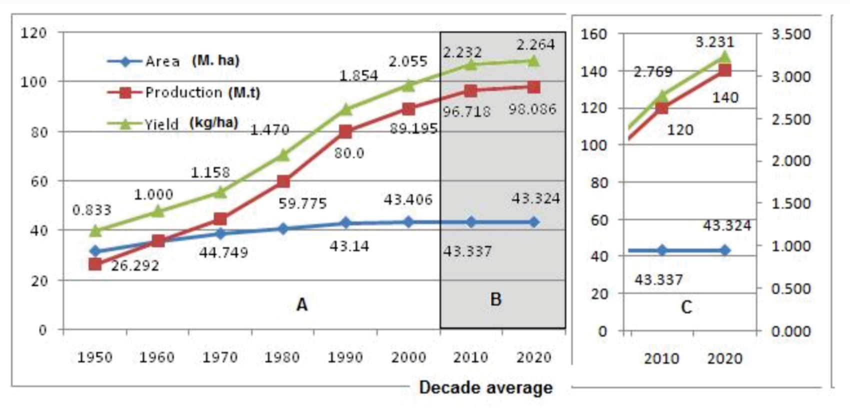


Fig. 2 : Trends (A), projections (B) and preparedness (C) in rice area, production and productivity 1950s through 2020s. Figures are decade averages.

Opportunities

One of the big opportunities to enhance the rice production is through partly bridging the gap between the potential yield and the actual yields obtained by the rice farmers. This estimated yield gap varies from ecosystem to ecosystem and from state to state. This is estimated to be around 20 to 30 percent in irrigated ecosystem, 30 to 50 percent in favourable shallow lowlands, and more than 50 percent in uplands and other unfavourable ecologies.

Several modern biotechnological tools are available now to enhance the efficiency of rice breeding and fortunately India has the needed trained manpower and the requisite facilities to deploy these modern tools. Availability of these modern biotechnological tools, trained manpower and the requisite infrastructural facilities for the rice breeders is a great opportunity to enhance the breeding efficiency and thereby the rice production in the country.

Easy availability to the required information through the modern means of communication is another opportunity for enhancing the rice production. Modern means of communication such as radio, TV, phone, mobile phone, internet audio-visual aids etc., have enormously increased our capacity for quick and easy communication and this greatly helps in increasing our efficiency in achievement of desired results in our efforts to enhance rice production in the country.

Another opportunity is the vast scope for increasing our rice exports. Presently India is second largest exporter of rice after Vietnam, with 4 to 5 million tons of export of basmati and non-basmati rices. There is an ample scope for India to become largest exporter, exporting the highly valued basmati rices, short slender aromatic rices, various types of which are endemic to various states in India, non-basmati high quality rices etc., to Gulf, African and European countries.

Directorate of Rice Research is having excellent linkages with national and international agencies. Any required information, knowledge and expertise required from any of these institutions can easily be availed because of the close and strong linkages with these institutions.

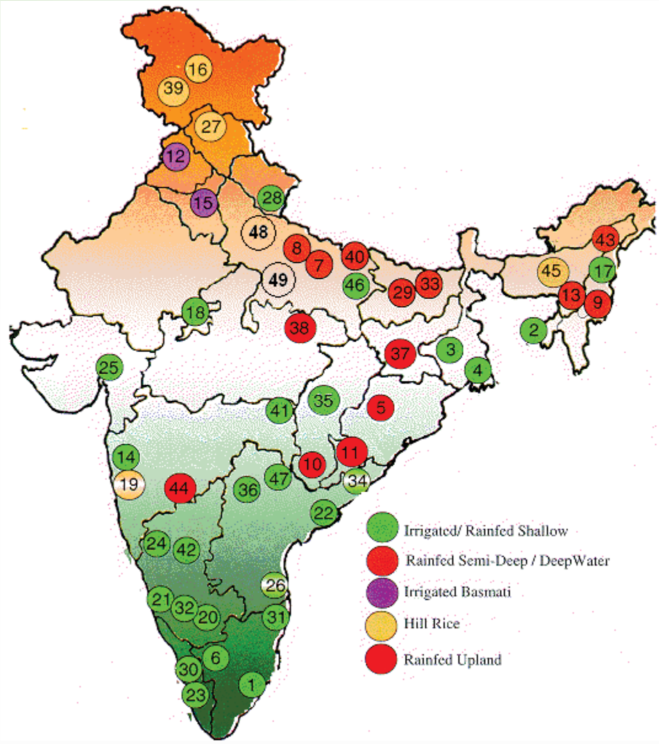
With the emergence of the private sectors as a key player in seed production, especially of hybrids, effective public private partnership is another opportunity for quick spread of the seed and related technologies.

National Rice Research System

Rice research in the country is being carried out by various organizations and Institutes under the Indian Council of Agricultural Research, State Agricultural Universities, Department of Agriculture of the states, traditional universities and other public and private sector national, multinational and international research organizations. Directorate of Rice Research (DRR), Hyderabad and Central Rice Research Institute (CRRI), Cuttack are the two ICAR institutes exclusively engaged in rice research for irrigated and rainfed ecologies, respectively. DRR also coordinates rice research across the country under All India Coordinated Research Project on Rice, known as AICRIP. This network, the largest in the world, has 47 exclusively funded research stations affiliated to state Agricultural Universities and Departments of Agriculture (Fig. 3) with over 350 scientific manpower. Besides, more than 60 centeres participate in AICRIP as voluntary centers.

Mandate

- To organize, coordinate and monitor multi-location testing at national level to identify appropriate varietal and management technologies for all the rice ecosystems.
- To conduct basic, strategic and anticipatory research in the major thrust areas of irrigated rice aimed at enhancement of production, productivity and profitability while preserving environmental quality.
- To develop, organize, coordinate and monitor research networks relating to problems of national and regional importance.
- To serve as major center for exchange of research material and information.
- To accelerate the pace of technology transfer through development and adoption of innovative extension training models, self learning modules and through organizing formal training courses, frontline demonstrations, exhibitions, farmers' day etc.
- To develop linkages with national, international and private organizations for collaborative research programmes.
- To provide consultancy services and undertake contractual research.



No.	Rice Centre	State	No	Rice Centre	State
1	**Aduthurai**	**TN**	25	**Nawagam**	**Gujrat**
2	**Agarthala**	**Tripura**	26	**Nellore***	**AP**
3	**Bankura**	**WB**	27	**Palampur/Malan**	**Himachal**
4	**Chinsurah**	**WB**	28	**Pantnagar**	**Uttaranchal**
5	**Chiplima**	**Orissa**	29	**Patna**	**Bihar**
6	**Coimbatore**	**TN**	30	**Pattambi**	**Kerala**
7	**Faizabad**	**UP**	31	**Pondicherry**	**UT**
8	**Ghaghraghat**	**UP**	32	**Ponnampet**	**Karnataka**
9	**Imphal/Wangbal**	**Manipur**	33	**Pusa**	**Bihar**
10	**Jagdalpur**	**Chhattisgarh**	34	**Ragolu***	**AP**
11	**Jeypore**	**Orissa**	35	**Raipur**	**Chhattisgarh**
12	**Kapurthal**	**Punjab**	36	**Rajendranagar**	**AP**
13	**Karimganj**	**Assam**	37	**Ranchi/Kanke**	**Jharkhan**
14	**Karjat**	**Maharastra**	38	**Rewa**	**MP**
15	**Kaul**	**Haryana**	39	**R S Pura**	**J & K**
16	**Khudwani**	**J & K**	40	**Sabour**	**Bihar**
17	**Kohima**	**Nagaland**	41	**Sakoli**	**Maharastra**
18	**Kota**	**Rajasthan**	42	**Siriguppa**	**Karnataka**
19	**Lonavla***	**Maharastra**	43	**Titabar/Jorhat**	**Assam**
20	**Madya**	**Karnataka**	44	**Tuljapur**	**Maharastra**
21	**Mangalore**	**Karnataka**	45	**Upper Shillong**	**Meghalaya**
22	**Maruteru**	**AP**	46	**Varanasi**	**UP**
23	**Monocompu**	**Kerala**	47	**Warangal**	**AP**
24	**Mugad**	**Karnataka**	48	**Nagina**	**UP**
*** test sites only**			49	**Kanpur**	**UP**

Significant achievements

Over the past four and half decades DRR has been instrumental in development and release of over 946 rice varieties for all the rice ecologies. Impact of these varieties is reflected in doubling of rice production and tripling of productivity during the same period. DRR itself has developed over 39 rice varieties and three hybrids. Of the varieties released under AICRIP, 19 are being cultivated in 25 other rice growing countries worldwide. These high yielding varieties and hybrids cover over 80% of the rice area. The national hybrid rice network coordinated by DRR helped in release of over 46 hybrids both from public sector and private sector. Area under hybrids is now about 1.25 million ha and with a minimum of 1 tonne yield advantage, hybrids alone are contributing to production of an additional 1 million tonnes per year. The directorate has also shouldered the responsibility of producing 20-30 tonnes of breeder seeds every year of the released popular rice varieties and parental lines of the hybrids. Frontline demonstrations sponsored by Department of Agriculture and Cooperation and organised by DRR have identified suitable varietal and other production technologies for all rice ecologies that could increase production by 10-15%. Recently released two rice varieties Improved Pusa Basmati and Improved Samba Mahsuri are the first products of marker assisted back-cross breeding – an example of application of biotechnology in rice improvement. DRR is reaching out to all the stakeholders through effective management of ITMU and harnessing the ICT tools for managing the Rice Knowledge Portal.

DRR 2030

The Directorate of Rice Research has been in effective service of the country since the past 46 years. Through this period it has strengthened its infrastructure and human resources and is well prepared to face the domestic and global challenges. It is committed to maintain its leadership and is responsive, vibrant and sensitive to the needs of its stakeholders.

Vision: Welfare of the present and future generations of Indian rice farmers and consumers by ensuring food, nutritional and livelihood security.

Mission: Develop technologies to enhance rice productivity, resource and input use efficiency and profitability of rice cultivation without adversely affecting the environment.

Focus: To accomplish the vision and mission of the DRR following areas have been identified as the focal themes.

- Strengthening frontier research for genetic enhancement of yield, quality and nutrition with stability
- Improvement of genetic resources / germplasm
- Developing and optimizing water saving technologies
- Improving soil health and input use efficiency for sustainable production
- Coping with the adverse effects of climate change
- Selective mechanization and value addition to overcome labour shortage and to enhance profitability
- Stabilizing yields through integrated pest management
- Accelerated technology transfer and commercialization through ICT and public private partnership.
- Identification of technologies suitable for different ecologies/ environments

Harnessing Science

Directorate of Research aims to increase rice productivity, enhance potential yield, input use efficiency, reduce cost of cultivation and yield losses, minimizing risks and improving quality through harnessing the power of science and knowledge. In the present context, technological options with new tools, methods, techniques and approaches are available to meet the complex challenges of increasing demand for food under dwindling resources.

Potential of genetic-resource enhancement

Genetic improvement will continue to be the primary driver for augmenting productivity in the near future. At present a vast variety of genetic resources of rice, its wild relatives and intermediates are available in our collections. Several of the germplasm have been well characterized with identified genes for resistance to major biotic and abiotic stresses. Need of the hour is to widen the genetic base of high yielding varieties through introgression of genes from wild and untapped genetic resources. This can be now addressed through improved tools for (i) characterization (ii) genetic enhancement and pre-breeding (iii) functional genomics, proteomics, phenomics etc., (iv) gene discovery (v) molecular breeding through tools like marker-aided selection and gene stacking and (vi) customized genetic engineering (development of trait-specific transgenics) and molecular nanosystems.

Power of biotechnology

The availability of rice genome sequences in public domain has opened the door for several advances such as the gene identification, fine mapping of genes, discovery of useful novel genes, functional analysis of genes, cloning and construct development and so on to speed-up breeding processes for increasing yields and minimizing production risks. The products of first generation biotechnology such as improved Pusa Basmati, improved Samba Mahsuri are in farmers field and yield enhancing QTL introgressed lines are in advanced stage of testing. The transgenic research would be continued and further strengthened to those traits that have shown low probability of research success in the past using conventional efforts.

Management of natural resources

Declining quality of natural resources like water and soil is a major cause of concern. The conventional method of amelioration are proving expensive and unstable. Hence production systems are to be efficiently managed for sustainability. Potential of conservation agriculture, zero tillage, precision agriculture and micro-irrigation need to be explored and suitable fine tuning to be made. With the advancement of weather forecasting and remote sensing technologies short term and medium term prediction can be made and effective amendments can be implemented to meet natural disasters like drought and floods. Complex simulation models enable us in predicting pest outbreaks and immigration whereby precautionary and prophylactic measures can be undertaken to avoid huge losses.

Changing socio-economic scenario

Under changing socio-economic world order due changes are also needed in restructuring institutionalized research activities. IPR related issues have already throttled free flow of germplasm and breeding material even within the country. Several of the rice biotechnology products developed by public organizations are likely to be entangled in proprietary related legal issues before seeing the light of the day. Hence it is imperative to evolve effective public and private sector partnerships and undertake confidence building measures for development of technologies which are good both for public and the private sectors.

Human-resource development

Improving quality of human resource is critical. Maintaining global standards and enhancing competitiveness are equally important. Efforts need to be made to develop state-of-the art infrastructure and to enhance faculty competence. Existing pool of talented human resource and infrastructure would be utilized to evolve effective rice production technologies.

Technology transfer systems

Latest ICT tools have revolutionized the pace and quantum of information flow. Proven technologies can now be taken to be end users and stakeholders rapidly and convincingly. Higher investments in these areas pay richer dividends. Novel approaches can be designed to reach out remotest part of the country. 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.

Strategy and Framework

To achieve the goals set above, a 12 points strategy has been developed to enhance and sustain rice productivity to meet future demands of domestic consumption and surplus for export. (Details given in the annexure: 1)

- **Enhancing genetic rice yield potential through**
  - Widening the genetic base
  - Improving germplasm
  - Wide hybridization and introgression
  - Exploiting hybrid vigor
  - Converting rice to C4 pathway
  - Allele mining and gene discovery
- **Stabilizing rice yields through**
  - Incorporation of disease and pest resistance
  - Tolerance to salinity, sodicity and alkalinity in soil
  - Submergence and drought tolerance
  - Low and high temperature tolerance
  - Tolerance to iron and aluminum toxicity
  - Enhanced N, P, K and Zn use efficiency
- **Improved grain and nutritional quality through**
  - Stringent selection of grain size before and after cooking
  - Incorporation of aroma determining genes
  - High Zn and Fe content and bio availability
  - Enriching β carotene content
  - Suitability for fast food and other products
- **Sustaining soil health through**
  - Improved integrated management
  - Monitoring soil quality
  - Adopting resource conservation technologies
  - Building up soil resilience through innovative carbon sequestration strategies
  - Utilization of microbial diversity

- **Enhancing water productivity through**
  - Soil water conservation
  - Implementing synergistic effects of water and nutrient interaction
  - Utilization of biomolecules to reduce water loss
- **Improving input use efficiency through**
  - Precision nutrient management
  - Diagnostics of soil and plant nutritional problems
- **Sustaining rice productivity under changing climate through**
  - Assessing climate change and its impact
  - Selecting crop genotypes resilient to climate change
- **Selective mechanization for**
  - Timely operations under labour shortage
  - Reduce human drudgery
  - Value addition and post harvest processing
- **Integrated pest management through**
  - Understanding molecular basis of tritrophic interactions
  - Precise delivery system for pesticides
  - Designing diagnostic tools
  - Developing decision supporting system
  - Exploiting ecosystems services
  - Pest risk analysis
- **Validation and transfer of technologies through**
  - Organizing FLDs
  - Breeder seed production
  - Sponsored and need based training programmes
  - Rice knowledge management portal system
  - Constraint analysis studies
- **Evaluation and identification of technologies suitable for different rice ecologies through**
  - Organizing multi-location evaluation trials

Epilogue

The Dirctorate of Rice Research is committed to address the future challenges in meeting the demands of the growing population and contibute in ensuring food, nutrional and livlihood security. We envision that future opportunies are equally numerous in the form of power of science, demand driven globalization, strong and emerging public-private partnership and enchanting potential of ICT that can be effectively harnessed to meet the goals. Our committed and empowered manpower and state-of-art infrastructure will ensure delivery of the promise. It is also hoped that appropriate policy environment is created to maintain the pace of progress and fruits of research reach all the concerned stakeholders.

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Annexure 1: Strategic framework

Goal	Approach	Performance measure
Redesigning rice plant type with more photosynthetic efficiency, biomass and harvest index to enhance genetic yield potential.	· Exploiting sub- specific gene-pool to introgress traits related to high yield and biomass. · Introgressing the yield enhancing QTLs from wild and traditional germplasm. · Improving the hybrid vigor by introgressing genes/ gene blocks from wild and intra- sub specific germplasm. · Search for the possibility of converging rice C3 to C4 pathway through genetic engineering. · Allele mining, identification and cloning of candidate gene(s) and transforming the rice with high photosynthetic efficiency.	· Developed rice varieties and hybrids with 20-30% higher yield than the present best variety and hybrids. · Pre breeding materials with C4 enzyme pathway
Germplasm improvement	· Developing pre-breeding material by effective utilization of rice germplasm. · Gene discovery and product development using high throughput molecular tools. · Developing the rice idiotype for conservation agriculture.	· Developed the pre-breeding genetic resources for future improvement of rice yield.
Stabilizing rice productivity through improving biotic and abiotic stress tolerance and high quality seed	· Identification, mapping and introgression of novel genes for major disease and pest resistance using conventional breeding and refined molecular marker technology. · Cloning, gene construct developments and transformation, from the other genome for resistance which is not available in rice. · Developing rice varieties with tolerance to salinity, sodicity, cold, heat, iron and aluminum toxicity, Zn and P deficiency tolerance. · Improving rice to high N, P, Zn and water use efficiency through conventional and MAS breeding approaches. · Cloning of weed suppressive genes from other genome and transferring in direct seeded rice through genetic engineering.	· Developed rice varieties with multiple resistance to biotic and abiotic stress tolerances. · Rice plant type/ variety for conservation agriculture to save water, fertilizers and pesticides. · Increasing rice productivity in nutritionally poor soil with several stresses. · Reducing the cost of cultivation and improving the profitability in rice cultivation
Improving the grain and nutritional quality and value addition of rice	· Improving rice quality for consumer preference for domestic and export through conventional and molecular breeding. · Comprehensive profiling of aromatic compounds and gene identification using next generation sequencing technologies. · Enhancing the nutritional quality of rice such as high iron, Zn, ß carotene, protein and low glycemic index and phytates. · Improving specialty rices for instant food through conventional breeding.	· Rice varieties with superior quality. · Rice varieties with high iron, zinc, protein, ß carotene and its bio availability. · Rice varieties with low glycemic index and phytates. · Instant food rice varieties

Goal	Approach	Performance measure
Sustaining soil health / quality in irrigated rice	· Assessment of abiotic stresses and their physiological / biochemical basis of tolerance (soil salinity, alkalinity, acidity, nutrient deficiency / toxicity, heat, temperature, elevated CO2, light intensity) for genetic manipulation and refining integrated management options · Monitoring soil quality changes under changing rice production systems (zero tilled / aerobic / SRI / DSR) and its improvement through resource conservation technologies · Integration of energy efficient cropping and farming systems and bio fuel crops to improve soil quality, C sequestration and profitability · Building up soil resilience to soil quality changes through innovative (accelerated composting, enrichment) carbon sequestration strategies · Utilization of microbial diversity in abiotic stress management, sustain soil health and improve nutrient use efficiency	· Mapping of soil problem areas · Development of improved resources conservation technologies to sustain soil quality · Identification of energy efficient cropping systems and composting technologies for carbon sequestration. · Identification of microbial population for water and nutrient stress management.
Enhancing productivity of irrigation water	· Improving soil water conservation and water productivity through integrated soil (eco-friendly molecules, compaction, FIRB), cultural (crop establishment, mulching, variety) and precision irrigation systems (ET, CPE, soil moisture – based, micro irrigation) · Harnessing synergistic effects of water and nutrient interactions to improve use efficiency · Utilization of bio-molecules to reduce water loss in emerging rice production systems	· Identification of soil water conservation molecules and cultural practices for enhancing water productivity. · Refining precision irrigation systems for efficient water use.
Improving input use efficiency	· Maximizing rice productivity and improving nutrient use efficiency in changing rice production systems through precision nutrient management · Exploring nano technology to improve nutrient use efficiency, C sequestration, pesticide delivery and in development of diagnostics for rice soil and plant nutritional problems	· Development of site specific nutrient management system and involving nanotechnology products
Sustaining rice productivity under changing climate	· Assessing regional level climate change intensity and its impacts on rice growth, respiratory metabolism, grain quality, nutrient use efficiency, soil quality, GHG emission, water balance and soil biodiversity for development of appropriate management technologies · Crop growth analysis for developing idio types suitable for emerging rice production systems	· Estimation of the impacts of climate change on rice production system · Identification of improved management options to mitigate the impacts
Selective mechanization in rice to reduce drudgery and improve profitability Integrated pest management	· Design and development of machinery for selective mechanization of rice establishment and nutrient and weed management · Value addition in rice, and post-harvest processing to reduce losses	· Development of efficient implements for rice establishment and nutrient/weed management · Value added products available

Goal	Approach	Performance measure
Validation and Commercialization of technologies developed and promoting public-private partnership	· Understanding chemical/molecular basis of tritrophic interactions using geneomic tools (plant/ pest/natural enemies/antagonist) · RNAi approach for disease and pest management. · Development of precise delivery systems for pesticides and bioagents. · Development of GIS/RS based DSS · Designing diagnostic tools for identification of pest/pathogen strains/races/biotypes · Exploting ecosystem services for pest management · Pest risk analysis for existing and potential invasive alien species	· Methods developed for effective and precise pest managment
Evaluation and identification of technologies suitable for different rice ecologies	· Organization of FLDs for validation and spread of proven technologies on farmers field · Organization of Breeder seed production for commercialization · Organization of sponsored and need based training programmes for capacity building · Development and maintenance of Rice Knowledge Management portal · Analysis of socio-economic and gender sensitive issues in adoption of rice production technologies · Organizing multilocation evaluation trials for validation of varietal and other production and protection technologies	· Spread of proven technologies · Spread of new varieties and enhance seed replacement rate · Trained manpower available for technology dissemination · Single window clearance for rice information · Identification of the constrains in adoption of rice production technologies · Suitable varieties and technologies validated for different rice ecologies

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