भाकृअनुप
ICAR

Vision 2050

ICAR RESEARCH COMPLEX FOR GOA

(Indian Council of Agricultural Research)
Old Goa - 403402, Goa, India

www.icargoa.res.in

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शरद पवार
SHARAD PAWAR

सत्यमेव जयते

कृषि एवं खाद्य प्रसंस्करण उद्योग मंत्री
भारत सरकार
MINISTER OF AGRICULTURE &
FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA

Message

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

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

I wish ICAR RC Goa all success in realisation of the Vision-2050.

(Sharad Pawar)

डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL

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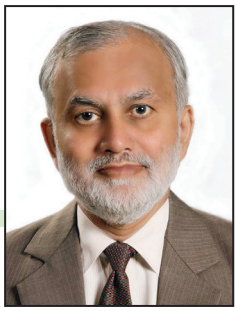

Foreword

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

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

generation and delivery, and enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy efficiency, agri-incubators and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive.

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

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

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

Dated the 24th June, 2013
New Delhi

(S. Ayyappan)

डॉ. एन. पी. सिंह
निदेशक
Dr. N. P. Singh
Director

गोवा के लिए भा. कृ. अनु . प . का अनुसंधान परिसर
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Preface

Agriculture continues to be the mainstay of the Indian economy. Despite a fall in its share from 55.1 per cent in 1950-51 to 14.0 per cent in 2011-12, the importance of agriculture has not diminished. The country achieved self-sufficiency in food production at the macro level, but still is a food deficit country facing massive challenges of high prevalence of malnourished children and high incidence of rural poverty. However, India is marching towards a global outsourcing hub in the production and supply of inputs needed for sustainable agriculture products and processes developed through biotechnology and Information and Communication Technology (ICT).

The Indian Council of Agricultural Research upgraded the ICAR Research Complex for Goa to a full-fledged Institute in April, 1989 keeping in mind the ever-growing needs of agricultural research, education and extension of the state of Goa. The Research Complex carries out applied and strategic research in field crops, horticulture, livestock and fisheries. However, economic viability of farming has to be improved by substantially increasing the net income of farmers. Protection and improvement of land, water, bio-diversity and genetic resources are essential for sustained increase in productivity, profitability and stability of major farming systems.

High rainfall to the tune of 2800 to 3000 mm and fertile soils and valleys in the undulating terrains of the west coast would be favorable factors for increasing production of many agriculture commodities particularly horticulture and plantation crops. As the natural resource base is strong, potential cash crops like cashew, spices as intercrops in coconut and arecanut gardens, fruit and flower crops can be produced in this region which can take advantage of programmes such as Agriculture Export Zone (AEZ). However, marginal and small holding

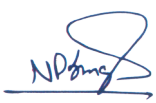
farmers with less than 1 ha in this region have many limitations in large scale adoption of technologies for increasing output.

The Institute would have to endeavour for developing modern technologies in the changed scenario of economic liberalisation for export oriented agriculture. The strategy in this direction would be a multi-disciplinary approach aimed at problem specified solutions to meet farmers' needs.

This vision document outlines a roadmap for self sufficiency in agricultural production through a multipronged approach. Farmer-to-farmer learning by establishing farm school in each block, adopting location-specific Integrated Farming Systems (IFS), ensuring timely availability of quality seeds, integrated and balanced nutrient application and management, efficient water management, water harvesting and water use efficiency deserve the highest priority.

Higher growth in agriculture assumes great importance and is a matter of concern for policy planners and research scholars in recent times. There is potential for enhancing yield of major crops through better soil and water management, profitable crop rotation, innovative marketing and genetic engineering. We need to strengthen the existing infrastructure through seamless integration at policy level so as to avoid functional bottlenecks in operation across stakeholders mainly collaborating institutions, state agricultural departments, SAUs, ICAR institutes, etc. for taking the major objectives forward. The Vision-2050 document is an effort to address the problems and challenges in relevant areas, for chartering a path of holistic development, monitoring, surveillance, decision making and policy formulation.

I take this opportunity to thank Indian Council of Agricultural Research (ICAR), especially our esteemed Director General and Secretary, DARE, Dr. S. Ayyappan for ushering a wide vision of Indian Agriculture through his visionary wisdom. I express my gratitude to Dr. A.K. Sikka, Deputy Director General (NRM) for his sincere advise and consistent encouragement for developing this vision document. I am also thankful to Dr. B. Mohan Kumar, ADG (Agronomy & Agroforestry) and Dr. Rajbir Singh, Principal Scientist (Agronomy) for their encouragement, guidance and critical comments to develop this document. I also thank all my colleagues from the Institute for their contribution to bring out this document.



Dated 25th June, 2013

Narendra Pratap Singh

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CONTEXT

In the new millennium, the challenges in Indian agricultural sector are quite different from those met in the previous decades. The enormous pressure to produce more food from less land with shrinking natural resources is a tough task for the farmers.

The state of Goa is situated along the Konkan tract bound by Arabian Sea on the West and the states of Karnataka and Maharashtra on the other sides. It is the smallest state of India with geographical area of 3.61 lakh hectares, out of which only 39% (1.41 lakh hectares) is cultivable area and the rest 61% (2.20 lakh hectares) includes forest area of 1,425 km^2 and uncultivable area. The warm humid and equanimous coastal climate ideally suited for all kinds of agricultural activities viz., cultivation of annual field and perennial horticultural crops, livestock enterprises and fish farming. The region produces certain unique products, ethnic food recipes commodities like feni, madi, kokum, tirphal. Goa has a coast line of 105 km, riverine networks and mangroves, mineral resources - iron and aluminum ores, range of soils (alluvial, clay, sandy, lateritic), habitats (khazan lands, estuaries, riverine, marine islands) and cultivation systems (mountains, sand dunes, Kumeri, Kulagars). Goa is also the most sought tourist destination with greater movement of the people.

Goa has rich flora and fauna owing to its location in Western Ghats which is classified as a biodiversity hotspot. The Western Ghats passes through Goa in an area of 600 km^2 (an arc of 125 km long). Western Ghats region is one of the most important mega-diversity centres of the world. The western region comprises 5.08 lakh sq. km with a coast length of about 2,442 km and with a population of nearly 17 crores. A total of 30 districts of three states viz., Goa, Gujarat and Maharashtra fall in this area and the population mainly subsists on agriculture. The Western Ghats are home to four tropical and subtropical moist broadleaf forest eco-regions – the North Western Ghats moist deciduous forests, North Western Ghats montane rain forests, South Western Ghats moist deciduous forests, and South Western Ghats montane rain

forests. There is a lot of variation in soil and physiographic conditions of the region. Thus, profitable utilization of land on sustainable basis is a major issue especially when priority is for mining and tourism activities. Identification of watersheds and their delineation and conservation and utilization of soil and water resources need to be addressed in all possible ways. The issues related to rehabilitation of mine reject soils and management of coastal saline soils for improved productivity need top priority.

The Indian Council of Agricultural Research, New Delhi, established the ICAR Research Complex for Goa in April, 1976. After a short spell under the ICAR Research Complex for North East Region, the complex was brought under the administrative and technical control of the Central Plantation Crops Research Institute, Kasaragod, Kerala. After functioning at different Government agricultural farm sites in Goa, the location was finally shifted to Ela, Old Goa in 1982. In order to intensify the transfer of technology and to impart grass-root level vocational training, a Krishi Vigyan Kendra was also established at the Research Complex in 1983.

The centre was upgraded to a full-fledged Institute in April, 1989 to cater to the growing needs of agricultural research, education and extension in the state of Goa. The Institute carries out basic, applied and strategic research specific to this region, in field and horticultural crops, livestock and fisheries. In all, the Institute has 50.83 ha land of which 33.67 ha was acquired during 1987. The staff strength of 93 comprises of 20 scientists from different disciplines on research side and another 19 technical, 21 administrative and 32 skilled support staff.

The research activities of the institute are grouped under five functional groups namely, Crop Improvement and Protection, Resource Management and Integrated production, Horticulture, Animal Sciences and Fisheries. Transfer of technology programmes are organized for farmers comprising both on campus and off campus training and field demonstrations through active participation of KVK. The Institute is also a centre for AICRPs on cashew, integrated farming system (IFS) and pig and a voluntary centre for AICRP on rice, arid legumes and vegetable crops.

Salient research achievements of the institute are identification of suitable varieties of different crops. For example, a short duration rice variety 'Annada' was developed for cultivation in the rainfed uplands. Similarly, new high-yielding varieties of rice were identified for cultivation in Goa (Pusa-44 and Karjat-3, found suitable for rainfed shallow lowland situation, Naveen for Rabi season and CSR-27 and CSR-36 for coastal saline soils). About 16 landraces of rice were collected and their characterization is in progress. Suitable technologies for rice based cropping / farming systems were identified, improved varieties in groundnut and cowpea for cultivation in rice fallows under residual soil moisture situations were introduced and tested, sugarcane varieties suitable for local situations along with fertilizer schedules were standardized and suitable species for rehabilitation of mine reject soils were identified. Different bio-engineering measures for soil and water conservation involving cashew and mango were initiated. Eco-friendly management of major insect pests and diseases in plantation, fruit crops, field crops and vegetable crops was developed and validated. Integrated pest management practices for management of red palm weevil in coconut through pheromone traps were popularized. Endophytes and rhizobacteria from different crops were screened for their antagonism against *Ralstonia solanacearum*. PCR based sensitive detection of *R. solanacearum* from soil and other sources was standardized. Sensitivity of detection is as low as 100 bacteria/g of soil.

On-going research includes identification and development of suitable high yielding salt tolerant rice varieties for coastal saline soils, identifying high yielding pulses including groundnut in rice fallows for increased production and productivity, standardization of spawn production technology for local mushroom production, standardization of technologies for production of bio-control agents for disease management and increasing production in field and horticultural crops.

Goa along with Daman, Diu and other small locations has a unique political history of being ruled by Portugal for 450 years. Portuguese introduced many plant species and varieties from their colonies such as Brazil. Cashew is one such introduction done first at Goa for soil and water conservation measures. Cashew being a major plantation crop of

the state currently occupies 55,732 ha with estimated productivity and annual production of 415 kg per ha and 23,138 tonnes, respectively. However, under the existing edaphic and agro-climatic conditions, there is vast scope for enhancing productivity and production by which the demand for the raw material for the processing sector can be easily met with. Cashew germplasm collection of 80 local accessions is being maintained. This collection is comprising of 14 jumbo nut types, 26 bold nut types, 12 medium nut high yielders, three dwarf types and the remaining 25 either high yielders/cluster bearers, irrespective of nut size. Improved and popular varieties of cashew developed elsewhere have used Goan germplasm of cashew.

The state has much variability in cashew and its utilization can go a long way in producing varieties which have both nut quality of international standards and big apple sizes for juice extraction. Goa is the only state where cashew apples are utilized for making alcoholic beverage, "Feni'. It has a great potential for revenue earning. Now Goan cashew feni enjoys the status of a GI product. Microflora of naturally fermented cashew apple juice was studied. The predominant yeasts isolated and identified from fermented cashew apple juice were *Saccharomyces cerevisiae, Pichia species* and *Issatchenkia orientalis*.

Coconut is the second most important crop of the state. There are two local popular tall varieties, Benaulim and Calangute. Inter/mixed cropping of new intercrops such as coriander (cv. Pusa Sugandha) were found highly productive and profitable.

The state also has varieties of mangoes like Mankurad, Hilario etc. with outstanding qualities those need to be conserved and economically exploited. A total of 114 varieties of mango germplasm are conserved at the Institute farm. Cardozo Mankurad is registered by the Institute as fibreless selection in Mankurad mango.

Kokum being a speciality of the region with high value products like juice, butter etc, its cultivation has to be planned either as a mixed crop in coconut/arecanut gardens or as border crop or as block plantations. Low cost polyhouses have vast scope for vegetable cultivation, like capsicum and flowers e.g. Gerbera. Diversification of cropping systems with vegetables, flowers and high value crops alone or as intercropping of crops like ginger, turmeric, vanilla etc

in coconut/arecanut has proved to be profitable. The technology on commercial production of turmeric and ginger has been successfully transferred to the progressive farmers.

Noni is a potential medicinal and dye crop of the future and occurs wild along the Konkan coast. Due to tourism activities the plant is being overexploited. A program to collect and conserve the germplasm of noni native to Goa and Maharashtra has been initiated. Six accessions of Goa were sent to NBPGR, New Delhi for conservation.

The institute has done research on computational genomics and developed softwares. Marker Express 1.0 software was developed to locate RAPD/ISSR primers and design iSCAR primers. It was validated using expressed sequences and published polymorphic RAPD primers on oil palm. DG-MAP software was developed for locating RAPD and SSR priming sites and to work out the distance between the priming sites. It was validated using genome sequence of cucumber. The software successfully mapped the known and predicted markers closely linked to F locus.

Small scale farm mechanization in agriculture is required. Introduction of tree climbers in coconut and harvesters in mango would reduce dependence on skilled labour. In rice, use of transplanters, cono-weeder, drum seeder, rotary weeder and harvester can reduce dependence on farm labours. As the land holdings are small, use of power tillers need to be promoted. Post-harvest management including preservation, processing, and value addition needs greater attention.

In the livestock sector, focal areas of attention include breeding of cattle and other meat animals, improvement of local breeds of cattle, scientific rearing of rabbits and goats, backyard poultry rearing, nutrition and health care. Pig being the preferred local species, some of its value added products like sausages need to be promoted to meet the needs of the tourism industry. Similarly, partial stallfed rearing of goats will be a high revenue earning proposition. Backyard rearing of poultry like Vanaraja, Giriraja and dual purpose poultry would be boon to rural areas.

Crosses of Yorkshire and local pigs were identified as suitable breed for coastal tropical humid climate and popularized. The complete package of meat rabbit production including suitable breed,

housing, feeding etc. has been standardized. Similarly, package of practices were standardized for improving fertility and fecundity in pigs and rabbits. The major issue with livestock farming in Goa is non-availability of feeds and fodders. The annual requirement of concentrate, green fodder and dry roughages is about 1.23, 10.08 and 1.67 lakhs tonnes, respectively. In terms of supply, the deficiency percentage is highest for concentrate at 93%, followed by 49% for green fodder and 50% for dry roughages. Feeding of green fodder as replacement of costly concentrate mixture was standardized and economic ration formulations for various types of livestock were popularized. Hydroponics technology for fodder production and feeding to dairy animals was standardized. Technology for preparation of silage without feed additives was developed to preserve the surplus green fodder. An indigenous technology for the preparation of bypass fat was developed and introduced for supplementation to the dairy animals. Economical feeding strategies were developed for dairy animals and pigs by utilizing the locally available unconventional feed ingredients like brewers' grain, cashew apple waste, etc. For the proper use of the locally available crop residues, feed block feeding technology is being popularized in Goa.

Disease investigation laboratory was established for taking up disease diagnosis work. State-of-the-art facilities to diagnose listeriosis and other foodborne infections in humans and animals and to subtype strains have been established. The Institute has been recognized as a Centre of Excellence for molecular epidemiology of *Listeria monocytogenes* and has excellent facilities for molecular subtyping of bacterial pathogens. PCR based diagnostic kit for detection of *Listeria monocytogenes* from food and clinical samples (human and animal) has been developed. A well characterized repository of the strains of *Listeria*, Indian *Listeria* Culture Collection (ILCC) has been established.

The water bodies in the coastal line present opportunities for exploiting both inland and marine fisheries. For fisheries, the areas needing consideration include Khazan (saline) land aquaculture production with identification of suitable cultural technology for species diversification, identification of suitable seed production technology and setting up of seed production units for the commercially important brackish water finfish and shellfish species for promotion

of aquaculture production. In the marine sector, conversion of unproductive trawlers into long line Tuna fishing vessels, cage culture/ mariculture of seabass and mussel and facilities/yards for drying fish to utilize the bumper marine catches need attention. Emphasis should also be on ornamental fishes for revenue earning.

The region also attracts tourists because of natural beauty and the pristine environment. Therefore, there is tremendous scope for intermixing agricultural technology with eco- tourism, for getting higher income and profitability to the farmers of the region.

However, increasing labour costs, land fragmentation, traditional way of farming and low returns from the sectors (both agriculture and livestock) compared to tourism causes great concern over the future of agriculture in the state. There is challenge of increasing production of crop, flowers, milk, meat, poultry and fish to reach a level of at least self sufficiency. The region also suffers from extensive land degradation and erosion.

ICAR Research Complex for Goa is proposed to be upgraded as ICAR Research Complex for Western Region with revised mandate and objectives. Horticultural crop productivity of the western region is high and there is a need to have research programmes addressing the specific problems in the region. Western Ghats is a major biodiversity hotspot and there is tremendous genetic diversity among the horticultural plant species. Hence, specific programmes to cover the conservation and utilisation of the horticultural genetic diversity in the region need to be formulated.

Being a multi-disciplinary and multi-commodity Institute and covering detailed aspects of field and horticultural crops, livestock, fisheries and related aspects, besides its location in a typical coastal ecosystem representing the West coast zone of the country, it can take up the challenges of agricultural research requirements of the coastal region and parts of the Western Ghats, in future.

❑

CHALLENGES

Increased industrialization, enhanced importance of tourism and mining in Goa have relegated the agricultural activities to third position. As a consequence, the number of people involved in agriculture is declining steadily and so is the investment and interest of the people in agriculture. Again, for the same reason, the cost of labour is increasing which may cause the profits from agricultural enterprises to decline. Concurrently, reduction in the availability of labour for agriculture has made the timely execution of agriculture operations difficult. This is also leading to fertile agricultural lands becoming fallow. This puts a question mark over the future of agriculture in Goa unless immediate corrective measures are taken to reorient our priorities towards high value agricultural products, increased mechanization and value addition to the produces.

Mine rejects pose a threat to the ongoing agricultural lands on the low lying areas and silting and pollution of rivers, which have to be properly looked into and corrective measures incorporated. The region has about 18000 ha of khazan land which is problematic and not suitable for many agricultural crops excepting rice cultivation and fisheries. Unless a planned development is envisaged this natural resource cannot be properly utilized. Goa has 2000 ha of mangroves which are very important for sustaining the coastal eco system and marine fish production. There is a need to protect these mangroves and proper study of its ecology. These challenges are going to be manifested in a long way.

The requirements for milk and meat for Goa are approximately 4 lakhs litres and 63 tonnes per day. However, Goa produces only 1/3rd of its daily milk and meat requirements and for the rest, it depends on the neighbouring states. The per capita availability of eggs and meat is 80 and 3 kg, respectively, which is less than the recommended levels.

The requirement for eggs and broilers for Goa is approximately 3.5 lakhs and 25000 per day. However, Goa produces approximately

1/3rd of its daily requirement and for the rest totally dependent upon the neighbouring states. The major issue with the poultry farming in Goa is non-availability of feeds and high cost of production. Increase in tourism sector has itself increased demands for fruits, vegetables, flowers, dairy products, poultry, eggs and fish. In this direction, prioritization has to be made for promotion of cash value crops, horticultural crops, appropriate livestock and fish species, integrated to suit the local agro-climatic situations. Crop improvement programmes have renewed orientation to address the new challenges posed by the climate change.

There are many issues related to coastal agriculture that need to be addressed including development of integrated farming system models for effective utilization of available homestead resources and holistic watershed development, diversification through development of agro-eco tourism, effective utilization of fallow lands for profitable production of field and horticultural crops, rehabilitation of mine reject soils, livestock rearing, diversification in brackish water aquaculture and secondary agriculture.

Some of the challenges which need attention are:

- Reclamation of coastal saline soils (*khazan land*) for paddy and fish cultivation.
- Remediation and rehabilitation of mine reject soils to tap their potential by cultivating suitable crops. In this context, development of eco-friendly and cost-effective techniques is of paramount importance.
- Development of multiple stress tolerant (salinity, submergence and mineral toxicity) rice varieties for coastal saline areas
- Collection, conservation, characterization and utilization of plant genetic resources for future breeding programme.
- Screening of genetic resources considering the trends in current climate changes and utilization of potential genetic resources in development of new varieties
- Management of insect pests and diseases in the major field and horticultural crops

- Climate change poses serious threat to biodiversity and agricultural production. Emergence of new pest and diseases, and emergence of minor pest and pathogens to major ones due to climate change.
- Insufficient availability of elite planting material and seeds of horticultural crops
- Non availability of reliable, rapid and low cost disease diagnostic methods
- Management of stem and root borer and tea mosquito bug in cashew
- Shortage of feeds and fodder, evaluation of fodder crops suitable for Goan conditions and development of feeding strategies for high producing animals
- Increasing productivity of the livestock to achieve the self sufficiency for the state of Goa through breeding, improving feed and fodder sources, improved health care, rural poultry and piggery development.
- Increasing productivity of eggs and meat through rearing of alternative poultry species like Japanese quails and ducks and use of alternate locally available feed ingredients to reduce the feed cost.

Operating Environment

The state of Goa forms the part of Western Ghats. Agriculture represents the third important economic activity in Goa providing livelihood to 16 % of the population after tourism and mining. The topography of Goa can be divided into coastal plains, sub-mountainous region and hilly region. In coastal plains mainly rice is grown in kharif and, rice and groundnut in rabi extended summer seasons. Sub-mountainous region is covered mainly by horticultural crops namely cashew, coconut, arecanut, mango etc. Thick forest areas cover hill region. The coastal plains and sub-mountainous regions are suitable for livestock rearing. There is a gradual shift from labour intensive field crop production to perennial horticultural plantations due to the better returns and lower risk. There is emphasis on mixed farming wherein farming system research including watershed management is gaining importance. Cashew is cultivated in nearly 55000 ha with paddy covering about 31000 ha. Problematic soils, khazan lands covering an area of 18000 ha are not suitable for cultivation of many crops except rice and fish farming. The region has substantial area under mine rejects which is problematic and not suitable for agriculture purposes. State of Goa is rich in rice diversity particularly land races tolerant to soil salinity. These landraces are potential source of genes for future use in variety development programmes.

The farming system forms the part of Agri-silvi-horti-pastoral coastal ecosystem. The important farming systems have been blessed with strong natural resource base and enchanting scenic beauty in the hinterlands of Goa are as follows:

1. Rice based farming systems
2. Coconut based cropping/farming system
3. Arecanut based cropping/farming system
4. Cashew based cropping/farming system
5. Animal based farming system
6. Fish based integrated farming system

Goa has an area of 3702 Sq. km. of lush green mountains, blue waters and white sands, winding rivers and picturesque villages with

local flora and fauna. It is thus capable of offering a wide variety of entertainment for the discerning tourist and the state has the capacity to diversify into newer fields like agro-eco-tourism for the future.

Development of integrated farming system and agro-eco tourism models has tremendous scope owing to the prevailing agro-climatic conditions for intermixing agricultural technology with eco- tourism. The coastal region, even though it occupies very small portion of the total geographical spread of the state, it has been the most popular tourist destination especially those coming from abroad. Farmers having agriculture as base with spice/ horticulture plantations, floriculture and natural resource like rivers, ponds, jungles with various flora and fauna, healthy and peaceful environment are venturing into this business along with agriculture.

Livestock especially cattle are a traditional component of sub-mountainous production systems. In some areas goats are reared as herds. In coastal plains besides cattle, pig farming is common. Organized poultry farms are confined to few pockets only. However, backyard poultry is common throughout the state. Immigrant livestock remains low. There is no recognized livestock market in the state of Goa. Therefore, dairy animals, goats, poultry are brought from neighboring states. Along with the animals, diseases are also introduced in new areas.

The state of Goa is deficient in production of cereals, pulses and vegetables, so also in livestock feed ingredients. These feed ingredients are brought from neighboring states, therefore, the cost of production of livestock increases. Agro-industrial by-products namely cashew apple waste, brewery waste, prawn head waste, coir dust are available in abundance. However, their digestibility is low. These products can be incorporated to some extent in animal feed to reduce the feed cost, thereby reducing the cost of production. Rural poultry production with use of suitable varieties like Gramapriya and Vanaraja has to be popularized to improve the rural economy and job opportunity with self employment. Further backyard poultry can be reared in the integrated farming system approach for better productivity and sustainability of the system.

For free flow of improved technologies, access to latest developments in the field of agricultural research taking place elsewhere and constant upgradation of agricultural research at the Institute, viable linkages and collaborations are maintained by the Institute with various other organizations, universities and NGOs related to agricultural research and development.

OPPORTUNITIES

Goa is having a favourable tropical climate conducive for the production and growth of many of the tropical crops and animal species. High rainfall to the tune of 2800 to 3000 mm and fertile soils and valleys in the undulating terrains of the west coast would be favourable factors for increasing production of many agriculture commodities particularly horticulture and plantation crops. As the natural resource base is strong, potential cash crops like cashew, spices as intercrops in coconut and arecanut gardens, fruit and flower crops can be produced in this region. The state is progressive with a high literacy rate. The farmers are receptive towards advanced technologies. Although the pace of agricultural development was not as fast as other parts of India, the potential is very high because of its rich natural resource base. Some of the opportunities are described below:

Biodiversity hotspot: Western Ghats region is one of the mega centers of diversity having many endemic species. The area is one of the world's ten "Hottest biodiversity hotspots" and has over about 4500 species out of which 35 percent are endemic. Nearly 2000 species of higher plants, 84 species of fishes, 87 species of amphibians, 89 species of reptiles, 15 species of birds and 12 species of mammals are endemic to the Western Ghats. At least 325 globally threatened species occur in the Western Ghats. It has been reported that approximately 17% of a set of 2500 microbial species are likely to be present in this region. Western Ghats scores over Eastern Himalayas in harbouring a larger number of species restricted to India alone.

Water resources: The State of Goa is located on the west coast of India and receives abundant rainfall from the South-West monsoonal winds. Rainfall in recent years has been below an annual average of 3000 mm. Though the State has a huge potential of assured water, a high percentage of the water resources get drained down owing to Goa's physiographical set up and ultimately joins the Arabian Sea. The state has nine rivers, of which six rivers originate and flow exclusively

within the state boundaries. Goa has a reasonable scope for fisheries production mainly from marine capture and inland culture resources. It has an equally good potential for production of fisheries processed products for both internal and export markets. More than 80 per cent of the population of Goa is fish eater. Per capita fish consumption is 7.4 kg compared to the national average of 5 kg and recommended average of 11 kg. Though Goa's coastline of 105 km forms only 1.25 per cent of the country's total of 8192 km, its recorded marine fish landing contribution to the country's total ranges from 2.2 to 3.8 per cent.

Meat and meat products: In Goa, about 80% population is non-vegetarian. The demand for meat and meat products is very high both for domestic consumption as well as for tourists. There is an opportunity to enhance production of meat, eggs and fish.

High Value Crops: Increase in tourism sector has increased demands for exotic fruits, vegetables, and flowers. In this direction, there is an opportunity for promotion of high value crops, horticultural crops integrated to suit the local agro-climatic situations.

Organic farming: Organic horticulture has a tremendous potential in the state of Goa. The concept is already well accepted by consumers as well as producers. Agro-tourism centres in the state are actively involved in promoting the organic products produced either at their own centres or by collecting from the vicinity of their centres. Some products such as organic cashew, organic spice products like black pepper, turmeric, nutmeg, chillies, banana, etc are already being promoted at agro-tourism centres and fetching premium price.

Floriculture: The western region of India has got high potential for cultivation of cut flowers and locally available flowers. Huge diversity exists in jasmine, crossandra and other flower species endemic to the region. Floriculture is highly neglected in Goa and accounts for less than one per cent of total horticultural crops. As per rough estimates, Goa has hardly 25 hectare of area under floriculture with the production of 40 tonnes per year. Considerable amount of flowers are brought to Goa region daily for its requirements from neighboring states. There is an opportunity to develop floriculture industry in the region to make the region self sufficient in meeting the demands created by the tourism and seasonal festivals.

Spices and Condiments: Nutmeg is one of the economically important tree spice crops suitable for commercial cultivation in Goa. Abundant seedling progeny exists in arecanut mixed cropping systems. Potential local germplasm stock of nutmeg needs to be identified, collected, evaluated and conserved for posterity. Scope for evaluating the promising nutmeg genotypes as intercrop in coconut gardens is enormous and needs to ensure it as a compatible tree spice crop component in coconut garden, besides introduction of other spice crops like cinnamon and black pepper. There is high degree of variability in chillies grown in Goa.

Secondary Agriculture: Reduction in the availability of labour for agriculture has made the timely execution of agriculture operations difficult. Therefore, there is an opportunity to reorient the priorities towards high value agricultural products and value addition to the produces. The potentialities for agro-based or bio- based industries have not been realized. Agro-industrial potentialities of crops such as ginger, turmeric, cinnamon, tuber crops such as tapioca, yams, sweet potato, groundnut, can be used as a source of carbohydrate, starch and protein. Agro-waste such as paddy husk, rice bran, rice straw, sugarcane bagasse, press mud, vermicompost can be good materials and require consideration and development.

Medicinal plant resources: The Western Ghats region is very rich in medicinal plants. Medicinal plant species of Western Ghats represent a variety of life form ranging from lichen, algae, herbs, shrubs, climber and trees, which are annuals to perennials. The auto-ecology and syn-ecology of medicinal plant species is complex and their proper understanding requires a sound knowledge of the ecology, taxonomy and ethno-botany for these species. Western Ghats with its species diversity is a treasure house of different kinds of medicinal plants. The limited knowledge on the varied use of the medicinal plants, their availability and extent of distribution weakens the ways to utilize these resources efficiently. Therefore, it is required to bring the information from various sources under one roof.

Agro-eco tourism: The booming tourism industry in the region may be taken as an advantage for promotion of agro-eco-tourism in the hinter lands in addition to coastal region.

Goals / Targets

Goa is richly endowed with biodiversity and the agricultural sector continues to play a major role in the Goan economy. Land fragmentation, traditional way of farming, low returns from the sector when compared to the tourism cause a great concern over the future of agriculture in the State. Owing to its location in west coast region and being a multidisciplinary and multi-commodity Institute covering different aspects of field and horticultural crops, livestock and fisheries related aspects, the Institute can take up the challenge of agricultural research requirements of the coastal region and Western Ghats. The strategy in this direction would be a multi-disciplinary approach aimed at problem specified solutions to meet farmers' needs and industries. A multi-pronged strategy would be adopted to accomplish the vision and the goals of the institute to enhance efficiency and effectiveness of the research resources. Following emerging areas of research for ICAR Research Complex for Goa have been identified for the next decades.

Emerging areas of Research

1. Farming system research
2. Agro- eco tourism
3. Organic farming
4. Land use planning and management of problematic soil
5. Breed improvement, nutrition, health care, management, product development and quality control in livestock and poultry
6. Plant genetic resources and genetic improvement of field and horticultural crops by conventional and molecular approaches
7. Climatic change impact, adaptation and mitigation
8. Bioinformatics
9. Protected cultivation for flowers and vegetables
10. Diagnostic kits for plant and animal health
11. Developing post harvest processing and value addition technology
12. Integrated pest and diseases management (biological agent)

In view of the Institute's vision, the following strategic frame work has been formulated for addressing these issues by 2050.

Goal	Approaches
Biodiversity Conservation and Genetic Enhancement	• Protection of plant varieties and farmers' rights and capacity building of farmers for on-farm conservation of plant genetic resource. • Collection, conservation, characterization, documentation and utilization of various crop genetic resources having tolerance to biotic and abiotic stresses • Integration of molecular breeding tools using QTLs for development of new generation varieties/genotypes suitable for nanotechnology-based production approaches such as ultra high density models, ultra precision farming, etc. • Development of precision farming technology for cashew production considering higher productivity targets through efficient use of genetic resources, natural resources and post harvest handling of the product. • Study on the diversity of rice in the west coast region and characterization of the germplasm by morphological and molecular methods • Screening of genetic resources considering the trends in current climate changes and utilization of potential genetic resources in development of new varieties or hybrids in mango, cashew and coconut • Development of strategies for improvement of fertility in livestock
Management of insect pest and plant diseases	• Development of sustainable and efficient insect pest and disease management strategies by incorporating bio- and nano-technology • Development of innovative, nonconventional methods of insect pest and disease management including biological control and integration into IPM • Production of quality bio-agents and awareness training to the farmers • Population dynamics, virulence and diversity of the insect pests and plant pathogens in the coastal ecosystem in the emerging scenario of changing climate change to design appropriate management strategies • Development of rapid, economic and reliable detection techniques of the plant pathogens • Study on the host-pathogen interactions

Management of natural resources	• Long term studies on the effect of different resource management strategies on soil health care including the sustainability • Evaluation and demonstration of soil and water conservation, land use systems and other management practices for sustainable crop production in the region on holistic watershed basis • Soil fertility management and coastal land use planning • Evaluation of technologies for amelioration of acid soils in West coast region such as with the application of lime • Development of suitable water harvesting technology • Reclamation of problematic soils (khajan lands and mine rejects) through Agri-Horti interventions
Farm mechanization	• Evolving labour saving technologies and low cost production technologies through mechanization.
Agriculture diversification	• Introduction and evaluation of improved varieties and hybrids in important vegetable crops of the state for large scale adoption • Introduction and evaluation of cut flowers like gerbera, anthurium, orchids, lillium, carnation etc under protected condition • Development of agribusiness modalities involving public and private partnership through establishing effective network for livelihood security and rural empowerment through horticulture industry. • Development of varieties, production techniques and practices for organic farming of horticulture crops employing the bio-fertilisers and biopesticides and unconventional energy sources • Design, development and popularisation of low cost protected cultivation structures for Goa • Agricultural diversification through integrated farming systems and agro-eco-tourism • Intensifying transfer of technology programme for effective farming and capacity building

Secondary Agriculture	• Diversification in floriculture through value addition especially to improve the shelf life and to standardize technologies for dry flower production, pigment and essential oil extraction • Novel products of horticulture for fast food market • Nanotechnology aided packaging • Value addition, packaging of locally available minor fruits, vegetables, spices • Product diversification and packaging of ethnic foods and recipes • Value addition of poultry products for better keeping quality and higher market value • Human resource development in PHT and value addition
Enhancement of livestock and fisheries production	• Development of economic feeding strategies to produce milk, meat and poultry and evaluation of alternate feed resources • Scientific exploitation of feed resources to fill the gap between demand and availability of livestock feedstuffs. • Improvement in pork production by introduction and evaluation of new pig breeds suitable for area • Rearing of alternate poultry species like Japanese quails and ducks to meet the growing demand of local people. • Improvement of animal health care and delivery systems. • Use of genomics to study the zoonotic and food-borne pathogens • Development of mitigation strategies to reduce adverse impact of climatic change on livestock production • Ornamental fish culture research with particular emphasis on breeding and feed formulation • Diversification of brackish water aquaculture with potential species such as mud crab, oysters and mussels • Application of remote sensing technique to augment marine fish production
Capacity Building	• HRD in new and emerging areas involving all stakeholders in the food supply chain. • Organization of trainings on speciality topics at national and international levels • Foster linkages and collaborations with public and private, national and international organizations

Way Forward

The Goa region has unique characteristics of richness in biodiversity, high rainfall, extensive plantations and forests. The water bodies in the coastal line present opportunities for exploiting both inland and marine fisheries. However, the region suffers from extensive land degradation and erosion. The region also attracts tourists because of natural beauty and the pristine environment. Therefore, there is tremendous scope for intermixing agricultural technology with eco- tourism, for getting higher income and profitability to the farmers of the region.

The way forward to achieve the goals of Vision 2050 would be a holistic strategy encompassing various programmes making the region self-sufficient in food production. There is need for strengthening knowledge-led and technology-based alleviation of food insecurity. More food has to be produced with lesser resources. The efficiency of production has to be increased through modern management of improved technologies. The agricultural research and development in this region would augment farmers' income, livelihood security, generate employment opportunities, conserve natural resources, and increase value addition for higher and inclusive agricultural growth. The institute will work to develop ideal integrated farming system models for the region and diversify agriculture through activities like agro-eco-tourism in a participatory mode. Emphasis will be given on diversification of fisheries activities for sustainable production. The Institute is strategically positioned for playing a bigger role for addressing the problems of West coast agriculture in an integrated and holistic manner. Emphasis will be given on rearing of alternate poultry species like Japanese quails and ducks to meet the growing demand for egg and meat.

Emerging technologies like information technology (IT) and computer application, super efficient and more accurate electronic equipment, geographic information system (GIS), geographic

positioning system (GPS), and hybrid seeds, biotechnology, gene revolution, next generation sequencing (NGS), laser technology, efficient micro-irrigation systems, zero or reduced tillage technology, site specific nutrient management system including balanced soil and plant nutrition and health management based on soil test for macro and micronutrient tests need to be used and synergized and monitored regularly.

Future road map of the institute would be to develop new centre of excellence in computational genomics, a repository for tropical orchids, a gene bank of plant genetic diversity of western region, a phenomics facility for screening germplasm for salinity, submergence, high temperature stress, a grand facility for seed and planting material production. The Institute will also strive hard to use genomics to elucidate newer paradigms in diagnostics for livestock diseases.

The institute will have the roadmap for conservation and utilization of core genetic resources of horticultural crops and livestock species for the posterity, taking into account the changing environment and socio economic development of the region.

The ICAR Research Complex for Goa has been developed into one of the excellent centres of multi-disciplinary primary research for Goa but the technologies and research carried out are relevant to much larger areas of West Coast. The Institute will play a much bigger and important role of addressing concerns of Western region agriculture besides agriculture of Goa. Institute will coordinate the development of technologies with various Institutions of ICAR as well as State Agricultural Universities in a network mode and also take the models of Integrated farming systems to other areas. This would lead to effective utilization of resources and much greater impact. The institute would strive to harness power of science in increasing productivity and profitability, enhancing resource use efficiency, developing suitable models of integrated farming systems, agro-eco-tourism, reducing cost and post-harvest losses, improving livestock productivity and diversification of brackish water aquaculture and ornamental fish culture.

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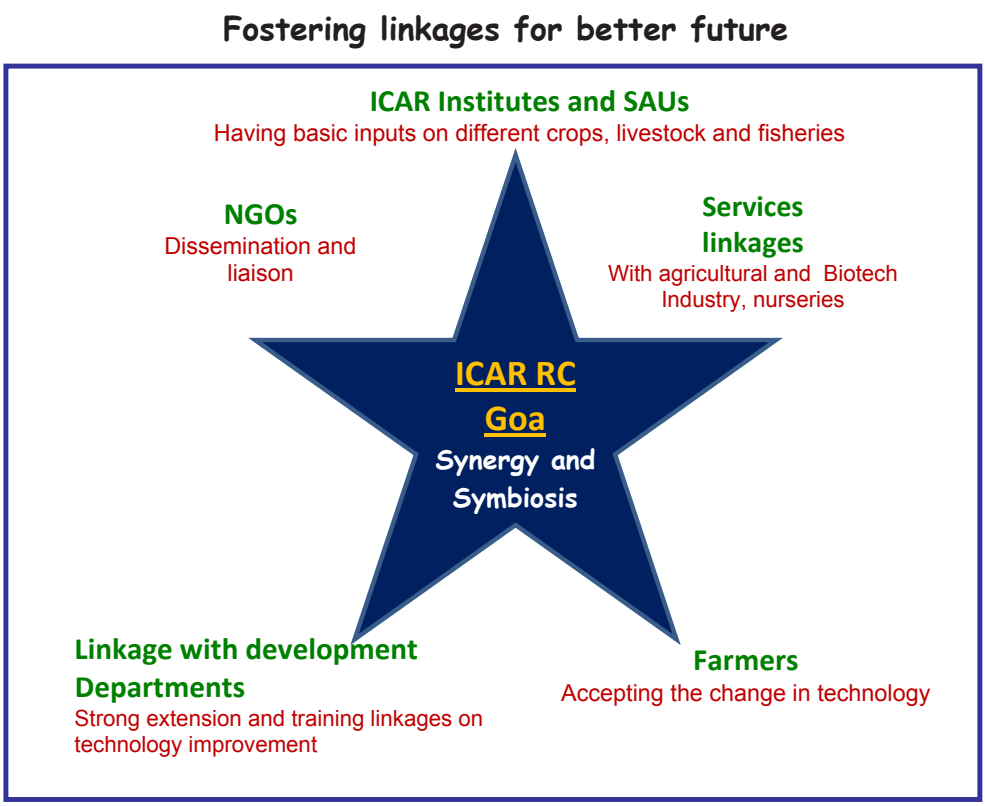

Annexure I. Abbreviations

AICRP	All India Coordinated Research Project
APEDA	Agriculture and Processed Food Export Development Authority
DBT	Department of Biotechnology
DST	Department of Science and Technology
GI	Geographical Indication
GIS	Geographic Information System
GPS	Geographic positioning system
ICAR	Indian Council of Agricultural Research
ICT	Information and Communications Technology
IFS	Integrated Farming Systems
INCOIS	Indian National Centre for Ocean Information Services
IPM	Integrated Pest Management
NGO	Non-Governmental Organization
NGS	Next generation sequencing
SAU	State Agricultural University

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