Vision 2050

Central Plantation Crops Research Institute

Indian Council of Agricultural Research

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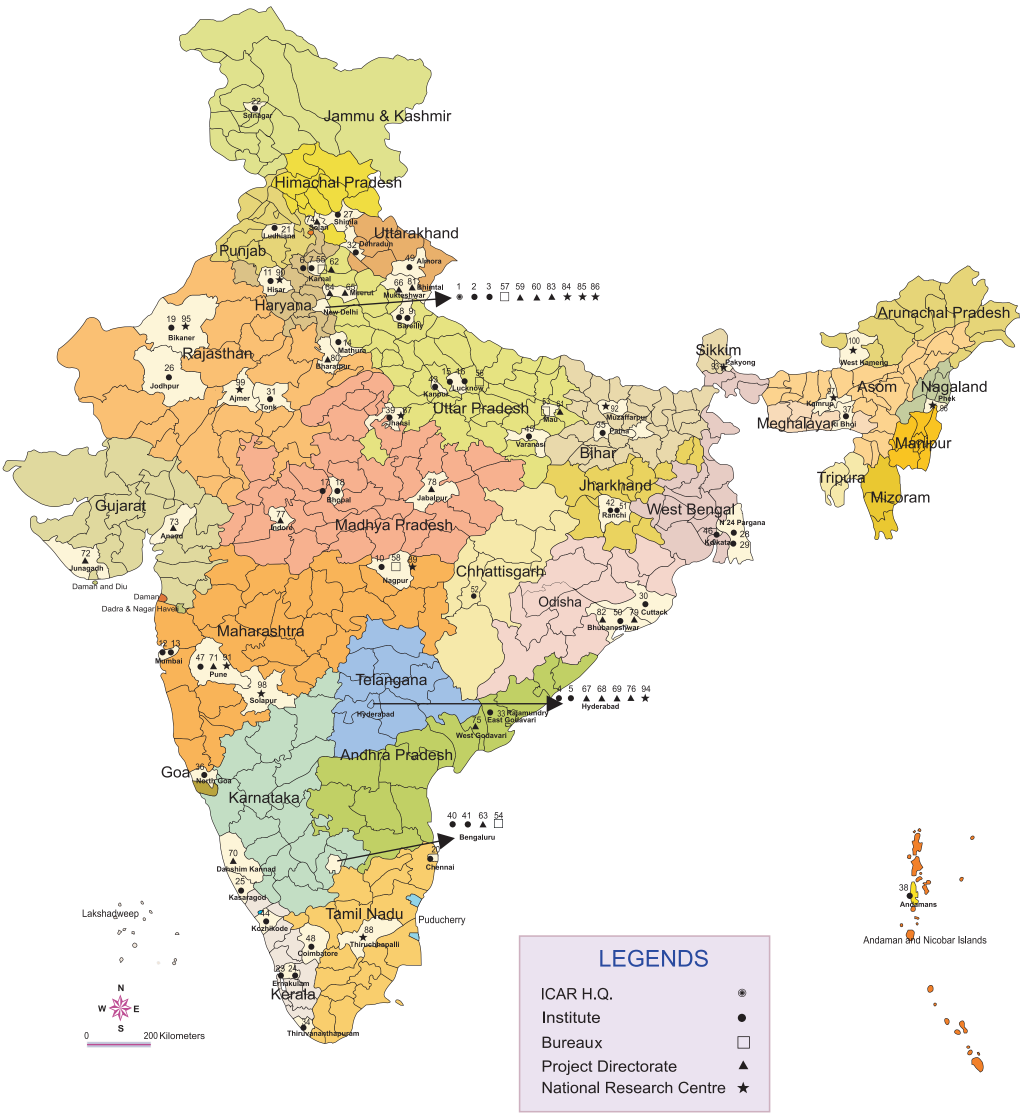

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Vision 2050

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संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो–तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट–परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान–जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन–2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

राधा मोहन सिंह

(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, 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. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-Central Plantation Crops Research Institute (CPCRI), Kerala has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

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Preface

Plantation crops are considered to be the major segment of the horticulture crops and the mainstay of agrarian economies in many states and union territories (UTs) of India. They contribute a significant amount to the national exchequer and country's exports by way of excise and export earnings. They also provide direct and indirect employment to a large number of people in the country. The major plantation crops in India include coconut, arecanut, oil palm, cashew, tea, coffee, rubber and cocoa. India is the largest producer and consumer of cashew nut and arecanut. Tea and coffee are the main and oldest industries in the country, which provide ample employment opportunities to the people and hold immense potential for export. Plantation crops like coconut and arecanut provide adequate interspaces for intercropping of seasonal crops and thus ensure food security to a great extent. Nevertheless, in India, plantation crops have been continuously facing the problem of lack of investment and depressed yields, and are in great need of modernization. Plantation crops sector in India, in recent times, is characterised by selective state intervention and the removal of tariff barriers wherein, its survival depends on international competitiveness. However, plantation sector in the country is dominated by millions of small and marginal farmers and mainly confined in the economically and ecologically vulnerable regions, plays a crucial role as far as the issue of sustainability is concerned. In the present context, the major challenge is to develop an equitable and sustainable plantation sector ensuring inclusive growth and at the same time, being internationally competitive.

Among the plantation crops, coconut and arecanut sectors in the country are faced with umpteen challenges like palm senility, natural calamities such as floods, drought, pest and diseases, and the use of unsuitable varieties and poor quality planting materials. In the case of coconut, most of the farmers are mainly dependent on copra and there is very little value addition at the community level. There is also minimal intercropping resulting in coconut farm productivity not being maximized. Above all, the emerging market and trade related challenges in the liberalized regime are difficult to cope up with. Market studies of arecanut reveal that major share of the arecanut trade is in the hands of private traders, which provides ample scope for hoarding and results in market imperfections and low price realization. Arecanut has a very limited export potential and does not hold the status of a food crop. It is noteworthy that, in the recent period, there are wide debates ongoing regarding the social cost of promoting arecanut. In the case of cocoa, another important plantation crop, there are potentials and possibilities in the form of massive acreage under coconut and arecanut wherein cocoa can be comfortably accommodated as an inter crop, an internal market with accelerated annual growth of confectionery industry, and a well established research and development back up. On the other hand, there are emerging and evolving hurdles to cross, in the form of highly fluctuating international prices for the commodity, ever increasing mergers and acquisitions in the cocoa industry, controls exerted by the retail supermarkets, stringent food safety standards in the international spectrum and lack of high-level technical competence and entrepreneurship in the domestic sector.

In view of these issues, it is imperative to assess the current status of coconut, arecanut and cocoa sectors of the country, and identify the gaps, commonalities and recommend opportunities for sectoral development in order to put a renewed focus for these sectors. The document analyses global and national production, consumption and trade aspects of coconut, arecanut and cocoa sectors in a heuristic fashion and subsequently, narrows down to the vision statement. It proceeds to describing the strategic plan framework on challenges and approaches to achieve the sectoral vision.

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Contents

1. Coconut

1.1. Background

Among the plantation crops, coconut is the major crop grown both under plantation and homestead management system. It provides livelihood security to several millions of people across the world, and capacity of coconut in providing improved nutrition, employment and income generation are well known. India produced 23351 million nuts in the year 2011-12 from an area of 2.07 million ha with a productivity of 11277 nuts per hectare. The coconut palm exerts a profound influence on the rural economy of the many states where it is grown extensively and provides sustenance to more than 10 million people in the country. The processing and related activities centered on the crop generate employment opportunities for over three million people in India. In addition, the crop contributes Rs.92000 million annually to the Gross Domestic Product (GDP) of the country. The coconut sector also contributes to foreign exchange earnings to the tune of Rs.21385 million through the export of coconut and coir products. Over 90 percent of coconut farmers in India are small holders and are considered resource-poor.

1.2. Scenario on production, consumption and demand

1.2.1. Global scenario

Although coconut is widely dispersed in most of the tropical regions, the global decadal rate of coconut area expansion and growth is about 1% (Table 1) indicating that scope for further area expansion is limited. Area under coconut would most likely remain at 12.5 to 13.0 million ha in the coming decades. Globally, out of 12.5 million hectares of area under this crop, close to nine million hectares (about 75 percent of the total area) is

Figure 1. Share of area under coconut in the major producing countries

contributed by only three countries, namely Indonesia, the Philippines and India (Figure 1; Table 2). The export market of coconut and coconut products is highly concentrated with less than half a dozen exporting countries accounting for over 80 percent of the total quantity traded in most cases.

Table 1. Decadal growth rate (CGR%) of area, production and yield of coconut in the world

Country	Area	Production	Yield
India	1.02	2.55	1.51
Indonesia	1.11	1.63	0.51
Philippines	1.12	1.34	0.21
World	0.93	1.51	0.58

Source: FAOSTAT

Table 2. Global scenario of coconut production & trade

Country	Area ('000 ha)	Production (million nuts)	Productivity (nuts/ha)	Export value (million US$)
India	2070 (16.6%)	23351 (32.1%)	11277	356
Indonesia	3796 (30.4%)	16,256 (22.3%)	4282	1091
Malaysia	112 (0.9%)	570 (0.8%)	5089	225
The Philippines	3574 (28.6%)	15,862 (21.8%)	4438	1957
Sri Lanka	417 (3.3%)	2741 (3.7%)	6573	428
Thailand	214 (1.7%)	806 (1.1%)	3766	53
World	12473	72758	5833	--

Source: APCC Year Book 2011, CDB Annual Report 2012-13

Coconut oil: Oils and fats are important constituents of human diet and crops constitute the main source of oil (80%), while the remaining source is from animals. World production of vegetable oils is dominated by four crops viz., soybean, oil palm, rape seed/canola and sunflower (Figure. 2).

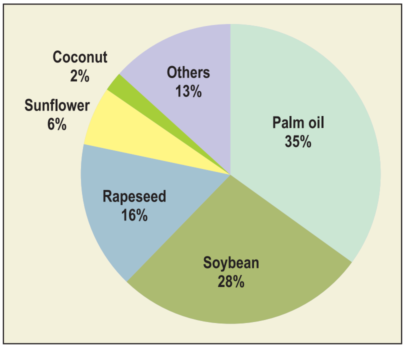

Figure 2. Production of major edible oils in the year 2013

Table 3. World production of edible oils (million tonnes)

Oil	2000	2012	% Change
Palm oil	21.87	52.81	141.4
Soybean	25.54	41.75	63.4
Rapeseed	14.46	24.21	67.4
Sunflower	9.7	9.62	-0.84
Coconut	3.28	3.24	-1.2
Others	13.667	20.26	48.2
Total	88.517	151.89	71.6

Source: FAOSTAT

Production of edible oils in the world increased to 71.6% (Table 3) and palm oil alone contributed to the tune of 34.5% due to tremendous increase of oil palm production to an extent of 141%. The increased availability of oil palm, soybean and rapeseed oils reduced the share of coconut oil in total edible oil production to 2.13%. Seventy percent of global coconut oil production comes from the Philippines and Indonesia (Figure. 3).

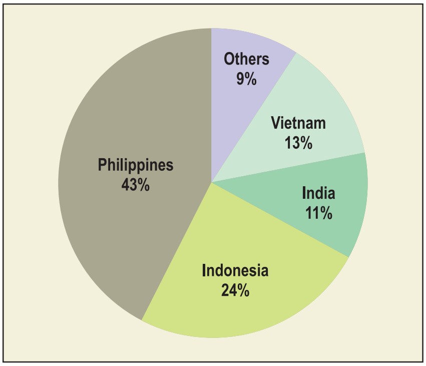

Figure 3. Production of coconut oil (mt) in the year 2011

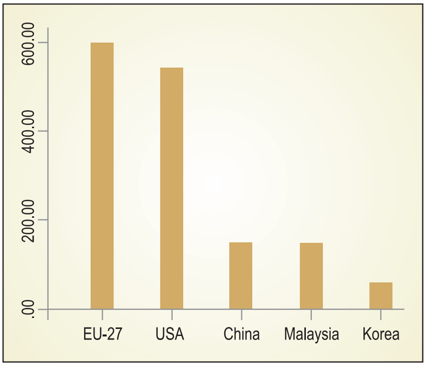

Figure 4. Quantity (in 1000 t) of coconut oil import in the year 2014, Source: indexmundi.com

World demand for coconut oil in the past decade also has not increased compared with other vegetable oils. A recent report on growth rate of coconut oil in the year 2014 indicated that only Malaysia recorded a positive growth rate (4.55%), while export from India, Indonesia and the Philippines showed a marginal decline by -0.25%, -0.31% and -1.29%, respectively. USA is the single largest importer of coconut oil (31%); the import share of EU-27 countries is 34% (Figure 4).

Table 4. Average export quantity and value of coconut oil by major exporting countries during 2001-2010

Country	Value (1000$)	Quantity (T)	CGR (%)
India	6517.4	5397.9	9.0
Indonesia	341905.9	562031.8	3.3
Malaysia	89950.6	142176.5	9.7
Philippines	592069.6	1033699.7	-3.5
Sri Lanka	2433.4	2342.6	-10.1
Thailand	1769.8	2915.6	-13.0

Source: FAOSTAT

Virgin coconut oil: Virgin coconut oil, a high value cosmetic and medicinal product, has a niche market. The Philippines, Sri Lanka and Solomon Islands are the major exporters of VCO. The average exports per annum from these countries are approximately 6,000, 88 and 1.5 tonnes, respectively. The USA, Canada, Germany, Lithuania, UK, New Zealand, Australia, Russia, Finland, and Turkey are the major VCO importing countries.

Desiccated coconut: Desiccated coconut is a well-established product from coconut. World production of desiccated coconut is around 290,000 tonnes. Largest exporter of desiccated coconut is the Philippines. In the recent years, export from India is picking up (Table 5).

Table 5. Average export quantity and value of desiccated coconut by major exporting countries during 2001-2010

Country	Value (1000$)	Quantity (T)	CGR (%)
India	385.9	822.9	32.6
Indonesia	33538.6	45941.3	6.3
Malaysia	5629.9	9610.6	-3.7
Philippines	123801.3	112993.5	6.1
Sri Lanka	41884.8	43970.4	-5.2
Thailand	249.5	463.3	24.9

Source: FAOSTAT

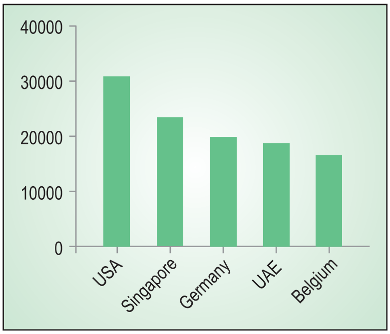

Figure 5. Quantity (t) of desiccated coconut imported in the year 2014, Source: UNCTAD

The major importing countries of desiccated coconut are the USA, Europe, Canada, Australia, Middle East, Japan and Russia. Out of 0.272 million tonnes desiccated coconut imported, 41% is to the five countries as shown in Figure 5.

Activated carbon: Activated carbon from coconut shell charcoal is of high demand for its superiority in terms of adsorption of gas/ vapour and removal of colour and odour of compounds. The global activated carbon market will grow faster in the coming decades chiefly because of its use in mitigating environmental pollution, especially removing heavy metal residues in industrial pollutants.

The global market for activated carbon was 1.25 million tonnes in 2012 and is expected to grow at a CGR of 11.7% from 2014 to 2020. Major activated coconut shell carbon exporting countries are shown in Figure 6. Just over 10% of global demand for activated carbon is met from coconut shell.

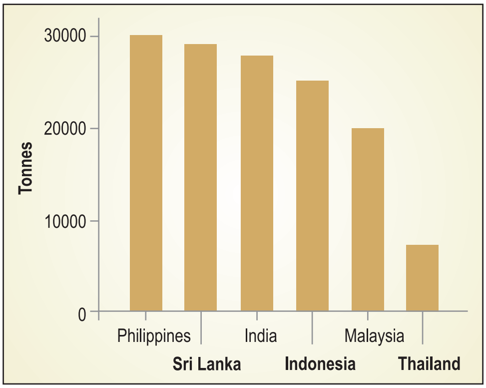

Figure 6. Global export scenario of activated carbon

Coir and coir based products: Till recently, India and Sri Lanka were the only coir producing and exporting countries. In the recent past, coir industry has established in few other countries as well (Philippines, Indonesia, Thailand, and Vietnam). Quantity of coir exported in the year 2011 was 0.63 million tonnes. Around 80% of the export is in the form of coir fibre. China is the major buyer of coir fibre (90%) and its requirement is expected to increase 10 to 20% every year. At present, there is deficit of nearly 20% in supply of coir fibre in the world.

1.2.2. National scenario

Tamil Nadu is the leading coconut producer in the country with an annual production of 7057 million nuts, followed by Kerala which produces 6211 million nuts annually (Table 6). In India, coconut is predominantly cultivated in small and marginal holdings. Most of these holdings neither provide gainful employment opportunities for the family labour throughout the year nor generate sufficient income to meet the family requirement. Presently, coconut growers are more exposed to economic risks and uncertainties owing to the high degree of price fluctuations. In this context it is needless to emphasize the importance of crop diversification in coconut gardens.

Table 6. Coconut: National scenario 2012-13

State	Area ('000 ha)	Production (million nuts)	Productivity (nuts/ha)
Andhra Pradesh	142	1985	13979
Karnataka	511	5915	11576
Kerala	766	6211	8109
Tamil Nadu	431	7057	16387
India	**2070**	**23351**	**11277**

Source: CDB, 2013

Trend in production

Coconut production in the country is around 23 billion nuts and the crop occupies an area of around 2 million ha (Figures 7 & 8), and is predominantly cultivated in small and marginal holdings. In the last decade the area expansion and increase in production was in slow phase with CGR as 0.3% and 3.5%, respectively.

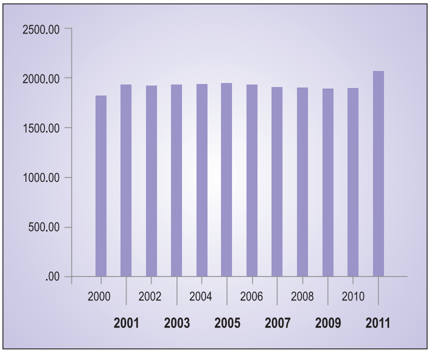

Figure 7. Area ('000 ha) under coconut in India

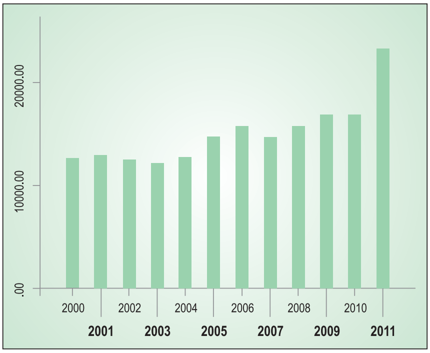

Figure 8. Coconut production (million nuts) in India

Demand and supply scenario

Assuming the projected population of India by the year 2050 as 1.62 billion, the projected coconut demand for 2050 is predicted to be about 45000 million nuts. With the projected supply of around 36000 million nuts, there would be a demand-supply gap of 8695 million nuts by 2050 (Figure 9). In order to meet the projected demand, the annual growth rate in production should be 3.20 per cent. As a matter of fact, coconut in future may experience a paradigm shift from the oil seed label, if promoted as food for nutrition, health care and environmental services to support the farming community. Moreover, the recent surge in export of coconut products and the rising demand for tender coconut in the country are noteworthy. In such a scenario, by 2050, the demand for coconut would be certainly more than the estimated figure. Therefore, it would be a challenge to meet the futuristic coconut demand, especially because of the scarce land, labour, water and energy resources at disposal. An appreciable growth in total factor productivity and appropriate capital substitution are the possible alternatives and to achieve these, strengthening the traditional coconut based farming system through the use of modern research tools would be the starting point.

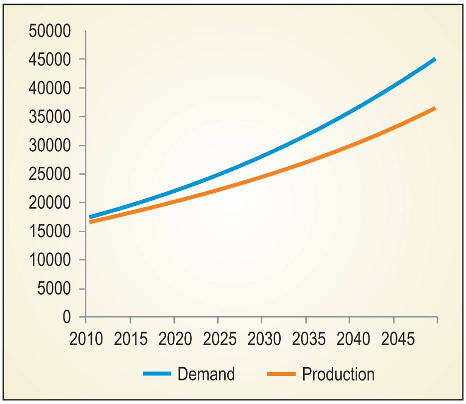

Figure 9. Projected demand and production of coconuts

Export-Import scenario

During 2012-13, export of coconut products (excluding coir items) was valued at Rs.102236 lakhs as against Rs.94329 lakhs during the corresponding period in the previous year (Table 7). This shows an increase in export by 26 percent in terms of value. Government of India has notified Coconut Development Board as an Export Promotion Council (EPC) for all coconut products other than those made from coconut husk and fibre vide Public Notice No.169 (RE-2008)/2004-2009 New Delhi dated the 1st April 2009. During the year 2012-13 (upto February 2013), import of coconut products (excluding coir items) in terms of value was Rs.5665.68 lakhs as against Rs.6916.02 lakhs during the comparable period during the previous year (2011-12). Coconut oil cake and coconut oil were the major two coconut products imported into India, of which coconut oil cake accounted for 86 percent and coconut oil 11 percent in terms of value of imports. During the same period, the quantity of coconut oil imported amounted to 1001.88 MT as against 2663.03 MT imported during the comparable period in the previous year. The striking benefit derived from the notification of designating CDB as EPC can be as attributed to the tremendous increase in the export share of coconut kernel products (Figure 10).

Table 7. Export of coconut products from India

Sl. No.	Year	Export value (rupees lakhs)
1	2007-08	6901
2	2008-09	17980
3	2009-10	21975
4	2010-11	49592
5	2011-12	94329
6	2012-13	102236

Source: CDB, 2013

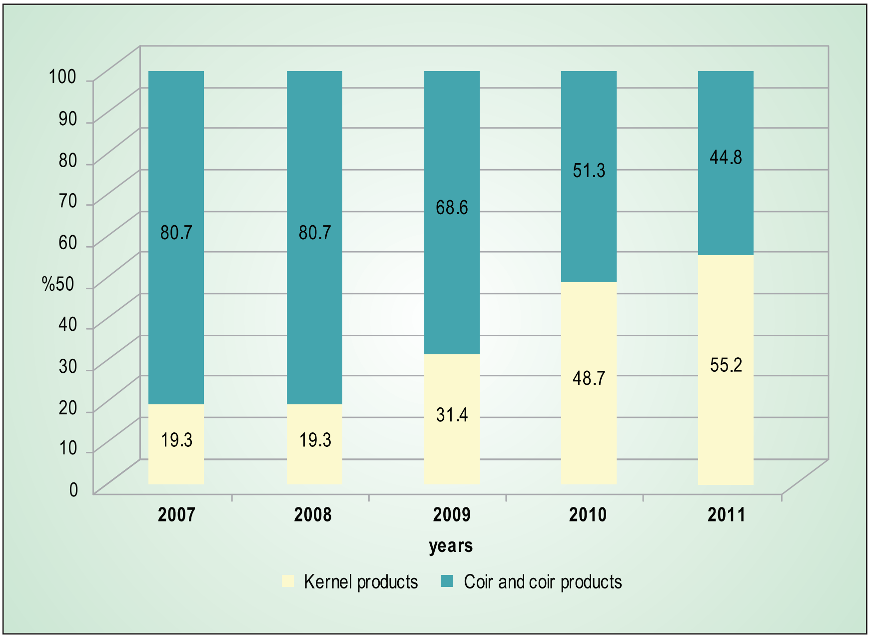

Figure 10. Breakup of export earnings from coconut sector

India, being deficient in edible oils, import of palm oil is a necessity. The price of coconut oil is closely linked with the prices of other edible oils. Among the vegetable oils imported in the last year, palm oil and its fractions account for 73.10 percent and palm kernel oil (crude and refined) accounts for 1.40 percent. Being an oil rich in lauric acid, imported palm oil seems to be the major competing oil for coconut oil and often beats down coconut oil prices in the domestic market. The excessive import of edible oils, especially palm oil that too during the peak coconut production season, would definitely trigger price crash of coconut oil.

1.3. Challenges and approaches

The plantation sector is confronted with a number of challenges which has resulted in declining farm income, deterioration of production environment and total factor productivity. The fact that the plantation crops sector in the country is dominated by millions of small and marginal farmers and mainly confined to the economically and ecologically vulnerable regions, plays a crucial role as far as the issue of sustainability is concerned. The paradox is that in the present scenario of integrated global markets, we are not a key market player in determining the international market parameters. To face these challenges, the inherent weaknesses have to be converted to opportunities, and technology has to be the prime mover to achieve sustainable growth of the coconut sector.

In the long term context, the major challenge is to produce enough to meet the growing demand under changing climate conditions, the dwindling agricultural land/water and other natural resources and skilled labourers. Impending global warming and related climate change might lead to prolonged drought as well as emergence of new pests and diseases in majority of the coconut growing regions, necessitating development of strategies for drought mitigation and pest management. There is a need to develop sustainable production systems along with proper management practices for judicial utilization of the harvested water in conjunction with the available ground water. There is also an urgent need to consider virtual water budgeting, carbon/water footprints while developing production systems/products. It also necessitates identification of genotypes tolerant to higher temperature and cold to perform well under extreme temperatures. Further, to mitigate the climate change threats, there is a need to promote environment friendly technologies geared to reduce green house gas emissions during entire chain from production to consumption.

The challenges facing coconut sector need to be resolved in a systematic and holistic way by prioritizing needs of stakeholders.

The key elements in our approaches for a sustainable and vibrant plantation sector are:

a. Enhancing yields using sustainable agricultural practices.
b. Access to quality, disease-free planting materials and the right inputs
c. Judicial utilization of natural resources
d. Value addition and effective market access
e. Effectively addressing the developmental and policy issues

1.3.1. Technological/research challenges

Coconut, the ‘Kalpa Vriksha’, is intricately woven into the socio-economic and cultural backdrop of the Indian subcontinent. With its multifarious uses, coconut offers scope for sustaining the livelihood of growers, farm communities and industries. However, the sector needs to evolve and surmount the challenges to be vibrant and self-sustaining in the long term.

1.3.1.1. Genetic enhancement

The average national productivity of coconuts in India is around 63 nuts/ palm/ year. To enhance the production through improved location-specific varieties, the process of germplasm collection, conservation and utilization has received considerable attention. India possesses the world's largest assemblage of 438 coconut accessions, which includes 132 exotic germplasm from 28 countries. The country is host to the International Coconut Gene Bank for South Asia, which is one of the five multi-site gene banks of coconut, and facilitates global exchange of information and genetic resources. At the national level, the National Active Germplasm Site for coconut facilitates the documentation, coordination of multi-location conservation under SAUs and sister ICAR Institutes, exchange and protection of coconut genetic resources in the country. Till date, 48 improved varieties, including 20 hybrids, of coconut have been developed by different ICAR Institutes/SAUs and recommended for commercial cultivation. The improved hybrids and varieties, so far developed, are capable of producing up to 6.28 tonnes of copra/ha/year.

It is also anticipated that climate change will usher in changes in the temperature, water availability, natural reserves, and resurgence of pest/disease leading to economic loss. Hence, there is a need to develop varieties or hybrids tolerant/resistant to above biotic and abiotic stresses. The major challenges to sustain the coconut sector will be mitigating the genetic erosion out of loss of habitat, enhancing crop productivity and profitability through climate resilient varieties that are suitable for diversification of coconut husbandry, product diversification in line with consumer demand and suitability for different site-specific/ precision farming systems. Considering, the global shift in outlook of growers, and the increasing trend to large-scale mechanized agriculture, there is a need to redefine coconut cultivation practices, taking into consideration growers' preferences and market outlook.

With the strength and expertise available on management of coconut genetic resources in the country, India can take a lead in formulation and implementation of conservation as well as global breeding initiatives and facilitate multi-country evaluation for development of adaptive as well as country-specific varieties for different stakeholders. The country can also provide a platform for hosting and dissemination of information on conservation, characterization and screening of germplasm for biotic/abiotic stress tolerance/resistance and advanced breeding efforts to address the challenges of the global coconut community. Partnership among the regional/international organizations and entrepreneurs also needs to be fostered for effective communication, cross-learning and providing consultancy services in augmentation of varietal wealth in coconut.

Improved coconut varieties/hybrids suitable for closer planting, tender nut purpose, inflorescence sap (Kalparasa) production, higher oil content/copra, ball copra production, wood production, resistance/ tolerance to biotic/abiotic stresses, suitable to different cropping/ farming systems in varied agro-climatic zones and possessing higher input use efficiency could be developed. Considering the amenability and compatibility of coconut with several other important annual and perennial food and horticulture crops, scope exists for establishment of multi-crop gene banks which will be more cost-effective, facilitate dynamic co-evolution process and also provide more information on performance of these crops under different environment. The variations in canopy traits such as leaf number, leaf size, leaf orientation, stem and root architecture need to be exploited for developing varieties amenable for closer planting and to enhance system productivity.

Focus should also be directed on development of varieties suitable for industrial uses for tapping the niche consumer-driven market for health foods and to meet the growing demands of the health conscious population. Considering the variations observed for fatty acid profile in coconut germplasm, possibility of breeding for varieties with higher content of essential fatty acids for human consumption with higher health benefits and also for development of varieties for oil suitable for various industrial applications requires due attention.

GIS-based mapping of coconut genetic resources on location and site-specific performance of known ecotypes and farmers' varieties grown in different agro-ecological conditions, and adoption of inclusive approaches in participatory plant breeding are expected to complement in mitigating gene erosion and effective utilization for climate resilient coconut sector. Multi-location trials are to be taken up for identification of varieties suitable for different agro-ecological zones considering the area expansion in non-traditional areas. This will also facilitate identification and possible utilization of adaptive traits in development of new selections and hybrid combinations as part of strategies for mitigating the effects of climate change.

There are several impediments to adoption of conventional molecular mapping and gene tagging methodologies in coconut. Perennial habit, long juvenile phase and predominant out-crossing nature of these palms, together with the lack of a strong method for screening against abiotic/biotic stress tolerance/resistance (disease induction and scoring) in segregating populations, dampen the prospects of conventional methods. More institutions, both public and private, should closely work together to identify highly polymorphic and closely linked molecular markers for a target trait for marker-assisted selection in coconut breeding. Development and application of high-throughput phenotyping facilities, coupled with high throughput genotyping, will hasten the process of development of trait-specific markers and provide a much needed impetus for identification of trait-specific accessions and facilitate the development of a repository of donor parents for utilization in the coconut improvement programme. The differential response of accessions and parental lines in exhibiting heterotic effects, influenced by their specific/general combining ability, offers scope for selection and development of improved hybrids in tune with the dynamic demands of the coconut sector. With the availability of cost-effective, next generation sequencing facilities, there is ample scope for deciphering coconut genome information. This would facilitate unravelling the metabolic pathways in coconut and also to understand how these pathways are affected by environmental conditions and can be used in development of improved varieties for product diversification and human nutrition. It offers immense scope in tackling issues relating specially to resistance/ tolerance to various biotic/abiotic stresses. Genomic information can also facilitate better understanding of the process of earliness in terms of flowering and fruiting, photosynthetic efficiency, plant architecture and other targeted traits for development of desirable, trait-specific and climate resilient coconut varieties.

1.3.1.2. Quality planting material production and *in vitro* techniques for rapid multiplication

High yielding varieties and hybrids of coconut have the potential to yield at least 30-40% more than the locally cultivated talls. The yield levels of the released varieties and hybrids of coconut ranges from 1.41-6.28 tonnes of copra/ha/year under optimum management conditions. In India, most of the coconut plantations are old and senile. To maximize the productivity from such coconut gardens, care should be taken to replant with quality planting materials. Root (wilt) disease is a major production constraint in states like Kerala and certain pockets of Tamil

Nadu. Hence, focus in these states should be to produce root (wilt) disease resistant/tolerant planting material. Considering the replanting needs of old and senile coconut plantations, replacing the diseased palms in traditional coconut growing areas and expanding the cultivation in non-traditional areas, about 22 million seedlings per year would be required for the country. The present estimated annual production of seedlings is estimated to be around 20 million, resulting in a likely annual deficit to the tune of 2 million seedlings. Further, the present quantum of production of planting material from the governmental sector works out to about six million seedlings, and accounts for only 25% of the total planting material requirement in the country.

It is of paramount importance to develop an exclusive policy by each state for production and supply of elite planting materials to the farmer. Each state should have a separate policy frame for the area expansion and rejuvenation programmes and for the generation of required planting material of suitable varieties. There also should be separate development schemes for the execution of the programmes according to the policy frame. Considering the likely huge requirement of planting material in the coming decades, there is urgent need for doubling the planting material production capability of governmental agencies viz., ICAR-CPCRI, Coconut Development Board, State Agricultural Universities and Department of Agriculture/Horticulture in different states. This will aid in increasing the annual planting material production from the governmental sector to 12 million seedlings. Further, to increase the quality seedling production in coconut, it is necessary to develop coconut seed gardens in a Private Public Partnership (PPP) mode so that the enhanced seedling production to the tune of 50% of the expected demand can be assigned to Coconut Producers Societies, accredited Coconut Nurseries and NGO's, through a decentralized seedling production programme which would thereby effectively complement the quality planting material production from the governmental sector. Further, research organizations like ICAR and SAUs should support these initiatives by imparting appropriate training on hybridization technique to the technical personnel involved in the planting material production programme.

Since most of the existing seed gardens in the traditional coconut growing belt (Kerala, Tamil Nadu, Karnataka and Andhra Pradesh) have been established more than 25 years back, the existing mother palms (especially dwarfs) in such seed gardens are nearing senility. Hence, urgent action should be initiated for replanting such seed gardens with parental lines of new and improved varieties recommended for the respective regions. Further, to increase the capacity for hybrid seedling production, a decentralized production mechanism is to be envisaged by maintaining a centralized pollen storage and supply mechanism. The mother palms identified in farmers' plots can then be used for hybridization with the pollen supplied from central pollen repositories. This farmer-participatory seed production can be undertaken with the participation of institutes of ICAR and SAUs, KVKs, Commodity Boards and Department of Agriculture/Horticulture.

It is also essential to develop a system of mandatory accreditation of all coconut nurseries. Meanwhile, sale of coconut planting materials from other non-recognized agencies should necessarily be banned to prevent sale of spurious planting materials. This is of greater significance in plantation crops like coconut, since there is a long juvenile phase and the genetic potential of the palm will be visualized only after a few years of planting, and use of inferior palms for planting would result in huge loss to the growers in terms of production capability and input-use efficiency.

Ensuring the quality of planting material also envisages the development of variety-specific standards and implementation of suitable certification process. The country also needs to expand the production capacities to not only service the national requirements, but also the requirements of friendly coconut producing countries by sharing the improved varieties for enhancing the livelihood of the coconut producers and promoting the global cooperation through coconut.

Considering the limitations in meeting the demand for elite planting material of improved varieties through conventional techniques, application of *in vitro* techniques, assumes importance as a plausible technique to produce large number of genetically uniform plantlets. Hence, research organizations in the country should focus on development of reliable and robust protocols for rapid multiplication of elite high yielding and disease resistant coconut palms and hybrids. In this context, there is a need to tap new avenues that have opened up such as bioreactors, which are a promising way for scaling-up micro propagation processes, particularly somatic embryogenesis. Transcriptomic and proteomic approaches also can be utilized for a better understanding of genes responsible for somatic embryogenesis and plantlet regeneration in coconut.

1.3.1.3. Efficient input management

Coconut is being grown in various soil types like sandy loams, sandy coastal alluviums and sandy river valleys, littoral (coastal) sand, laterite, lateritic red and alluvial soils. The varying fertility of these soils leads to lower productivity of the crop. The present blanket recommendation of fertilizer in such soils will not help in improving the yield of the crop. As population is growing, most of the ideal lands are being converted for the production of other profitable food and cash crops, and hence, only unfavourable areas will remain the sanctuary for coconut production.

The soil loss due to erosion is to the tune of 10.52 t/ha and nutrient loss from coconut gardens due to heavy rainfall and sloppy nature of soil is 105, 22 and 167 kg N, P, K/ha/year, respectively. Studies conducted at CPCRI indicated the bio-engineering measures have reduced the soil loss and nutrient loss to the tune of 98 per cent. Thus the result can be replicated in all the coconut growing areas wherever the problem of degradation of resources are severe.

As most of the plantation crops are cultivated in high rainfall areas, the soil is highly eroded and poor in soil organic matter (SOM). As a consequence of decreased organic matter, response to applied fertilizer is lower. Maintenance of adequate levels of SOM by way of effective recycling of on farm crop residues through vermicomposting is very much essential to keep the soil healthy through efficient microbial activity.

Even though many technologies are available for improving productivity of coconut, the new problems emerging over years have become a challenge for the researchers. Some of them are listed below:

- Increasing problems of micronutrient deficiencies
- Degrading soil fertility and reducing source of water
- Varying crop requirement of different nutrients
- Increasing awareness and problems associated with organic farming

Since the blanket recommendations lead to imbalanced nutrition in coconut, precision application of nutrients as per the soil and crop requirement is essential. This requires classifying the soil based on soil fertility. Soil nutrient mapping using GIS is needed which can be achieved in association with NBSS&LUP. Further, considering the future demand for different coconut products such as tender nut, inflorescence sap or value added products, separate nutrition plan for the coconut plantation management may be required to enhance product quality.

The major problem for organic farming is the availability of inputs which can meet the nutrient demand of the crop. Apart from recycling the wastes from the garden, bioinoculants and PGPRs have to be developed for specific purpose. Technologies like precision application of PGPR need to be developed for more effective utilization of the bioinoculants. There is a need to develop PGPR-based bioinoculants for different soil ecological conditions for soil health sustainability. The organic sources have low quantity of potassium and coconut needs more potassium. Thus enriching the organic inputs with potassium is essential. The products like biochar have to be given importance in developing inputs for organic farming.

1.3.1.4. Cropping/farming systems

Coconut interspaces provide ample scope for mixed and intercropping and about 70-75% of the plantation area can be utilized for cropping systems. The pioneering effort of CPCRI has resulted in the development of technologies for coconut based inter/mixed, multi-storied multi-species cropping systems and these are being widely adopted by the farmers. The high density multi-species cropping system and coconut-based mixed farming system, involving annuals/biennials/perennials grown in different tiers by exploiting soil and air space more efficiently and integrating with poultry and animal husbandry, helps to maximize profits and can even buffer the price crash of the main crop. For maximizing economic returns, high value medicinal and aromatic crops, vanilla and flower crops have been recommended in the palm based cropping system. The net return per rupee invested from the cropping/farming system ranges from 1.7 to 2.7. It has been already proved by researchers that growing of inter/mixed crops in coconut improves the productivity of coconut. But this needs supply of irrigation for the component crops. Coconut is an irrigated crop in the states of Tamil Nadu and Andhra Pradesh. This gives ample opportunity to grow many inter/mixed crops in the coconut gardens. The recyclable biomass from coconut based cropping system varies from 15-20 t/ha. This can be conveniently utilized as vermicompost which can reduce the requirement of chemical input to the system. This will pave way for organic farming for improving the health of the soil and for sustained productivity. Even though the technology is available for cropping/farming system, the future challenges need further research in this line. The challenges ahead are:

- Reduced resources like water
- Nutrition security for the increasing population
- Changing climatic scenarios

The crops selected for a cropping system should be compatible with the main crop and it should have local demand. The climate change is likely to result in reduced water resources. So we need to develop a system which can thrive under limited water conditions. The systems should be developed for different agro-ecological zones wherever coconut is grown. Since the research should be location specific, collaboration with State Department of Horticulture/Agriculture, All India Coordinated Research Projects, and State Agricultural Universities is most essential. Integration of moisture conservation measures with the cropping/farming system need to be given equal priority.

The studies conducted within the cropping system have shown that the system has comparatively reduced temperature, less evaporation and low wind velocity compared to monocropping of coconut. Thus cropping/farming systems has to be developed in such a way that the final system will withstand the climate change vagaries in all the agro-ecological zones.

Combining animal component with coconut has proved a successful and sustainable technology. This is to be further diversified to make it more sustainable even for small and marginal farmers. The system has to be made self sustainable in terms of nutritional security.

1.3.1.5. Water conservation

Impending global warming and related climate change might lead to prolonged drought in majority of the coconut growing regions. Stiff competition from industrial use would limit irrigation water availability further. Ample opportunity exists for *in situ* moisture conservation and water harvesting in majority of the coconut growing areas. Efforts are required to develop low cost water harvesting structures to augment the surface and ground water resources. A proper management practice also needs to be evolved for judicious utilization of the harvested water in conjunction with the available ground water. This along with *in situ* moisture conservation practices could be a potential to mitigate the effects of climate change to a great extent. The sensor technology along with communication technology needs to be upgraded continuously. A major constraint in automation and improving efficiency of irrigation system is combining sensors with operation of irrigation system for field conditions.

Developing low cost water harvesting structures and moisture conservation measures to augment soil moisture and thereby mitigating the effect of global warming in coconut farming is a priority area of research. A simple and rugged sensor technology for estimating on-field irrigation and nutrient requirement needs to be developed. This, when coupled with control system, would optimize irrigation and nutrient requirement and would minimize the manual labour in irrigation. Productivity of water could be enhanced during water stress by applying the concept of deficit irrigation. This could help achieve greater economic gains under a water deficit scenario.

1.3.1.6. Plant disease management

The spread of root (wilt) disease, outbreak of *Phytophthora* and Ganoderma wilt or basal stem rot disease are the major challenges in the coconut sector. Apart from these major diseases, certain minor diseases like leaf spot or leaf blight and stem bleeding are becoming severe, probably with changing climate and difficulty in adopting the management strategies in time due to various socio-economic reasons. Lack of effective national level surveillance and monitoring for preventing accidental entry of the severe diseases prevalent in other countries and not yet noticed in India namely cadang–cadang, foliar decay virus and red ring (nematodes) are another major concern. The upsurge of new diseases of coconut in recent years from other coconut growing countries warrants the strengthening of the disease surveillance, diagnostics and management techniques. Climate change coupled with pathogen-vector evolution is another challenge which requires immediate attention. Though integrated management strategies have been developed and recommended for management of *Phytophthora* and *Ganoderma sp.*, these strategies have limitations i.e. they need to be applied before the infection or at the early stage of infection. Non-availability of skilled climbers for application of the biocontrol agents or chemicals to the crown regions of the tall coconut palm for management of the disease is the reason for non-adoption of many of the crop protection technologies. The mechanism of host-pathogen interaction at molecular level is not clear and reliable molecular diagnostic methods for early detection of the pathogen or diagnosis of the disease is also lacking.

Towards effective plant health management at the national level, top most priority should be towards establishment and strengthening of network of domestic quarantine stations with diagnostic labs to prevent the spread to non endemic areas. In addition to development of environmentally safe integrated disease management strategies by considering the climate change, variability in pathogen population and socio-economic changes in the coconut farming community, diagnostic kits for early and accurate detection of diseases like root (wilt), basal stem rot and bud rot need to be developed.

The pathogen diversity in *Phytophthora* and *Ganoderma* in relation to host and non-host plants and identification of the effector gene regions would lead to develop host induced gene silencing strategies for effective management of these diseases. Further, studies on the interaction effect of climate change variables with bud rot disease, in coordination with research institutes, Indian Meteorological Organization, State Department of Agriculture/Horticulture, Coconut Development Board and development of region specific forecasting models is essential for undertaking timely prophylactic measures for effective disease management.

Tissue specific transcriptome analysis in root (wilt) disease and leaf rot disease affected coconut palms can help elucidate host-pathogen interaction for better understanding and development of appropriate disease management strategies. Further for management of RWD, possibilities of siRNA to silence the phytoplasma symptom expression in coconut need to be explored. Application of molecular techniques in screening for resistance to specific diseases can hasten the resistance breeding programme towards better management of the palms for higher production.

Metagenomic analysis of microbiome of root (wilt) affected and healthy (resistant or tolerant) coconut palms could lead to understanding and identification of the role of microbes in inducing resistance and exploit the beneficial microbes (or endophytes) for management of the disease. Development of an effective and easy way of delivery of biocontrol agents or chemicals with machineries for the management of the diseases like bud rot, leaf rot, leaf blight or basal stem rot, is to be given top most priority to achieve success in plant health management in the scenario of labour constraints in the agricultural sector.

1.3.1.7. Invasive and emerging pests

Invasive species like hispine beetle, *Brontispa longissima* and the scale insect, *Aspidiotus rigidus* Reyne pose a threat to coconut cultivation in the country as they are prevalent in the neighbouring countries in South Asia. The outbreaks of minor pests like scale insects, mealy bugs, inflorescence caterpillar and slug caterpillar is also on the rise. The surveillance mechanism for the pest of plantation crops is weak and there are little or no forecasting and forewarning systems for pests and diseases of plantation crops.

Bioagents identified to manage the pests are often reported to provide varying results. Physiological status of the pest and its response to odorants plays a key role while developing pest management methods based on chemo-ecological approach. Application of pesticides and bioagents on the target area/plant body is a hurdle in tall trees. Mechanized delivery of pest control agents is a major challenge in palms. Besides, coconut, arecanut and cocoa being cross pollinated crops, indiscriminate use of pesticides in coconut/arecanut/cocoa cropping ecosystem will have adverse effect on insect pollinators. There is also scanty information on the role of pollinators in coconut.

Detection of damage caused by cryptic insects like red palm weevil is difficult. The gadgets currently available elsewhere in the world to detect palm weevils have poor signal to noise ratio to make a meaningful diagnosis.

Considering the growing threat to coconut production and productivity from alien invasive species, there is an urgent need to formulate and establish an efficient 'Biosecurity System' to regularly monitor quarantine and contain the invasive pests in porous borders. The international and domestic quarantine have to be strengthened to prevent the pest and disease entry through sea/air ports in India and also their spread within the country.

Efforts to identify the local strains of bioagents and exploit the genetics of tolerance to abiotic factors so as to suit the environmental conditions where they are released require focused attention. In addition, pollinators need to be effectively employed for enhancing fruit set and improving productivity levels in the coconut plantations.

Attempts are to be made to unravel the chemistry to understand the trophic interaction between plant, pest and natural enemies.

A non-invasive technique by either sound capture technique or imaging technique is essential to identify the palms subjected to biotic stress to enable early diagnosis and effective management of the pests with minimal detrimental effect on the coconut ecosystem.

1.3.1.8. Climate Change: Implications, adaptation and mitigation strategies

General circulation models (GCMs) project increases in the earth's surface air temperatures and other climate changes in the middle or later part of the 21st century, and therefore crops such as coconut, arecanut and cocoa will be grown in a much different environment than today. The 2nd National Communication to the United Nations Framework Convention on Climate Change projects an all-round warming over the Indian subcontinent of 1-4°C towards 2050s. The monsoon rainfall in some parts of the southern peninsula, where plantation crops are largely cultivated, is predicted to decrease by 10-20%, along with a decrease in the number of rainy days. The number of cyclonic disturbances in the Arabian Sea is likely to be less, but more intense. Climate change will affect coconut through higher temperatures, elevated CO_2 concentration, precipitation changes, increased weeds, pest, and disease pressure, and increased vulnerability of organic carbon pools. Yields are projected to go up in Kerala, Tamil Nadu, Karnataka and Maharashtra. In coconut, the impact of present year's moisture stress is worst in the third and fourth year following the drought stress period and the recovery will take three to four years, thus causing a perennial loss in farm income. Increase in temperature is also believed to have a detrimental effect on coconut oil quality, aroma and flavour. Increase in temperature is reported to reduce the oil content in coconut endosperm, resulting in increased content of starch, carbohydrates and reducing sugars in copra.

Research conducted over the years indicated that agronomic adaptations like soil moisture conservation, drip irrigation and fertilizer application improved the productivity substantially. Further, genetic adaptation measures like growing improved local tall cultivars and hybrids under improved crop management is needed for long-term adaptation of plantation to climate change, particularly in regions that are projected to be negatively impacted by climate change. Such strategy can increase the productivity by about 33% in 2030, and by 25–32% in 2080 climate scenarios.

Plantations have immense potential for mitigation of GHGs, it is estimated that the coconut plantations sequester carbon into stem at ~2.0 Mg CO_2/ha/year. On all India basis, the coconut plantations can sequester about 7.54 Mt C/year. Apart from these, plantations also reduce the effects of weather aberrations. Thus the ecosystem services provided by plantation crops need to be understood, assessed and realized for resilient plantation systems in India.

Generation of region-wise future climate data at a reasonably small scale is to be undertaken for effective integration of global climate models with simulation models and its utilization for the prediction of future coconut production, through collaborative efforts of ICAR-CPCRI, IMD, Pune and IIT, Delhi.

Identification of high temperature, drought, flooding and salinity tolerant phenotypic and genotypic traits is to be given top priority to identify donor lines for crop improvement research. Population improvement through identified stress tolerant plants, breeding for temperature stress tolerance, high retention of set fruits under climatic risks and improved source-sink balance and identification of multiple stress-tolerant cultivars have to be addressed to develop improved varieties suitable for different agro-ecological conditions.

Agronomic adaptation options should focus on low carbon technologies with mitigation as an 'adaptation co-benefit'. The focus should be shifted from a mere 'cost: benefit' based selection of technology to 'cost: benefit and ecosystem service' based selection so as to generate more 'green income'. Soil moisture conservation, drip fertigation, high density multi-storied multi-cropping systems, efficient nutrient recycling in the system contributes to the resilience of the plantations against climatic extremes.

Research initiatives should also focus on the pest and disease scenarios in changing climates since new pests may emerge and minor pests may become major pests. The development of pest forewarning systems and decision support systems and advisory systems are of high priority.

Linking farmers with a two way mobile-based communication systems for providing customized advisory is one of the top priority areas. Further, development of weather forewarning systems, decision support systems, and analysis of market demand and supply nexus in the back drop of weather aberrations, research on farm income based insurance in plantation crops and use of renewable energy for product processing also need the focus.

1.3.1.9. Value addition and by-product utilization

India has tremendous potential for the production and sale of value added products both in the domestic and international markets. Any successful coconut processing industry should have a plan for economic utilization of all the by-products. The existing technologies for production of coconut oil, VCO (virgin coconut oil) and coconut chips, neera collection and processing, vinegar production, tender nut water bottling, fat-free, gluten-free, egg-free, nut-free and soya-free ice creams, lactose-free beverages from coconut milk and coconut milk residues, coconut-based balanced health foods like bakery, extrudates, confectioneries, candies in the country are neither efficient nor globally competitive. Further, value added products from coconut inflorescence sap, endosperm and tender nut water need to be developed to tap the market for health foods and nutraceuticals and improve profitability of the sector. At the same time, conversion of coconut shells into charcoal and subsequent conversion of the charcoal thus produced into activated carbon opens up an avenue for community level processing for value addition of these by-products. Activated carbon being a high value-added product from charcoal and charcoal being the single raw material required for manufacturing activated carbon, rather than selling the charcoal, scope exists to use it for the production of further value-added products, like activated carbon. On a global scale, biomass from tender coconut husk and trunks of uprooted young coconut represents a considerable problem as well as new challenges and opportunities.

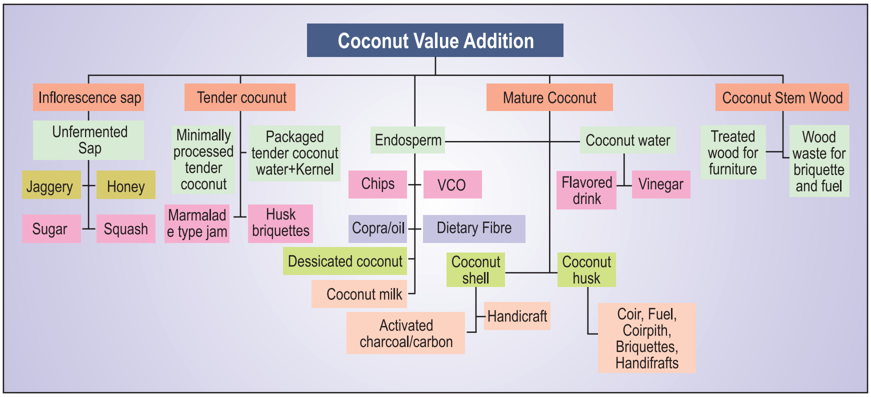

Figure 11. Schematic depiction of value addition in coconut

In view of potential health benefits of dietary fibre, protein and anti-oxidants, development of health foods, nutraceuticals from neera, coconut sugar, coconut milk residue, VCO cake and copra cake is the need of the hour. Towards this end, due focus should be to standardize/ optimize the formulations of various coconut products such as tender coconut water, coconut water, coconut milk and coconut neera powder, RTS beverages, coconut ice cream, coconut jam, coconut honey, coconut jaggery, coconut based traditional sweets and confectioneries.

Further, in view of low shelf-life of coconut products, new approaches such as nanotechnology/nanocomposite technology for packaging and preservation, spray drying, drum drying, foam mat drying, high pressure processing, ohmic heating, microwave heating, pulsed electric fields, ultra sound, irradiation and microencapsulation need to be employed to enhance the shelf-life of the coconut products.

The use of nanotechnology in the production of nano-fibres from coconut husk and shell need to be envisaged for its application in food packaging, converting into nano-sized bioactive compounds for its easy absorption in the body, nano-encapsulation of antimicrobials and anti fermentation compounds in order to improve the shelf life of tender coconut water, coconut water, coconut milk and coconut neera. The use of nano-level coatings of edible grade antimicrobials and preservatives on the surface of highly perishable tender and mature coconut kernel and coconut haustorium, also needs to be explored to develop nutritive and marketable products.

Application of advanced processing technologies in collaboration with ICAR-CIPHET, ICAR-CIFT, IICPT, CFTRI and DFRL, nanotechnology based packaging product formulation with ICAR-CIPHET and IIP, process standardization and product development in collaboration with CFTRI, NIN, TNAU, KAU and UAS etc. is envisaged for better utilization of coconuts for value addition and by-product development.

1.3.1.10. Mechanization

A serious problem confronting the coconut industry is dwindling labour needed for various activities related to both production and processing sectors. Most of the operations like pit making, basin opening, weeding, irrigation, plant protection and harvesting are performed manually. Mechanization in the coconut sector has not progressed much. The cost of labour too has gone up making some of the processes un-remunerative. Attempts made to develop manual as well as self propelled climbing device for climbing palms have led to the development of manually operated climbing machines developed by CPCRI, TNAU and an innovative farmer (Shri Chemberi Joseph), which unfortunately, were only partially successful. Among them the paddle type climbing machine (the 'Chemberi Joseph' Model) is quite popular and used by many professional climbers. However, the physical exertion required for climbing and fear factor prevents many from attempting the machine and hence, warrants the development of a mechanized climbing device. It has been a challenge to the technology developers to fabricate simple, reliable and affordable harvesting and spraying devices to undertake these works from ground. There exists a huge market potential for such devices.

Irrigation has become much easier ever since the introduction of high frequency irrigation systems. However, need-based irrigation needs to be developed to save precious water. Development of automatic irrigation systems based on soil moisture measurements is the need of the hour, considering the depletion in water resources across the country.

Robotics need to be utilized to harvest either mature or tender coconut by adopting the acoustic and visual technology, for effective farm mechanization and overcoming constraints of skilled agricultural labour in the coconut sector.

Simple cost effective devices for spraying, tapping neera, irrigation etc. in collaboration with major research organizations like IITs, NITs and ICAR-CIAE, need to be developed for improving efficiency of farm operations and overcoming labour scarcity in the agricultural sector and maintaining a sustainable coconut production environment.

1.3.1.11. Technology transfer

At present, dissemination of technologies is mainly through trainings, demonstrations and published materials. There should be a paradigm shift in extension approaches by 2050 to meet the demands of well educated network of clientele groups. Emphasis needs to be given for effective utilization of social media/mass media in technology dissemination. Streamlining of extension approaches is to be undertaken to suit the fragmented small and marginal holdings. Participatory group approaches, targeted programmes for youth and women entrepreneurs are to be strengthened.

Extension framework for using farmer organizations in technology transfer and entrepreneurship development needs to be explored and developed.

Extension mechanisms for empowering labour groups with special emphasis on mechanization and skill upgradation for improving labour efficiency and fostering functional linkages with farmer organizations needs to be explored.

ICT-based technology transfer mechanism are to be developed, such as, location specific or problem-based decision support systems to cater the needs of growers, mobile-based application, converging mass media utilization with ICT, utilizing social media platforms for timely technology transfer, facilitating E-infrastructure for providing marketing information and input delivery, for empowering growers and other stakeholders in the coconut sector.

Participatory research, involving farmer groups for refining and fine tuning of technologies for higher efficiency of the sector is to be given greater emphasis. Farmer organizations are to be facilitated for meaningful partnership in technology generation and transfer and for achieving efficiency in commodity value chain.

Integrating youth/women farmers organizations with other main stream groups in agriculture with leadership roles and mainstreaming functions should be supported with policy prioritizing, for empowerment of the target groups and sustained development of the coconut sector.

1.3.2. Developmental and policy aspects

1.3.2.1. Impediments in the trade spectrum

The significance of analyzing coconut sector in India in the light of recent policy issues, especially the ASEAN-India Free Trade Agreement (AIFTA) emerges in the context of commodity crisis. The likely impact of AIFTA cannot be undermined for three reasons. Firstly, the present context should be seen as a continuation of evolving trade liberalization regime and the effects of such a regime on the agrarian sector, especially plantation crops sector. Secondly, although coconut and coconut oil is put under the negative list, the tariff reduction in palm oil, which is a close substitute of coconut, would turn up detrimental in the near future (Table 8). The surging palm oil imports in the recent years are noteworthy and substantiate this argument. Thirdly, the agreement is an evolving one and the tariff rates fixed are ceiling rates (the maximum level to which tariff can be fixed), thus providing adequate flexibility to fix the tariff rates to lower levels. Although coconut and coconut oil are in exclusion list of AIFTA, there is a general commitment under AIFTA to review the exclusion list every year with a view to improve the market access. Obviously, there will be pressure to reduce the number of tariff lines kept in the exclusion list. Therefore, there always exists a threat for the domestic coconut industry, considering that, the existing price difference may facilitate the cheap imports in case coconut is removed from the exclusion list.

Table 8. Tariff reduction schedule: Special products

Tariff line	Base rate	2010	2015	2019
Crude palm oil	80	76	56	37.5
Refined palm oil	90	86	66	45
Coffee	100	95	70	45
Tea	100	95	70	45
Pepper	70	68	58	50

Regional trade agreements are becoming inevitable in the growth path of trade liberalization and globalization. The most important aspect in the evolving trade agreements regime is to appropriately reflect the sectoral interests/issues in the national agenda so that the sectoral apprehensions are well represented in the regional/ free trade agreements. In order to materialize this, in-depth sectoral studies in collaborative mode on various facets of coconut economy in India has to be conducted and well chalked out sectoral policy documents should be brought out. It is also necessary to find out the leverage points of the coconut sector wherein we can gain the competitive advantage vis-a vis the other competing countries in the international arena.

1.3.2.2. Price volatility

The coconut market in India is always unstable and uncertain due to frequent fluctuations in prices. Usually fluctuation in price occurs due to change in market conditions in response to seasonal and annual variation in production apart from competition from other edible oils, particularly palm oil.

While examining the price movement of coconut for the past ten years, the price instability during the past four years is noteworthy (Figure 12). The analysis revealed that steep rise in coconut price is associated with less supply due to decline in productivity and high demand for export and processing units within the country. Five major reasons are attributed to the price escalations which are: a) the supply deficits, b) price rise in substitute oils, c) surging industrial demand, d) high volume of exports and e) a global shortfall in edible oil supply. Any price rise due to the demand pull is always sustainable, or else the price rise period will not last for a long time. Such a scenario will create perplexity among farmers with respect to their approach towards coconut farming. Therefore, long term strategies for the price stabilization of the coconut and coconut products are imperative in the current juncture.

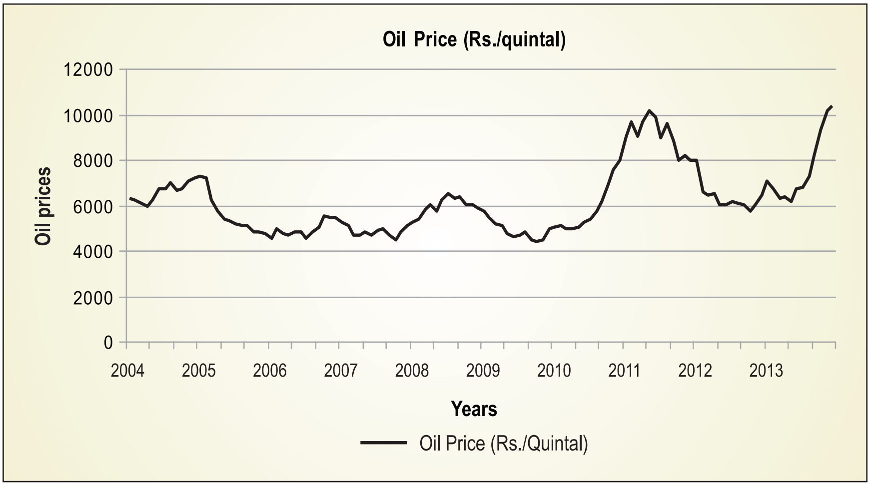

Figure 12. Price movement of coconut oil (2004-2014)

An effective price signaling with expert market intelligence system is of paramount importance to mitigate the frequent price fluctuations in coconut and its major products.

In this connection, a collaborative effort to chalk out a supply chain frame wherein the coconut oil lobby syndicates are brought under the control of Coconut Development Board/NAFED should be an urgent initiative. The problems of low income from the coconut holdings due to decline in the prices of coconut and its products necessitated the need for development of appropriate coconut based farming systems to enhance the farm level income and development of broad based processing technologies for the sustainable growth of the industry. It is categorically proved that, scientific coconut based farming systems will mitigate the price risks of coconut monocropping by providing adequate additional returns. Therefore region specific coconut-based cropping/farming system models are to be evolved to moderate the price risks.

1.3.2.3. Consumption pattern of coconut and coconut products

Of the total production of coconuts in the country, about 50 percent is used as mature nuts, 35 percent is used for copra and 15 percent is consumed in the tender form for drinking purposes (Figure 13). Ninety two percent of the mature raw nuts are consumed for domestic purpose and a meagre eight percent is absorbed by the industry for converting into value added products like desiccated coconut, coconut milk/cream/powder and other products. In order to upgrade into a commercially vibrant sector, there is an urgent need to restructure the existing consumption pattern through providing more emphasis on value added coconut products.

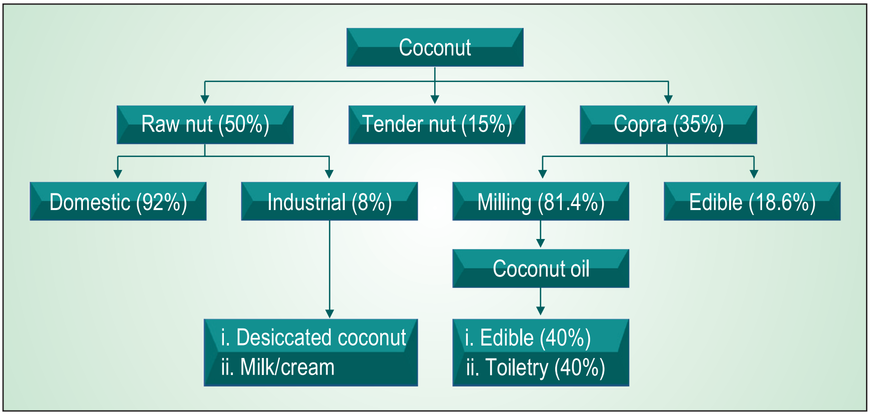

Figure 13. Depiction of consumption pattern of coconut and its products

A general decline in household level consumption of coconut for culinary purpose has been observed invariably among major states as well as at the all India level (Tables 9 & 10). Most surprisingly, in tune with the all India decline in per capita coconut oil consumption, Kerala, which traditionally uses coconut oil as its major cooking oil, has also shown a decline in consumption both in rural as well as urban sectors. These changes in the consumption pattern will definitely have a policy level implication as far as the demand of coconut is concerned.

Table 9. Percentage households reporting consumption of coconut oil in India

State	1993-94	1999-00	2006-07
Andhra Pradesh	---	---	0.3
Karnataka	5.9	7.1	1.5
Kerala	83.7	83.7	83.5
Tamil Nadu	1.8	4.1	1.3
India	3.4	4.1	3.0

Source: NSS (3 rounds)

Table 10. Consumption of coconut (per capita per month in numbers)

State	Rural		Urban	
	2000	2007	2000	2007
Andhra Pradesh	0.22	0.27	0.30	0.33
Karnataka	1.32	1.19	1.46	1.16
Kerala	4.89	5.03	4.81	5.02
Tamil Nadu	1.66	1.36	1.71	1.42
India	0.37	0.35	0.51	0.47

Source: NSS (2 rounds)

Product positioning is an important aspect to be taken care of with regard to increasing the demand for high value coconut products. Concerted efforts to break the cognitive belief on adverse health effects of coconut and its products need to be revamped with authentic medical certification.

Coconut products can be certified as organic, GMO-free, natural, healthy and environment-friendly. To improve market access of coconut products, the conduct of market promotional campaigns through participation in high-impact trade exhibitions, technical seminars on health and nutritional aspects of coconut products need to be intensified.

1.3.2.4. Policy distortions in procurement and tariff structure

The supply of coconut oil has been consistently higher than the corresponding demand as shown Figure 14. This excess supply has been exerting a downward pressure on coconut oil prices in recent years and thereby depressing the prices for the main raw material, copra. This is in contrast to the widening gap between domestic consumption and production of total edible oils. Edible oils are India's largest agricultural imports with India importing US$ 11.2 billion worth of edible oils in 2012-13. Imports of edible oils constitute almost half of total domestic consumption of edible oils and the largest chunk (about 70 percent) of these imports consists of palm oil.

The price of milling copra is influenced by the demand and supply position of coconut oil. However, various edible oils are substitutable; linking the price of coconut oil to price of other vegetable oils especially palm oil. Palm oil is the closest and the cheapest substitute of coconut

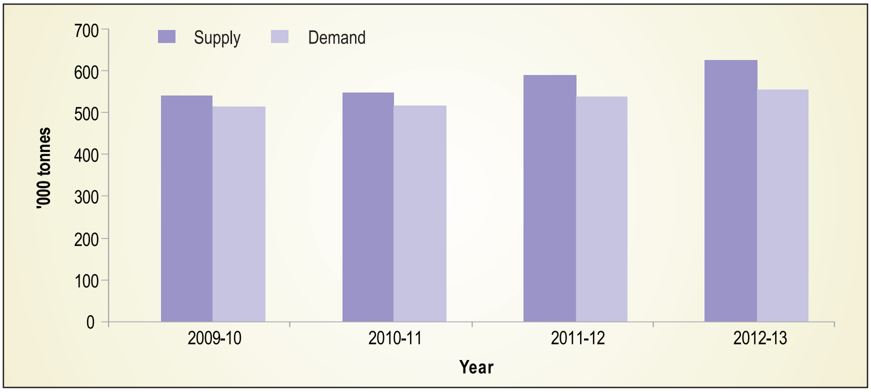

Figure 14. Demand and supply of coconut oil
Source: CDB, Kochi

oil as far as industrial and culinary purposes are concerned and it is also the largest imported edible oil.

As far as market stabilization of coconuts is concerned, National Agricultural Cooperative Marketing Federation of India Ltd (NAFED), established in 1958, has been entrusted to procure the copra from market with a Minimum Support Price (MSP) in the event of price crash. The procurement system of copra in India has never elevated the market prices to a higher level (Figure 15). From the NAFED's point of view, the agency, though could procure large quantum of copra and has the capacity to convert the copra into coconut, could never find the market to push their product with at least a minimum profit margin.

Another related reason for crashing of market price of copra below the MSP is the inability of NAFED and the respective state designated nodal agencies to carry out large scale procurement operations. At all India level, procurement was 8.0 percent of the total copra production in 2009, which decreased to 3.2 percent in 2010, but increased to 9.2 percent in 2012 (Figure 16). This level of procurement is too low to create an impact on the market prices. This is due to some basic constraints which include lack of adequate infrastructural facilities, problems in getting storage space, delay in selection of state agencies for procurement etc. In addition, in 2013, the government has decided to restrict procurement operation to ninety days in one calendar year. The procurement plan on 90 days' period at a stretch is insufficient as the harvesting season for coconut is much longer.

Figure 15. Minimum Support price of copra vis-à-vis market price
Source: CDB, Kochi

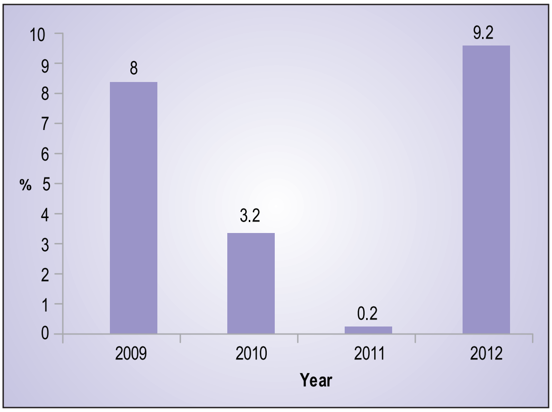

Figure 16. Procurement of copra as percentage of production
Source: NAFED

The import duties on edible oils have moved basically in counter-cyclical nature to the level of edible oil prices in global markets. This is a rational policy choice which is required to stabilize edible oil prices in the domestic market. Figure 17 shows the trend in international palm oil prices and correlates it with the Indian import duty structure for palm oil. In 2007-08, the international prices of palm oil were on an uptrend and therefore, the import duties on crude palm oil (CPO) and refined palm oil were reduced drastically to nil and 7.5 percent, respectively, with effect from 1st April, 2008 to moderate the domestic prices of edible oils. But since 2012, the palm oil prices have been declining and the import duty still remains at a low level. In view of fall in international prices of palm oil, the import duty on crude palm oil was increased to 2.5 percent but remains the same for refined palm oil.

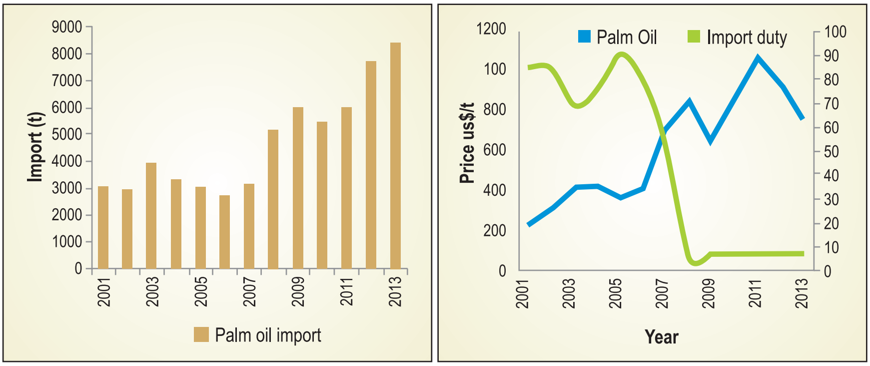

Figure 17. Palm oil imports and tariff structure

A major distortion in the domestic edible oil markets is being created by the government policy of giving a subsidy of Rs. 15 per kg on imported palm oil and soya bean oil for PDS consumers. This is further accentuated by states like Tamil Nadu and Andhra Pradesh which give additional subsidy on palm oil distributed through PDS to the tune of Rs 18.2 per kg and Rs 11.5 per kg, respectively. This heavy subsidy on palm oil erodes the demand for coconut oil and leads to falling prices of coconut oil and thereby copra. By following a pro-consumer policy, these states are inadvertently harming the coconut farmers and processors.

The import duty for palm oil has to be dynamically adjusted to its international prices as palm oil prices acts as an anchor to all edible oil prices. A bearish trend in palm oil prices exerts downward pressure on prices of all edible oils with an adverse effect on domestic production and further rise in palm oil imports. Therefore, there is an urgent need to re-calibrate the import duty structure. The policy of low duty import and further subsidization of palm oil price through PDS at the cost of domestically produced coconut oil implies a serious fallacy of policy and needs to be corrected urgently.

In order to create an impact in the market and for the benefits of MSP to reach the genuine coconut farmers, adequate quantity of copra should be procured. The studies on pattern of distribution of annual yield of coconut indicates that the number of nuts harvested varied from harvest to harvest and 60% of the production of a coconut palm is harvested during the peak production period i.e., the first six months of the calendar year, and hence a stable price during these periods is of utmost importance for achieving profitability in coconut based farming system. The copra procurement scheme should be designed keeping in view this important aspect of coconut production in the country.

1.3.2.5. Innovation system of coconut sector

The innovation system for coconuts in India is unique wherein several governmental agencies/institutes undertake the research and development for the commodity, evidently lacking collaborative efforts. Six components identified in the innovation system of coconut are: (i) CPCRI is spearheading technology generation for coconut production. The SAUs are also working in coordination under the AICRP on Palms for location-specific technology generation in coconut (ii) At the policy level, Coconut Development Board (CDB) is the key organization, which is a statutory body under the Government of India for the integrated development of coconut production and utilization in the country (iii) For marketing aspects of coconuts, National Agricultural Cooperative Marketing Federation of India Ltd, established in 1958, has been entrusted to procure the copra from market at the minimum support price (MSP) in the event of market price crash. However, the procurement system of copra in India has been ineffective, and it has never elevated the market prices (iv) The unorganized producers with small and marginal holdings constitute the fourth component of the coconut innovation system (v) The intermediaries in the coconut sector operate in a very large grey area forming syndicates, lobbies and also practice the copra/coconut oil hoarding which causes continuous price fluctuations in the market (vi) The consumers of coconut and coconut products, these include a large number of households as well as industrial consumers.

It is worthwhile to note that there is no direct link between activities of different stakeholders in the coconut sector, and the co-ordination across research agencies and concerted effort of developmental agencies are the missing links in the coconut sector of India. This has apparently reflected in the technology channelization and technology adoption in many ways. The current sectoral innovation system of coconuts in India has huge strengths on the research front of coconut, but unilateral increase in productivity is not the sole solution for the sectoral crisis. The lack of price stability, inadequate price support mechanism and marketing facilitation are the other factors detrimental to the functioning of coconut value chain. The lack of effective group coherence and professional approach (among different stakeholders) still remain as problematic facets.

The Institutes should take a lead role to re-engineer and revitalize the coconut sector in the country by providing adequate emphasis on product diversification and creation of neo-market platform to promote coconut as a high nutrient value product with Good Management Practices (GMP), Good Agricultural Practices (GAP) and Hazard Analysis and Critical Control Points (HACCP). Facilitation of co-creative, innovative, vibrant social enterprises is warranted to pass on the value creation in the coconut sector to farmers in an appropriate manner and to reduce the social disparity. With the growing realization of lesser profitability in small farm holdings, producers/farmers should be encouraged to get together and form small cooperatives or crop based organizations to develop and utilize community facilities for farm operations, post harvest processing and marketing to economize on production as well as marketing costs. Further, research orientation will lead to an increase in the number of economically viable coconut farms of different sizes and increase in the number of processing enterprises. For the vision of developing a sturdy and vibrant coconut industry which does not depend on copra/oil to come true, we need to come up with more breakthrough coconut products with Unique Selling Proposition (USP) which is strong enough to capture the niche export market segment. As the technologies are adopted only when

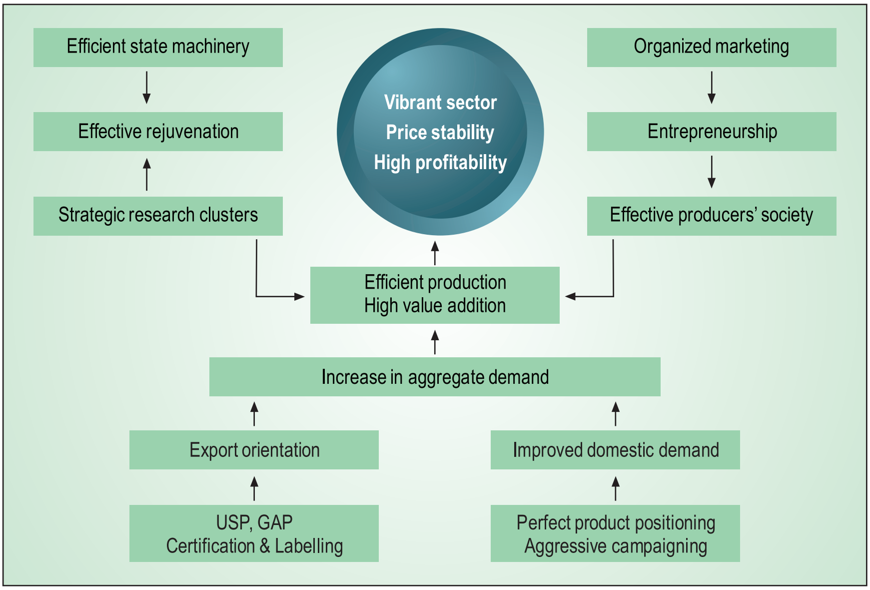

Figure 18. Restructured innovation system of coconut sector for a vibrant coconut economy

profitable, policy interventions in market and regulation of trade tariffs to the benefit of the industry to compete with global players are the way forward. To encourage investments in the coconut sector, the government, as a matter of policy, must consider coconut as a priority crop in its national agricultural development agenda. The government and private financial sector through the banking system should provide support through reasonable credit schemes for coconut processing business ventures. The schematic representation of the proposed sectoral innovation system of coconut is depicted in Figure 18.

❑

2. Arecanut

2.1. Background

Arecanut is an important commercial crop of India providing livelihood to a substantial number of farm families. Although the production of arecanut is localized in a few states, the commercial products are widely distributed across the country and are being consumed by all classes of people. Arecanut industry forms the economic backbone of nearly six million people in India and for many of them it is the sole means of livelihood. Ever since 1970s, as per the government policy, area expansion of arecanut is discouraged. Nevertheless, the area increased by 70% during the last two decades and the production increase was mainly due to area expansion. Area expansion of arecanut is taking place in non-traditional tracts like cleared forest lands, paddy converted lands, plains and in clay soil belt. The productivity has remained stagnant at 1200 kg/ha due to climate, soil, crop and management constraints and also due to its cultivation in unsuitable areas. The yield gap of 120-180% between national/state average and on-station experiments clearly indicates low rate of adoption of suitable technologies. Stagnating market prices and increasing cost of production, especially the skilled labour charges in the recent times have generated livelihood concerns for arecanut farmers.

In view of these issues, it is imperative to assess the current status of the arecanut sector in the country and identify the gaps, commonalities and recommend opportunities for sectoral development in order to put a renewed focus for the sector. The information generated through such documentation is vital for the policy institutions for determining and fixing the future of the crop and also for further planning on the crop keeping in view the existing conflicts and livelihood concerns. The document analyses global and national production, consumption and trade aspects of arecanut sector in brief and subsequently proceeds to describing the strategic plan frame work on challenges and approaches to achieve the sectoral vision.

2.2. Scenario on production, consumption and demand

2.2.1. Global scenario

The current production of arecanut in the world is about 127 thousand tonnes from an area of 925 thousand ha (Table 11). India ranks first in both area (49%) and production (50%) of arecanut (Figures 19 & 20). Other major arecanut producing countries are Indonesia (16% area and 15% production), China (5% area and 11% production) and Bangladesh (20% area and 8% production).

Table 11. Country wise area, production and productivity of arecanut

Country	Area ('000 ha)	Production ('000 t)	Yield (kg/ha)
India	453.6	632.6	1395
Indonesia	149.9	187.0	1247
China	46.0	135.0	2935
Bangladesh	184.0	108.0	587
Myanmar	56.5	122.0	2159
Thailand	18.0	35.0	1944
Sri Lanka	15.9	37.7	2370
Others	2.0	17.5	----
World	925.9	1274.8	1377

Source: FAOSTAT

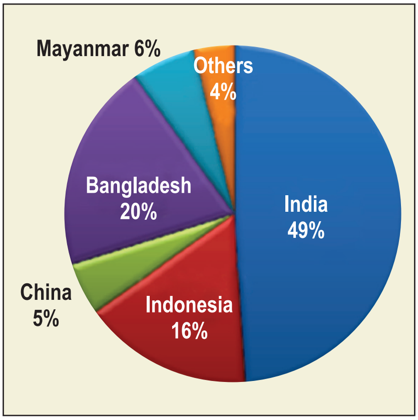

Figure 19. Share of area in major countries

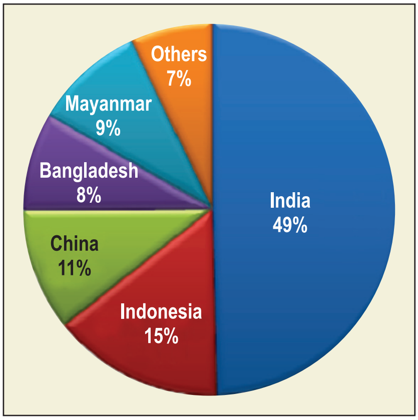

Figure 20. Share of production in major countries

2.2.2. National scenario

In India, arecanut is cultivated in an area of 453,000 hectares with an annual production of 632,000 tonnes (Table 12). In India, arecanut is popular for masticatory purpose and used either with betel leaves or as scented supari. Arecanut cultivation is concentrated in South western and North eastern regions. The states of Karnataka, Kerala, Assam, West Bengal and Meghalaya are the major producers and account for more than 70% of the area and production (Figures 21 & 22).

Table 12. State wise statistics of Arecanut in India

Country	Area ('000 ha)	Production ('000 t)	Yield (kg/ha)
Karnataka	221.4	358.6	1620
Kerala	101.7	118.2	1162
Assam	75.1	72.6	967
West Bengal	11.4	21.2	1857
Meghalaya	16.0	23.0	1626
Others	28.0	39.0	---
India	453.6	632.6	1395

Source: NHB Final, 2012-13

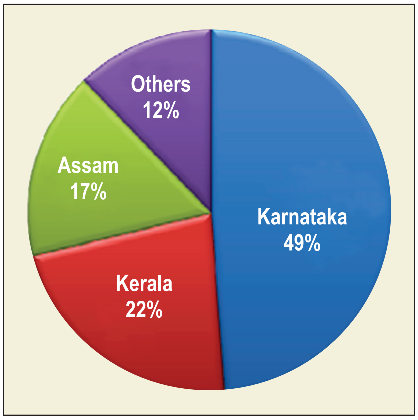

Figure 21. Share of area in major states

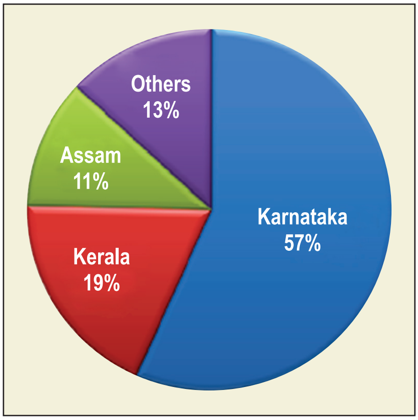

Figure 22. Share of production in major states

2.2.3. Demand and Supply scenario

The analysis of demand of arecanut reveals a consistent and steady demand after 2003. The estimated demand of arecanut, based on the utilization pattern by 2050 is 1214,000 tonnes against the estimated supply of 1254,000 tonnes (Figure 23).

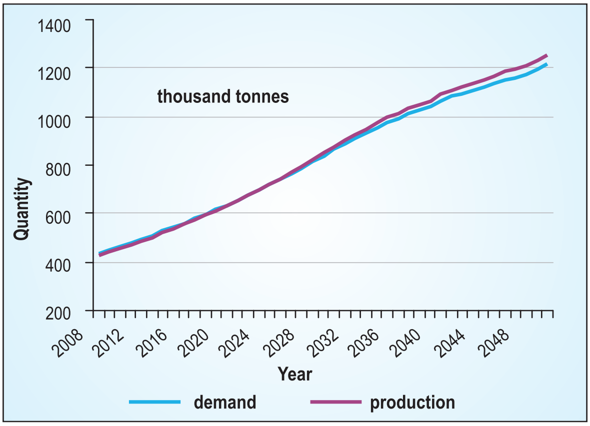

Figure 23. Projected demand and supply of arecanut

2.2.4. Export-Import scenario

Major destinations of arecanut export are Vietnam, Indonesia, Malaysia, UAE, Maldives, UK and Singapore. Supari/scented supari and 'pan masala' are two major value added products of arecanut having sizeable quantity of export. From 1999 onwards, import of arecanut to India registered a significant increase due to change in global scenario in the context of trade liberalization. Total imports were about 97316 tonnes of arecanut, which was valued at Rs 58979 lakhs during 2012-13 (Figure 24 & 25).

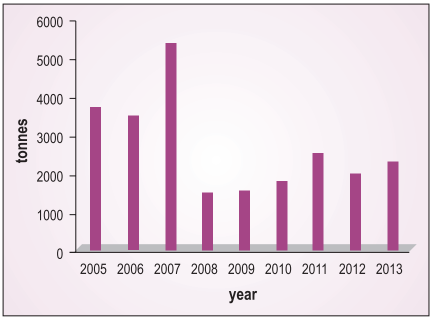

Figure 24. Export of arecanut from India
Source:DASD

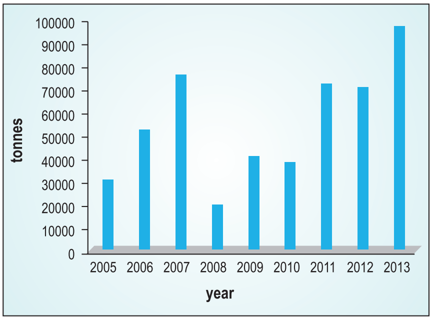

Figure 25. Import of arecanut to India
Source:DASD

2.3. Challenges and Approaches

2.3.1. Technological/research status, challenges and strategies

2.3.1.1. Varietal wealth and genetic enhancement

The cultivation practices, post harvest processing and consumption types differ in different parts of the country. The post harvest processing varies from tender nut processing to mature fresh fruit processing to drying of matured nuts. The problems like diseases and pests also vary from place to place. The varieties suited for tender nut processing may not be suitable for mature fruit drying and vice versa. Though quite a few varieties have been released by different agencies like ICAR institutes and State Agricultural Universities, there is lack of trait specific varieties suitable for different needs. In the recent period, availability of skilled labourers has become a problem for operations like spraying pesticides and harvesting. The dwarfing genes in arecanut have been exploited to develop dwarf hybrids with yield levels at par with other varieties. But the production of dwarf hybrid seedlings has been a tedious task. Yellow leaf disease and fruit rot are major diseases in arecanut leading to substantial crop losses. The varieties tolerant/resistant to these diseases will help in reducing the cost of production.

CPCRI has developed a protocol for somatic embryogenesis and plantlet regeneration from leaf and inflorescence explants of arecanut. The protocol is being exploited mass multiplication of dwarf hybrids and identified yellow leaf disease (YLD) field tolerant palms in endemic areas. The studies on molecular markers in arecanut are scanty. Identification and utilization of molecular markers linked to economically important traits, viz., plant height, hybrid vigour, resistance/tolerance to biotic/abiotic stresses and higher yield is of paramount importance towards marker-assisted breeding for hastening the arecanut improvement programme. Approximately 50-60% of the arecanut plantations have become either senile or unproductive in the country. In order to enhance the productivity, the old and unproductive palms are to be removed and planted with improved high yielding varieties, including hybrid dwarf types.

The vast collection of arecanut germplasm is available at Vittal, Regional Station of ICAR-CPCRI, which can be utilized for developing trait specific varieties. Mass multiplication of released/promising dwarf hybrids utilizing tissue culture techniques should be carried out in a public-private-participatory mode. Development of molecular markers associated with quantitative traits will facilitate marker-assisted molecular breeding to enable trait-based breeding and faster development of varieties for specific requirements.

Considering the looming threat of moisture deficit, screening of germplasm to identify lines tolerant to abiotic stress/low moisture regimes are to be taken up for variety development, along with testing of dwarf hybrids/promising varieties to identify location specific moisture deficit tolerant varieties/hybrids.

To mitigate challenges of fruit rot disease and YLD, in addition to intensive screening of the arecanut germplasm and dwarf hybrids for disease tolerance, survey and identification of fruit rot and YLD tolerant/resistant mother palms in endemic areas needs to be undertaken. Prospects of utilization of RNAi technology for management of biotic stress in arecanut is also to be explored. Simultaneously, mass multiplication of disease free, especially YLD tolerant/resistant dwarf hybrids/varieties is to be undertaken through tissue culture to ensure adequate supply of elite planting material for the disease affected tracts. The available tissue culture protocols needs to be further refined to increase the plantlet multiplication rate and reduce plantlet production cost for enabling cost-effective mass multiplication of high yielding arecanut varieties with tolerance/resistance to biotic/abiotic stress through in-vitro culture.

Inter-specific and inter-generic hybridization in arecanut is a significant plant breeding tool for incorporation of desirable characters such as tolerance to fruit rot, YLD and moisture deficit from wild into the cultivated arecanut in future crop improvement programme. In line with this, development of high yielding disease tolerant/resistant arecanut varieties/hybrids using inter-specific and inter-generic hybrids between *Areca catechu* (H. Dwarf) with *Areca triandra, Normanbya normanbyi* and *Actinorhytis calapparia* and identified field tolerant palms is to be taken up with high priority.

Globally, depleting natural resources is a matter of great concern and in the field of arecanut production, there is also a need to develop varieties with greater resource use efficiency and for different cultivation regimes. This would necessitate assessment of the input-use efficiency in the available germplasm for facilitating development of high yielding varieties with higher input-use efficiency as well as developing varieties suitable for low-input sustainable agriculture with reduced carbon footprints.

Establishment of new seed gardens of improved dwarf hybrids/varieties in public private partnership in various areca growing tracts is to be given priority. *In situ* conservation/participatory plant breeding and seed production is to be given greater emphasis for enabling the farmers in up-scaling the varieties/hybrids with desirable features.

Upscaling of planting material production, through mass multiplication of released/promising dwarf hybrids/varieties, utilizing tissue culture techniques is to be given greater priority and is to be taken up in collaboration with different stakeholders, including private agencies and NGOs in order to facilitate replanting of old and unproductive plantations and enhance the seed replacement rate of improved arecanut varieties.

Considering the need for hastening the breeding programme for development of varieties for specific requirements and facilitate marker-assisted molecular breeding, there is a need to identify trait-specific molecular markers associated with quantitative traits for robust screening of breeding lines in the juvenile stage.

2.3.1.2. Climate resilient and resource efficient arecanut based cropping/farming models

In the scenario of changing climate, changes in phenology, pest and disease proliferation and reduced recovery are the imminent consequences in arecanut. Several long-term studies have resulted in development of highly productive, sustainable and remunerative arecanut based cropping system models. These studies have indicated that the cropping system approach results in moderation of microclimatic parameters like wind velocity, evaporation, air and soil temperatures and higher resource use efficiency than sole crop of arecanut. Cropping models for heavy rainfall zone are arecanut + cocoa; arecanut-based high density multispecies cropping system with cocoa, banana and pepper, arecanut + pepper + cocoa + banana, arecanut + medicinal and aromatic plants and arecanut + vanilla. The intercrops in these cropping models have potential to increase the net return per rupee investment by 1.66-4.50. Root crops like ginger, turmeric, tapioca, elephant foot yam, dioscorea and sweet potato and perennials like banana and pepper have been found to be ideal for intercropping in all arecanut growing regions in the country. Acid lime, pepper and banana are ideal component crops for arecanut for Sub-Himalayan humid regions in West Bengal, Assam and NE region. For high altitude areas in Kerala and Karnataka, arecanut+ cardamom system have been found to be highly profitable. Arecanut-based mixed farming models have been developed with dairy and fishery as livestock components for different land holdings. It is postulated that small and marginal farmers with less than 2.5 hectare area can increase the net income by 40-90% with inclusion of livestock components like dairy and/or fishery over arecanut monocrop.

It is vital to explore value added and export oriented crops like flower crops, vegetables and short statured fruit crops for intercropping in arecanut for nutritional security and increased returns by increasing the spacing of arecanut.

Arecanut has a potential to sequester 1.45 Mt C/year. Potential of arecanut-based cropping models in carbon sequestration and moderation of climate change issues needs to be studied thoroughly. The ecosystem services rendered by plantation crops need detailed investigations. Development of cropping system models and suitable management strategies for dwarf hybrids is the need of the hour in view of labour shortage in the arecanut belt.

2.3.1.3. Input use efficiency and soil fertility management

Arecanut yield has remained stagnant for the past two decades. Since the area expansion is not recommended in arecanut, increasing the productivity is the only answer for meeting the demand of arecanut. Majority of the arecanut area is under lateritic soil. These soils have low nutrient retention capacity and moisture holding capacity because of low cation exchange capacity and wide spread micronutrient deficiency. Other soils like clay soils have the problem of aeration and hardening of the subsurface layer. Low input use efficiency is one of the reasons for stagnant productivity of arecanut (1250 kg/ha) in laterite soils in traditional heavy rainfall zone and clay soils in non-traditional arecanut tracts. The nutrient use efficiency is very low (20-40%) in arecanut. Improved resource use efficiency is most important for reversing the stagnant trend of productivity.

The future agriculture needs reduction in cost of production with increased yield. Precision farming will become important under such circumstances. The trend of applying excess inputs to achieve higher yield has resulted in excess soil fertility. This may lead to nutrient imbalances, less response to input application, higher incidence of pests and diseases and lower profits. The incidence of disorders like crown choking, crown bending, shortened internodes and oblique nodes are increasingly noticed. Unless these issues are resolved, arecanut will not be a profitable crop in future. The research efforts of different organizations have to be directed towards input use efficiency and soil fertility. But the research on need-based application of nutrients is lacking. Optimum nutrient norms for arecanut in laterite soils have already been established. But the nutrient norms are soil specific. There is a need to find out optimum nutrient norms for all the soils where arecanut is grown. Based on these norms, it is observed that soil fertility status is above optimum in farmer's fields but leaf nutrient status showed deficit of nutrients like N, K and Zn. The variation in soil fertility across the arecanut growing regions in the country needs different nutrient recommendations for each region.

Nutrient uptake pattern indicated that arecanut is heavy feeder of N and K and requires 350 g N and 300 g K per palm per year to produce 3 kg kernel. Potassium, calcium and zinc are identified as yield limiting nutrients. This indicates the need for discontinuation of blanket recommendations and precision application of inputs based on biomass and yield levels. Long term studies revealed that organic waste recycling as vermicompost in arecanut sustains yield levels at 2800 kg/ha but requires K supplementation through alternate sources. Continuous application of organics alone for a long time leads to K depletion in soil and plant in arecanut ecosystem. Organic waste biomass production from arecanut is 2.3-3.3 million tonnes per annum in India and recycling of these wastes using earthworms can produce about 2.2 million tonnes of vermicompost (2% N: 0.4 % P: 0.9% K). These wastes can supply substantial quantity of nutrients amounting to 44000 t of N, 8800 t of P and 19800 t of K and vermicompost has potential to reduce the dependence on imported N and P fertilizers completely and to some extent K fertilizers.

Water stress for 30 days results in yield reduction upto 75% in arecanut. Water shortage is expected in future either due to rainfall deficit or ground water depletion in both high and low rainfall regions. Due to reduced ground water table and increased temperatures, drip irrigation is the only option for increasing the water productivity. Drip irrigation is very efficient and results in 44% water saving and 45% yield increase in arecanut. Drip-fertigation is another important input saving technology and better adaptation strategy under changing climate scenario as it ensures higher efficiency of the two most critical inputs i.e., water and nutrients. The annual maintenance cost in drip-fertigation technology is only 50% of conventional method of arecanut cultivation.

Development of instantaneous soil and leaf testing kits and moisture probes and nutrient formulations are required for precision application of inputs for the convenience of farmers. In view of the growing preference for organic farming, further studies are required to find out alternate K sources to overcome the problem of low K in organic cultivation. Studies on biochemical markers and activities to identify nutrient imbalances are to be given greater emphasis.

It is pertinent to evolve nutrient management strategies with focus on precision agriculture by considering soil fertility, leaf nutrient status, nutrient uptake pattern and yield level. It is also vital to streamline the management strategies for long standing problems like nutritional disorders and Yellow Leaf Disease (YLD). Intensive studies on water harvesting and *in situ* water conservation measures are needed for conjunctive use of ground water and harvested water.

Development of PGPR formulation-based bioinoculant technology and precision application technology for different soil ecological conditions is to be given greater thrust for maximizing crop productivity and profitability. Studies on value addition to leaf vermicompost by PGPR amendment and developing biostimulants are required for facilitating holistic cultivation strategies. The potential changes in the composition of key plant-beneficial microbial communities in response to climate change can give important leads for exploiting rhizosphere microorganisms to make the arecanut cropping/farming system climate resilient and resource efficient.

2.3.1.4. Integrated plant health management

Fruit rot caused by *Phytophthora* and YLD caused by phytoplasma are currently the most important yield limiting factors in arecanut. The increasing incidence of other diseases like inflorescence dieback and basal stem rot are other major concerns. Control of yield loss (10-90%) due to *Phytophthora* diseases is a huge challenge. Prophylactic spraying of 1% Bordeaux mixture is recommended for the *Phytophthora* disease control. Heavy rainfall, non-availability of skilled climbers for spraying during rainy season, absence of machinery for effective delivery of fungicides, variability of the pathogen and occurrence of more virulent strains of the pathogen are leading to ineffectiveness of the recommended control measures. YLD is taking a heavy toll of areca palms every year and the disease has rendered arecanut cultivation unremunerative to the farmers due to severe reduction in yield. Non-availability of curative measures and YLD resistant varieties is another major challenge. Non-availability of effective forecasting models for *Phytophthora* disease in arecanut is a hurdle in effective disease management. Timing of using biorationals is very critical in pest management programmes and delivery techniques for pest management have to be improved considering the palm canopy. Impact of pesticides on ecosystem especially bio-magnification is a matter of concern. Screening and engagement of ecosystem compatible biorational molecules and biocontrol agents poses great challenge.

Fruit rot: Understanding the diversity of *Phytophthora* in relation to the outbreak of the fruit rot disease of arecanut at molecular level is the most important aspect. Identification of effective endophyte against *Phytopthtora* and development of management strategies for fruit rot disease with biocontrol agents and chemicals are also imperative. Elucidation of resistance mechanism of certain wild *Areca* species to *Phytophthora* and identification of the genes governing resistance, and exploring the possibility of using resistance genes to develop improved arecanut varieties with resistance to fruit rot disease require greater focus.

Yellow leaf disease: Identification of effective endophyte, alternative biocontrol agents and PGPRs are essential for yellow leaf disease management. It is of significant importance to develop multiplication protocol for disease-free planting materials. Besides it is vital to evolve a robust diagnostic kit for identification of the disease well in advance. Above all, survey and monitoring of the diseases at regular intervals on the national level using satellite images is essential, for chalking effective disease management strategies.

Inflorescence die back: Studying the diversity of *Colletotrichum* species involved in causing inflorescence die back is required in order to develop an integrated management tool for combating the disease. Apart from this, it is important to study and monitor the effect of change in temperature, rainfall pattern and cropping systems on outbreak of the disease and develop effective forecasting and management strategies.

Foot rot: A three pronged strategy is to be executed for the control of foot rot; i) understanding the cross infection potential of *Ganoderma* isolates to other hosts like coconut, oil palm etc., ii) Identification of effective microbial bio control agent by comparing the microbiome of healthy and diseased palms, iii) Study the influence of various cultural practices in the non-traditional areca growing areas on 'anaberoga' and find out the practices for management of the disease.

2.3.1.5. Mechanization

Timely spraying of plant protection chemicals against pests and diseases is continuing to be the biggest problem for arecanut farmers. Prototypes and models of several spraying devices are available in the market but there is a difficulty in reaching the crown with these devices, which needs to be addressed. Moreover, skilled climbers are becoming scarce and labour charge for climbing operation is escalating. Arecanut climbing devices available in the market are not popular among the farmers due to various reasons like involvement of drudgery, complicated design, high cost and requirement of prior experience.

Various types of climbing devices like tractor operated, self propelled, manually operated and robotic type (electronic) devices have been developed and tested for harvesting of coconut by both the government and private sector since early 1970s. These devices need to be tested for suitability to arecanut palm. Attempts are being made by several state and private institutions as well as innovative farmers to develop such a device. There exists a huge marketing potential for such a prototype for plant protection operation and harvesting.

Efforts are needed to develop an efficient sprayer to spray on arecanut bunches from ground. This requires collaboration of various ICAR institutes, such as CIAE, Bhopal, SAUs and private entrepreneurs. Efforts are also needed to develop a self propelled arecanut palm climbing device with synergized efforts of sectoral stakeholders.

Developing automated irrigation systems to save water and energy either with solar or wind energy operated pumps should be strategically addressed and, development of integrated dryers (solar, agricultural wastes and electrical based) for drying arecanut is needed to reduce the drying time and improve the quality of the produce.

2.3.1.6. Value addition and product diversification

Arecanut is a good source of flavonoids, polymerized leucocyanidins and tannins, besides containing small quantities of catechin, leucopelargonidin and leucocyanidin. The major constituents of arecanut are carbohydrates, lipids, proteins, crude fibers, polyphenols and alkaloids (arecoline, arecaidine, guvacine and guvacoline). Among the alkaloids, arecoline is the most potent and active constituent that is suspected to cause health hazards and the World Health Organization classified arecoline as carcinogenic. Till today, the required scientific data is not available to classify arecoline as carcinogenic. Thus, a multi-disciplinary research effort involving chemical, medical and social sciences are to be coordinated to dispel such claims. It is desirable to separate alkaloids/polyphenols from arecanut to obtain alkaloid-free polyphenols and subsequently use it for nutraceutical/therapeutic purposes and also for suitable use of arecoline in the pharmaceutical industries. Therefore, it is essential to develop an efficient method for extraction of polyphenols from arecanut with minimum arecoline content and identification of arecanut varieties with less arecoline content.

Tannins extracted from arecanut can be used for dyeing. Husk can be used for furfural production and as a source of potassium (mulching). Bio-softened arecanut husk fibers can be exploited commercially for the production of furnishing fabrics, textiles etc. by blending with cotton, viscose and polyester.

In view of suspected health impacts of arecanut alkaloids, there is a need to investigate the emerging non-thermal and thermal processing techniques such as high pressure processing, ohmic heating, pulsed electric fields, irradiation, ultrasound, microwave heating, infrared heating on different stages of matured arecanut (very tender, tender and mature) in order to see the effect on reducing impact of alkaloids and bioactive compounds. In addition, there is a need to investigate the effect of some relevant ITKs (for instance, dipping arecanut in boiled milk) on reduction of tannins and other alkaloids.

The studies on alternate uses of arecanut in the production of wines, toothpaste, herbal mouth wash etc. and pharmaceutical formulations to control leucoderma, anaemia and obesity should be given paramount importance and popularized with authentic scientific back up.

Process optimization and standardization is needed for the utilization of 'chogaru' (arecanut tannin enriched liquor) in the formulation of food colors, dyes, adhesives, inks etc. Besides, process optimization and standardization of protocol for the production of tooth brush, paper boards, ply boards, hardboards and plastics from arecanut husk mixed with conventional raw materials should also be taken up.

2.3.1.7. Arecanut-based agribusiness

Even though several value added technologies are available for arecanut by-product utilization such as making of eco-friendly disposable plates and bowls from areca leaf sheath, leaf sheath fodder, oyster mushroom production from leaf and bunch wastes and vermicomposting, there are only very few commercial small-scale ventures. About 3.5 billion arecanut leaves and leaf sheaths are produced every year and have the potential to facilitate production of 0.3 billion kg of mushroom and Rs.7 billion worth areca leaf sheath plates and bowls. Production of vermicompost from arecanut wastes is done on a very limited scale by farmers. Vermicomposting of arecanut leaf wastes per hectare can generate a net income of Rs. 20,000 and can be taken up as micro-enterprise instead of unscientific dumping of wastes in the plantations.

Skill development/capacity building for women SHGs and rural youth for efficient by-product utilization in arecanut by various means is necessary to ensure value addition and income generation. In this regard, required support for establishment of producers associations, societies and companies at village level for production of disposable plates/bowls by providing credit, quality grading and marketing facilities coupled with export promotion of this eco-friendly product need to be given due attention.

Initiating village level mushroom and vermicompost production units in arecanut with the help of local manpower and establishment of large scale enterprise by integration of plate making, mushroom production and vermicomposting on a single platform and ensuring online trading facilities are also strategic considerations for supporting entrepreneurship development in the arecanut sector.

2.3.1.8. Arecanut supply chain

The first and foremost area of concern is the streamlining of the market and marketing system of the sector. It is a researched fact that more than 75% of the domestic arecanut trade is in the hands of private traders, wherein cooperatives have little bargaining position. This eventually results in frequent fluctuations in prices due to poor market intelligence, market hoarding and imperfect market formation. The price spread analysis of arecanut indicated only a meagre share of producer in the consumer price. There is an urgent need to enhance the marketing efficiency by reducing the middlemen and strengthening the cooperative marketing and forming farmers groups or associations. As far as the trade transactions of arecanut are concerned, as a matter of fact, the low quality/low grade arecanut is imported to India in huge quantum.

Improvising domestic markets for arecanut is indubitably a key issue of debate especially in the context of growing concern on the social costs of promoting the crop. Emphasis needs to be given for organizing village level farmers groups, primary processing/grading units, marketing and storage units. Marketing efficiency may be improved by reducing middlemen and strengthening cooperative marketing. Production of value added products through small scale industries/Women Self Help Groups should be encouraged by providing credit facility for initial investment.

Adequate steps should be taken to explore international markets for arecanut and its value added products and provide facility for online trading by farmers and farmers groups. Trade policy measures should be initiated in this regard along with enforcing stringent food safety based trade barriers to safe guard the remunerative prices in the domestic sector.

2.3.1.9. Technology transfer

At present, dissemination of technologies is mainly conducted through trainings, demonstrations and published material. There should be a paradigm shift in extension approaches by 2050 to meet the demands of well educated network of clientele groups. Emphasis needs to be given for effective utilization of social media/mass media in technology dissemination.

Extension approaches should be streamlined to suit the small and marginal holdings wherein participatory group approaches, targeted programmes for youth and women entrepreneurs are to be strengthened. It is also important to restructure the extension framework for using farmer organizations in technology transfer and entrepreneurship development. Extension mechanisms should be evolved for empowering labour groups with special emphasis on mechanization and skill upgradation for improving labour efficiency and fostering functional linkages with farmer organizations.

ICT-based technology transfer should be enhanced through i) location specific or problem based decision support systems to cater to the needs of growers, ii) Mobile based application, iii) converging mass media utilization with ICT, iv) utilizing social media platforms for timely technology transfer and v) facilitating E-infrastructure for providing marketing information and input delivery.

Farmer organizations are to be facilitated for meaningful partnership in technology generation and transfer and for achieving efficiency in commodity value chain. Youth and women farmer organizations should be integrated with other main stream groups in agriculture with leadership roles and mainstreaming functions should be supported with policy prioritizing.

2.3.2. Developmental and policy aspects

Social cost of arecanut promotion: Arecanut sector in India is facing a crisis owing to the policy level conflicts of interests and is a matter of concern for the millions of small and marginal farmers who are solely dependent on arecanut farming for their livelihood. On one hand the possible huge social cost of growing arecanut with all the existing institutional support for the crop and on the other hand the possible marginalization of millions of farming community in the event of threats of partial or complete ban on the cultivation and allied activities of the crop are major issues to contemplate.

Complex domestic value chain: The supply chain of the arecanut is long as well as complex. There exists a huge knowledge gap about the arecanut consumption pattern and the distribution across the commodity chain. The available researched information on these aspects has mostly contributed to the academic knowledge rather than to the policy institutions and developmental agencies.

Price volatility: Fluctuating market prices and increasing cost of production, especially the skilled labour charges in the recent times have generated livelihood concerns of arecanut farmers. Market studies reveal that around 75 percent of the arecanut trade is in the hands of private traders, which has provided ample scope for hoarding and resulted in market imperfections and low price realization. While considering the period from the year 2000 onwards, we may broadly categorize the arecanut price pattern into 'price stagnation' (neglecting some intermittent price boom and bust periods). The price stagnation of the crop for such a long period has evidently caused disinterest among arecanut farmers. From 2001 onwards import of arecanut in to the country registered a significant increase due to change in global scenario in the context of trade liberalization. Surging imports, which is around 12 percent of the domestic production, certainly has a significant role in price stickiness (Figures 26 & 27).

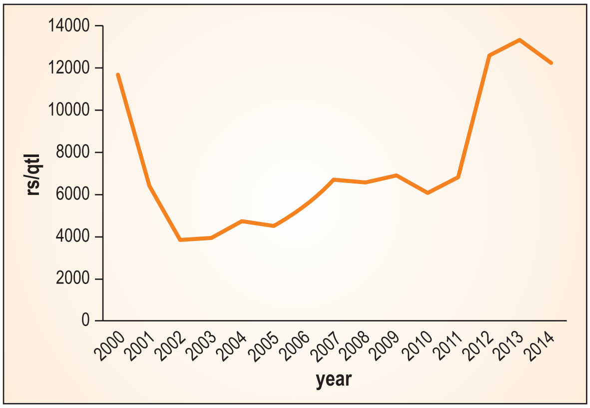

Figure 26. Arecanut prices (2000-2014), Source: DES

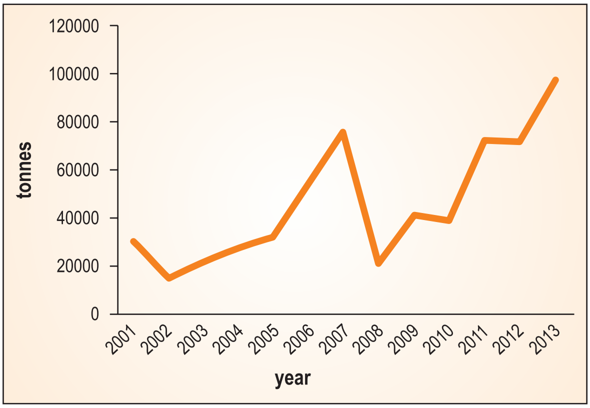

Figure 27. Import of arecanut to India (2001-2013), Source: DES

Indiscriminate expansion of arecanut: The area under arecanut in the country has increased about 40% during the period from 1998-99 to 2010-11. This increase in area has been mainly attributed to the state of Karnataka with 71.4% increase in area during the same period. Area under arecanut has also increased in Kerala with 38% increase during the last decade. These indiscriminate expansions of area under arecanut due to the remunerative price prevailing during the period of 1995 to 2000 have resulted in the surplus production of arecanut in the country.

Integrating youth/women/farmer organizations with other main stream groups in agriculture with leadership roles and mainstreaming functions should be supported with policy prioritization. An in-depth and comprehensive study on the market channels of arecanut (both chali and red varieties), consumption pattern, market structure and distribution pattern covering the entire nodes from production to consumption is imperative, thereby providing a clear depiction of the distribution scenario of arecanut produced in the country. The information generated through such a study is vital for the policy institutions for determining and fixing the future of the crop and also for further planning on the crop considering the existing conflicts of interest and livelihood concerns.

Additional area expansion both in traditional and non-traditional areas is to be strictly prohibited and simultaneously the arecanut-based cropping systems should be encouraged in the existing arecanut plantations in the country. We need to have a futuristic vision to evolve integrated and scientifically planned areca based cropping models in the country which include livestock, fishery component, and staple food/nutritional components. Evolving region specific arecanut-based sustainable cropping system models and promoting multi-species cropping system in collaboration with Directorate of Arecanut and Spices Development should be given emphasis.

Available alternative uses of arecanut for medicinal and industrial purposes have to be promoted in a wide manner to increase the domestic consumption of the produce, through institutional funding.

Rejuvenation of senile and unproductive areca gardens should be carried out using high yielding varieties/hybrids. The technological interventions should be implemented through farmer participatory group approach. Clusters of a contiguous area of 25 ha each is to be delineated and Community Based Organizations (CBOs) of farmers are to be formed to implement the interventions.

❑

3. Cocoa

3.1. Background

Cocoa, a beverage crop having high commercial potential, is mostly grown in India as a mixed crop in arecanut and coconut gardens. In the global production scenario, India is a very small player with the production share of a meagre 0.3%. It is mainly cultivated in four major southern states of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. The cocoa industry in the country has expanded to a considerable extent in recent years, with a production of 15133 tonnes of cocoa from an area of 71335 hectares and contributes about Rs.2000 million annually to the GDP of the nation.

Although the per capita cocoa consumption in India (0.04 kg/head) is meagre in comparison with major cocoa consumers, the consumption is continuously increasing over the last 10 years, reflecting a bright prospect for the cocoa sector. Taking into consideration the present day consumption patterns and growth of confectionery industry in India at around 15%, the demand for cocoa is likely to increase in coming years. The procurement strategy of the major buyers has shifted to the domestic sphere where they can save the transaction costs. Nevertheless, the domestic cocoa prices are highly integrated with the international prices and the price instability is also very high. Therefore any supply shock in the international arena may influence the domestic prices as well. The growth of purchasing power in emerging markets and the confirmation of the health/nutritional benefits of cocoa have led to a significant increase even in the global demand for cocoa. At the same time, the market has become more stringent in terms of quality requirements particularly with regard to pre and post harvest bean handling.

As a matter of fact, cocoa for India is a high potential crop with broad positive externalities for the sector as a whole. We are, as of now, a very small player in the international arena, and need to explore the possibilities to make cocoa sector a dynamic and vibrant one.

3.2. Scenario on production, consumption and demand

3.2.1. Global scenario

3.2.1.1. Production aspects

Cocoa is grown in 58 countries in around 10 million hectares with a production of four million tonnes (Figures 28 & 29). The average world productivity is 500 kg/ha, wherein among major countries, Côte d'Ivoire has the highest productivity (Figure 30). The four West African countries viz., Côte d'Ivoire, Ghana, Cameroon and Nigeria accounted for 63% of worldwide cocoa production, whereas Côte d'Ivoire alone contributed 33%. Adding the production of Indonesia to the output, the five countries reach a market share of 80%. Latin America, where the cocoa plant originated, presently accounts for only 13% of worldwide cocoa production. With the exception of Brazil, cocoa production is mainly concentrated in small-scale farms. Cocoa production is therefore highly important for many households, as it is a key source of income and livelihood.

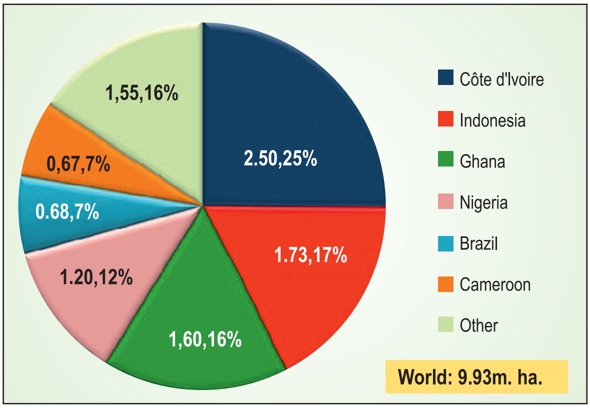

Figure 28. Cocoa area in the world (million ha), Source: FAOSTAT

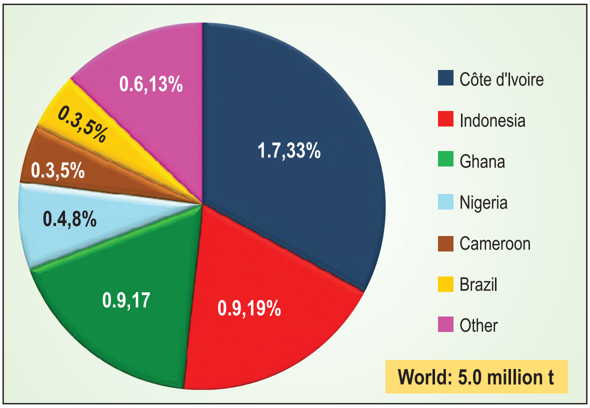

Figure 29. Cocoa production in the world (million tonnes), Source: FAOSTAT

While analyzing the production data of last ten years (2004-13), it was observed that world production has increased by 3.3% per annum. Africa's production expanded at an average annual rate of 3.7%. Cocoa output in the Americas grew at a lower average rate of 3.1%, with its share in global production stagnating at 14%,

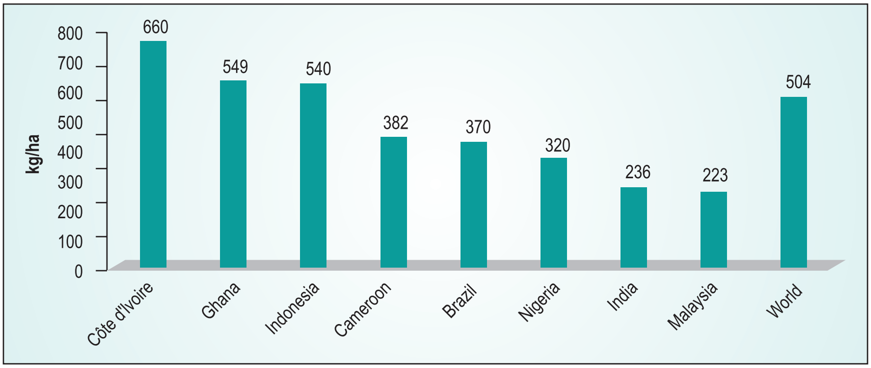

Figure 30. Cocoa yield of major cocoa growing countries (kg/ha), Source: FAOSTAT

while production of cocoa beans in the Asia and Oceania region was the least dynamic of the three cocoa cultivating regions of the world, recording an average increase of only 1.9%. Over the past decade, weather-related conditions, namely *El Nino* and *La Nina* have also had a significant effect on countries such as Indonesia, Papua New Guinea, Ecuador and Peru, with *El Nino* events reducing global cocoa output by 2.4%, according to a study conducted by the International Cocoa Organization (ICCO).

3.2.1.2. Cocoa consumption scenario

Between 2004 and 2013, world cocoa consumption expanded by 24% with most of the increase coming from higher consumption in the traditional cocoa consuming countries of Europe (up by 17%) while consumption increased by 22% in the Americas over the same period. The most dynamic regions in terms of cocoa consumption were the Asian region (up by 50%) and the African region (up by 74%). In 2013, as shown in Figure 31, the leading consumers of cocoa by country were the United States, Germany, France,

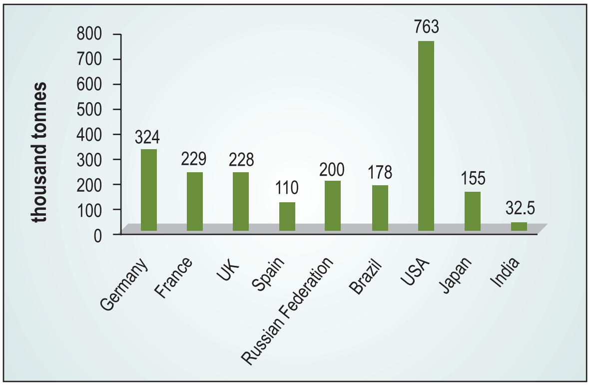

Figure 31. Domestic consumption of cocoa in selected countries (1000 tonnes/year-2013), Source: ICCO

United Kingdom, Russian Federation and Brazil. The world per capita consumption of cocoa has increased from 0.60 kg in 2004 to 1.09 kg in 2013. Switzerland recorded the highest per capita consumption (5.9 kg/year) while the per capita consumption of India is a meagre 0.04 kg (Figure 32).

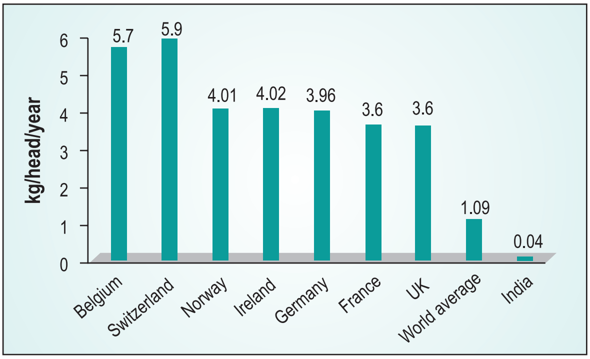

Figure 32. Per capita consumption of cocoa in selected countries(kg/head/year-2013), Source: ICCO

3.2.1.3. Trade related aspects

Information on net exports of cocoa beans contained in Figure 33, shows that the African region, accounting for 70% of net world exports, is by far the largest supplier of cocoa to the world markets. The cocoa market remains highly concentrated, with the top five countries accounting for 87% of world net exports. Côte d'Ivoire is the world's leading exporter of cocoa beans, representing 28% of global net exports, followed by Nigeria (21%) and Ghana (19%). It is worthwhile to note that cocoa continues to be an important source of export earnings for many producing countries, in particular in Africa. Africa's heavy dependence on cocoa as well as on other primary commodities as a source of export earnings has made them vulnerable to market developments, in particular price volatility, and weather conditions.

The net imports of cocoa beans for the year 2013 is depicted in Figure 34, which shows that European countries accounted for

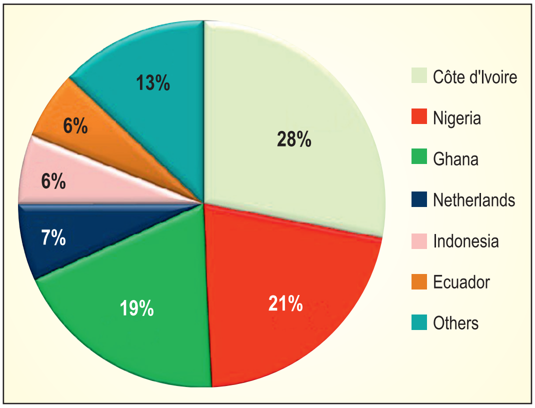

Figure 33. Share of cocoa beans export by major countries, Source: FAOSTAT

major net imports of cocoa beans, followed by the USA (14%) and Malaysia (10%). It is worth noting that although the Netherlands imports a considerable amount of cocoa beans, most of these are used for the manufacture of cocoa products which are subsequently re-exported.

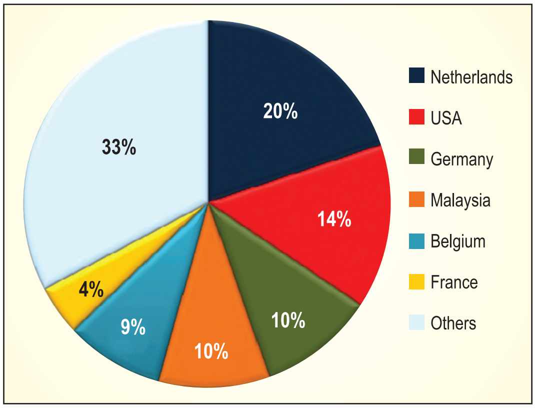

Figure 34. Share of global cocoa beans import by major countries, Source: FAOSTAT

3.2.2. National scenario

3.2.2.1. Domestic production aspects

In India, cocoa is cultivated mainly in the states of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh (Figures 35 & 36). At present, demand for cocoa beans far outstrips the local production, necessitating large scale imports to meet the national requirements. India produces 15100

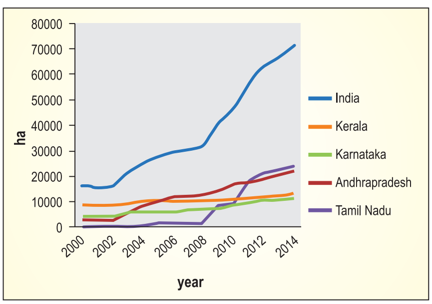

Figure 35. State wise trend in area of cocoa (2000-2014) Source: DES

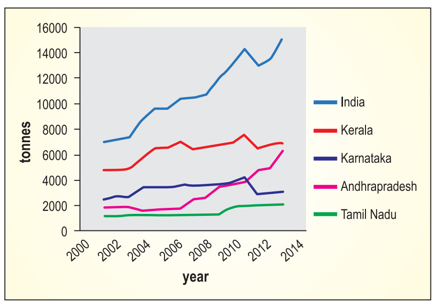

Figure 36. State wise trend in production of cocoa (2000-2014) Source: DES

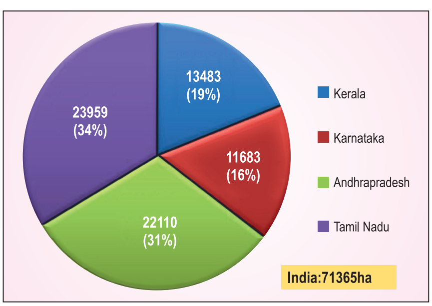

Figure 37. State wise share of cocoa area

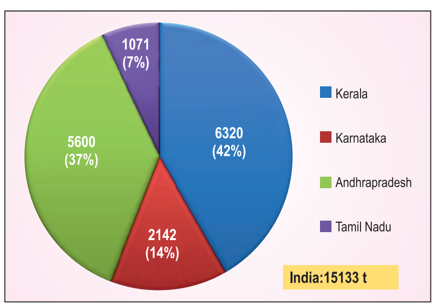

Figure 38. State wise share of cocoa production

tonnes of cocoa from an area of 7100 hectares (Figures 37 & 38). Tamil Nadu has the highest area under cocoa (34%) while in the case of cocoa production, Kerala has the major share (42%).

The compound annual growth rate of area and production among major cocoa growing states were worked out for two periods (2000-07 & 2007-14). The all India growth rate in area of cocoa in the recent period was an impressive 14.2%. The growth rate in area was impressive invariably among all states except Andhra Pradesh, which has recorded 20% reduction in growth rate in comparison with the earlier period (Figure 39). In contrast to this, overall growth rate in all India cocoa production has come down to 5% in period II from 8% recorded in period I. Except Tamil Nadu, all other states recorded lower growth rate in period II, and in the case of Karnataka, it was negative (Figure 40).

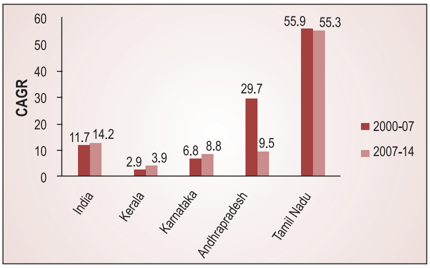

Figure 39. Compound growth rates of cocoa area among major states

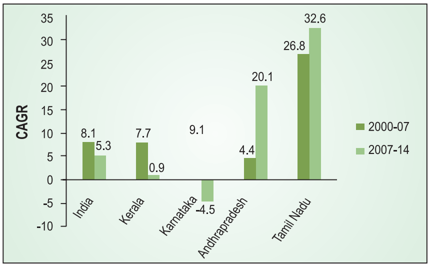

Figure 40. Compound growth rates of cocoa production among major states

3.2.2.2. Domestic import-export scenario: A glance

The import (value) of cocoa and cocoa products increased at a compound growth rate of 31% during the ten years period (2002-11), which shows a surging domestic demand for cocoa and cocoa

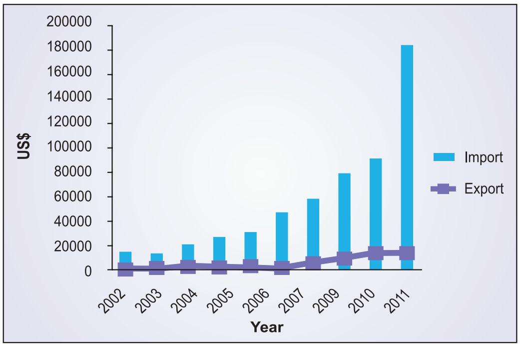

Figure 41. Trade flow of cocoa and cocoa products
Source:FAO

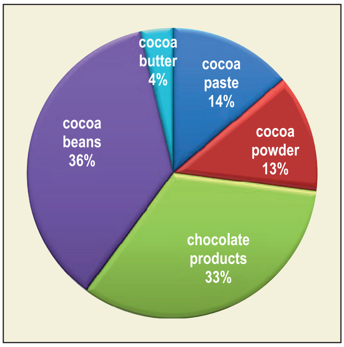

Figure 42. Constitution of cocoa imports to India
Source:FAO

products as well as surplus processing capacity existing in the country (Figure 41). On the other hand, the export growth was almost stagnant which accounts for only around 9% of total value of exports during the period under consideration. Cocoa beans and chocolate products together constitute around 70% of the value of cocoa imports to India (Figure 42).

3.2.2.3. Demand and supply forecast

The projected demand of cocoa by 2050 is 212 thousand tonnes against the estimated supply of 121 thousand tonnes (Figure 43). With the projected supply, there would be a demand-supply gap of 90 thousand tonnes of cocoa beans in 2050. To achieve this target, the cocoa production in the country should increase at an annual growth rate of 7.68 per cent considering the market growth at 20% and the cocoa sector has a great potential to develop in future years.

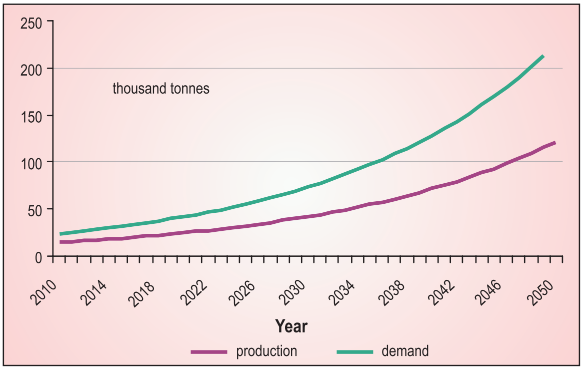

Figure 43. Projected demand and production of cocoa

3.3. Challenges and Approaches

3.3.1. Technological/research status, challenges and strategies

3.3.1.1. Enhancing productivity through varietal improvement

Cocoa genetic resource management and development of varieties with desirable traits are the major concern in the breeding programme of research institutes. ICAR-CPCRI is recognized as the national active germplasm site and diversified clones from both primary and secondary centers of origin have been collected and conserved in field gene banks and evaluated for their adaptability in the introduced environment and for their potential yield. Apart from selections, promising genotypes are effectively utilized in development of hybrids. The institutes in the traditional zones through three to four decades of research have developed high yielding elite clones and hybrids, with yield range of 1 to 2 kg dry bean yield/tree and with varying processing qualities. These varieties can contribute effectively as a mother source for the improvement of cocoa productivity in the country. Cocoa clones, specifically suitable to grow under arecanut and coconut canopies and suitable for both the shades have been identified. Even though concerted efforts have been made for varietal development these have mainly been confined to the states of Kerala and Karnataka. Of late, the area expansion has occurred in non-traditional zones of Tamil Nadu and Andhra Pradesh, the challenge is to identify high yielding clones suitable for these locations and also different cropping systems. The prevailing agro-climatic conditions should be taken into consideration while introducing the crop into new areas especially the factors like rainfall and humidity. In the Indian condition, cocoa is facing about 4-6 months of rainless period and hence development of the moisture-deficit tolerant varieties should be given adequate priority. Systematic physiological characterization of cocoa germplasm at ICAR-CPCRI has resulted in identification of tolerant genotypes and two tolerant varieties viz., VTLCH-3, VTLCH-4 have been developed for commercial cultivation in the country. The challenge is to test these varieties in extreme dry situations to assess their true potential to withstand low moisture stress conditions.

Trees yielding more than 100 pods with bold beans and high bean indices are to be utilized to enrich the cocoa production in the country. The identified elite high yielding clones and improved varieties developed by different agencies should be tested in multi-locations and under different cropping systems in various states wherever coconut and arecanut plantations are available. Before introducing cocoa in new areas, due consideration should be given to the basic agro-climatic conditions like mean sea level, rainfall, humidity, temperature and availability of water during the dry period. Cocoa is sensitive to moisture stress and requires shade. While cultivating cocoa in oil palm plantations, the spacing, age of the main crop and light infiltration should be assessed and the management strategies should be adopted accordingly. Systematic physiological and biochemical characterization of genotypes will help in identification of location specific, moisture-deficit tolerant cocoa varieties. There are certain specific problems in the traditional zones related to high rainfall and high humidity and therefore disease resistance breeding should concentrate on screening of germplasm and development of disease tolerant/resistant hybrids especially black pod rot and vascular streak die back (VSD) tolerant varieties of cocoa. On the other hand, evaluation of clones for cold tolerance may be taken up in the north eastern zones of the country for development of location specific high yielding clones suitable for the region.

3.3.1.2. Increasing productivity through canopy architecture engineering

Cocoa in its native zone is grown as an under storey crop either under permanent shade or under temporary shades. In the Asian continent, cocoa cultivation is widely undertaken in palm-based cropping systems. Cocoa, with its typical growth habit of branching in tiers, tends to grow high which is considered as unfavourable in the cropping system models. There are genotypes with erect, intermediate and pendulous branching habits in which intermediates are considered compatible in the inter-cropping systems. Different spacing under arecanut, single and double hedge systems of planting under coconut, triangle system of planting under oil palm are being followed in cocoa cultivation with canopy modifications. Formation pruning and training in young plants, structural and sanitary pruning in matured trees, canopy architectural engineering in both grafted and seedling plants are developed, standardised and are being practiced regularly in cocoa plantations. The challenge is to expand these methods in different cropping systems and agro climatic zones and to maintain optimal canopy area for achieving productive yield of cocoa.

Based on the prevailing agro-climatic conditions, type of shade, spacing and age of main crop, cocoa is to be introduced and plots are to be designed in different regions through the centres under the ICAR-All India Coordinated Research Project on Palms. Depending on the establishment rate and vigour of cocoa, and availability of resources, training and pruning methods are to be developed for different zones. Morpho-physiological characterization of genotypes, right from young age with studies on branching habit, canopy density, light transmission, flushing, flowering, fruiting, cherelle wilting behaviour etc. will help in deciding the pruning regimes and judicial usage of water and other resources. Canopy architecture may be maintained as cone shaped canopy by modifying the east-west and north-south spread to have an optimal 15-20 m^2 canopy area. Regular removal of upward growing orthotropic shoots and plageotropic hanging fan branches should be carried out to facilitate infiltration of more sun light into the main stem and branches. Open centre or central leader type of canopy can also be maintained for easy management. Soil conservation measures like mulching with cocoa leaves, fertigation combined with modified manageable canopy architecture will improve the cropping efficiency of cocoa even in adverse situations. In the cropping system, clones are to be grouped, aiming for medium vigour and optimal canopy to get higher pod yield.

3.3.1.3. Biotechnological interventions

Genetic diversity assessments through molecular markers have paved the way for marker-assisted selection. DNA extraction protocol has been standardised and characterisation of cocoa collections and hybridity testing with SSR markers has been taken up. Availability of large quantity of cocoa ESTs in public domain has helped in identification of genes related to *Phytophthora* pod rot resistance and moisture stress tolerance related genes. Cocoa genome has been sequenced and access of genome resources has enabled identification and reconstruction of biosynthetic pathways contributing to fatty acid and flavonoid biosynthesis as well as biotic and abiotic stress related pathways. Databases have been developed with these EST and genome resources. Development of markers from seedlings for both biotic and abiotic stress tolerance/resistance and identification of genes for self-incompatibility are few challenges in the molecular breeding programmes.

Usage and utilization of molecular and bioinformatics tools will help to speed up the traditional breeding programme. Identification of markers in young seedlings offers wide opportunity for marker assisted selection in cocoa improvement. Though systematic hand pollinations are carried out to assess the self-incompatibility in the cocoa genotypes, genetic basis of incompatibility has not been well-studied. It is important to identify genes responsible for self-incompatibility through better utilization of the genome resources. Markers are to be developed for both biotic and abiotic stress tolerance, specific to Indian cocoa germplasm. Gene expression studies during different developmental stages, tolerance/resistance to *Phytophthora* pod rot and moisture-deficit conditions and validation with genotypes are also important in the molecular breeding program.

3.3.1.4. Integrated disease and pest management

Presently, cocoa cultivation is facing threat of *Phytophthora* related diseases in the traditional high rainfall zones, in seedlings, trees and pods, manifested through seedling dieback, stem canker and black pod rot. Sowing before the onset of monsoon, soil solarization, biopriming measures, and adequate drainage facilities will reduce the incidence and spread of disease in the nursery and facilitate the healthy growth of seedlings. Stem canker is seen mostly in young plants and flood irrigated gardens of Tamil Nadu and Andhra Pradesh as compared to drip irrigated gardens. Shade regulation, timely harvest of pods, removal and destruction of infected pods, systematic annual pruning, smearing with Bordeaux paste on cut ends, spraying with copper fungicides are the remedial measures. Germplasm collection of clones exclusively resistant to black pod rot has been undertaken and the Kerala Agricultural University (KAU) has developed VSD resistant varieties of cocoa for cultivation in the disease affected tracts of the country. Though *Phytophthora* diseases are amenable to disease management and is controlled to some extent still it is considered as a major challenge for cocoa cultivation.

Mealy bugs and tea mosquito bugs are the major pests affecting cocoa, primarily during the summer season. It is observed that unscrupulous cutting of trees has aggravated the pest problems in the recent years. Screening of cocoa germplasm has identified clones tolerant to tea mosquito bug based on grades of damage levels in flushes, cherelles and fruits.

Continuous and systematic field screening of germplasm for black pod rot resistance/tolerance over different seasons, cropping systems, densities, locations and in controlled conditions are to be taken up by all cocoa research institutes and AICRPP centers. Studies on intrinsic resistance with reference to resistance to infection and pathogen multiplication and management strategies on shade regulation, pruning regimes, and identifying disease escapes over period of fruiting/ ripening will be effective in controlling the disease. It is important to use the available resistant clones for production of relatively resistant hybrids with higher yield. Identification of molecular markers for *Phytophthora* resistance and genes responsible for disease resistance through utilization of cocoa genome resources is to be taken up for advanced research on the disease resistance breeding programme. Biocontrol agents like *Trichoderma* formulations are to be developed for effective disease management. For area expansion programmes, it is advised to use only the disease-free planting material, with respect to VSD. Since clones, seed pods and seeds are designated under high risk category, quarantine supply of planting material from diseased tract is to be restricted by the research institutions/developmental agencies.

Community-based approaches are to be taken up by state departments to prevent the unscrupulous cutting of trees/forest clearings to avoid sudden outbreak of pests. Continuous and systematic screening of germplasm for tea mosquito bugs in post monsoon and summer seasons, during flushing, flowering and fruiting stages are to be taken up in all cocoa research institutes, to identify tolerant/resistant clones. Attractiveness of genotypes with respect to colour and pod texture, intrinsic resistance, anti-biosis/anti-xenosis and tolerance mechanism to pest resistance are to be studied and implemented. Documentation, conservation and maintenance of natural enemies, predators, spiders in areca-cocoa, coconut-cocoa ecosystems through ICAR institutes, AICRPP Centres and State Agricultural Universities will facilitate safe and environment friendly pest control measures.

3.3.1.5. Exotic pests and diseases

World cocoa is severely affected by few debilitating diseases such as cocoa swollen shoot virus (Africa), witches' broom disease (Latin America), frosty pod rot (Latin America), cocoa pod borer (South East Asia) and *Phytophthora megakarya* (West Africa). Indian cocoa is presently safe and no significant economic loss is experienced even with *Phytophthora* diseases. Since cocoa pod borer is a major threat in the South East Asian region, the country needs to be alert and vigilant. At present, exotic collections of cocoa germplasm are routed through Intermediate Cocoa Quarantine Centre, University of Reading, UK and through NBPGR, India and exports from the country are controlled by National Biodiversity Authority (NBA). Continuous surveillance over imports is a challenge with respect to germplasm collection from international gene banks and major cocoa producers.

Procedures for safe movement of germplasm are to be strictly followed and procurement of cocoa germplasm is to be undertaken only through quarantine centers, both at national and international level, in order to prevent entry of new pests and diseases. Establishment of secondary quarantine facilities is mandatory in the research institutes for further screening, assessment and evaluation of the introduced clones. Continuous surveillance over established and emerging pests and diseases by research institutes in all cocoa growing regions will protect the cocoa cultivation in future. Identification of genotypes with best husk characteristics through penetrometer studies is an option for identification of possible level of insect and disease tolerance/resistance especially for resistance to pod borer in the Asia-Pacific region.

Asia-Pacific region has become an important production site for cocoa and so it is important to identify the common problems in the Asia-Pacific region, select genotypes with desirable traits for production of hybrids in the research institutes for sharing, exchange and evaluation among participating/collaborating organizations. The problems related to VSD, BPD, TMB, pod borer, moisture-deficit in India, Malaysia, Indonesia, Philippines, Vietnam and Papua New Guinea are to be addressed in the immediate future. Formulating Asia-Pacific Regional Breeding Group in collaboration with World Cocoa Foundation and Mars International will provide new impetus to the cocoa production programme in this region.

3.3.1.6. Post harvest processing, bean and flavour quality

Cocoa is considered as a functional food because of its richness in terms of polyphenols and antioxidant properties. Genotypes, growing conditions, seasons, pre and post harvest handling etc. decide the quality of beans. Bean size with respect to bean indices, moisture content, shelling percentage, nib recovery and fat contents add value to the marketable bean. Elite clones and hybrids are developed with rich bean qualities. Clones rich in polyphenols, procyanidins, fat, antioxidant properties etc. have been identified. Fatty acid profiles obtained from clones and hybrids are high in stearic acid. In the recent years, flavour improvement aspects have been given importance in order to develop specialty chocolates with a blend of Criollo and Forastero beans. Bean size is highly varying with genotypes, changes in climate and processing which are to be taken care of in order to maintain the quality of the cocoa beans.

Assessment of cocoa germplasm for physical characteristics of beans and processing value viz., bean size (bean index), shell percentage, nib recovery percentage, butter content (fat percentage), hardness, colour and organoleptic parameters by all research institutes over different agro climatic zones, cropping systems and cultivation practices is important. Sufficient water, nutrients, timely harvest, correct fermentation and drying methods will improve the quality of beans. White bean or Criollo types may be utilized for development of hybrids for flavour improvement by the research institutions. Seasonal and genotypic differences in biochemical components and antioxidant properties should be studied over different agro-climatic zones. Development and refinement of minimal cocoa bean processing techniques is to be taken up on priority basis, to facilitate the small farmers. On-farm processing facilities are to be improved and encouraged through financial facilitation from state development machineries. Design and development of fermentation chamber for cocoa bean is required to replace the conventional fermentation system in order to reduce the fermentation period. Dryers need to be developed for traditional (high rainfall) zones, to prevent fungal infection of beans. Integrated dryers (solar, agricultural wastes and electrical based) are also to be developed for quick, efficient and cost effective drying of cocoa beans.

3.3.2. Developmental and policy aspects

3.3.2.1. Projected supply deficits

Taking into consideration the past growth trends, the demand for cocoa beans in India by the year 2050 would be about 220 thousand tonnes and the projected supply is expected to be only 120 thousand tonnes, thereby forming a huge supply deficit of around 100 thousand tonnes of cocoa beans. The projected supply deficits for four data points (2020-2050) are depicted in Figure 44. A desirable situation of demand and supply movement is illustrated in Figure 45, in which the supply deficits are very small during the projected periods and eventually the deficit becomes surplus during the year 2050. We need to chalk out a logical and pragmatic strategy to achieve the desirable projected demand-supply equation. Increasing per capita consumption of cocoa

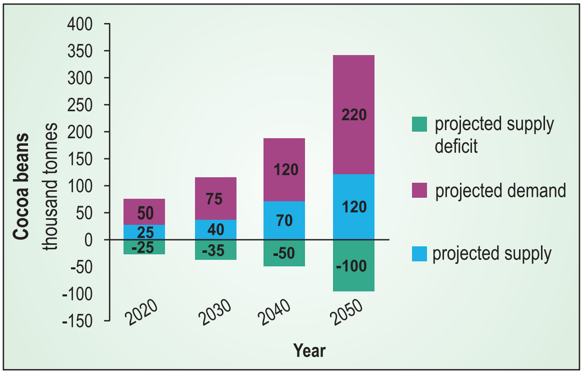

Figure 44. Projected (actual) supply deficits of cocoa beans in India

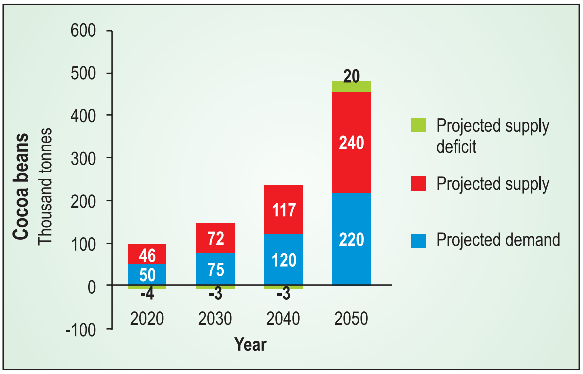

Figure 45. Projected (desirable) supply-demand scenario of cocoa beans in India

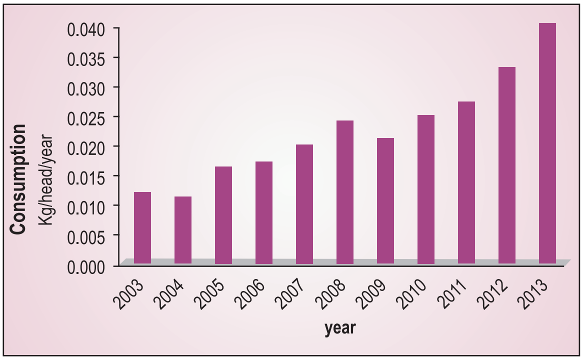

Figure 46. Per capita consumption of cocoa in India
Source:ICCO

in India is the motivating factor behind the projection of an optimistic supply-demand scenario (Figure 46).

About 23 lakh ha area is available in India under coconut and arecanut plantations for cultivation of cocoa plants (new area expansion) and around 35% of this land is under irrigation. Thereby, the total potential area for cocoa planting comes to around eight lakhs ha. Availability of such areas in the states of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Orissa will therefore offer ample scope for newer area expansion of cocoa. At present the area of cocoa is around 71 thousand ha and we can have a realistic target of introducing an additional 40 thousand ha into cocoa plantation by the year 2020. Meanwhile the productivity should be increased to 700 kg/ha, and we assume that 60% of the newly introduced area will give full potential yield and thereby produce 46 thousand tonnes of cocoa beans by the year 2020. The projected demand by 2020 is 50 thousand tonnes of cocoa beans, and there would be supply deficit of around four million tonnes. The scheme for progressive increase in production for years 2020 to 2050 is schematically illustrated in Figure 47. Through the projected schedule we might attain a production surplus of 20 thousand tonnes by the year 2050.

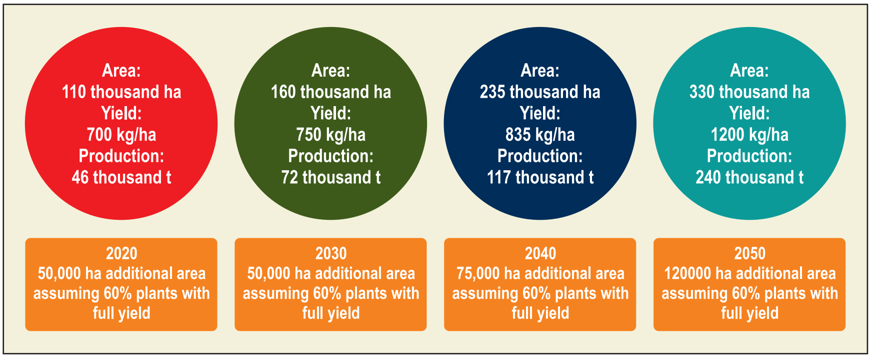

Figure 47. Scheme for becoming a cocoa bean surplus nation by 2050

3.3.2.2. Membership of International Cocoa Organization (ICCO)

The International Cocoa Organization (ICCO) is a global organization, composed of both cocoa producing and cocoa consuming member countries. Located in London, ICCO was established in 1973 to put into effect the first International Cocoa Agreement which was negotiated in Geneva at United Nations International Cocoa Conference. Since then, there have been seven Agreements. The Seventh International

Cocoa Agreement, negotiated in 2010 in Geneva, came into force provisionally in October 2012. It should be taken as a challenge to become a member of ICCO, which is of utmost importance in order to realize the vision of India to become one of the major players in cocoa production and trade in the world. It will be the first step towards making the presence of India in the world cocoa map in all the four spheres namely cocoa production, trade, processing and consumption.

In order to become a member of ICCO, we need to become a signatory of the next International Cocoa Agreement (ICA). The next ICA is tentatively scheduled to be held in the year 2020. We need to have realistic goals to raise our area, production and trade aspects with respect to cocoa and cocoa products in a phased manner as schematically suggested in Figure 20. The modalities to become a member of the ICCO should be closely followed after becoming a signatory of the ICA.

3.3.2.3. Spatial integration of cocoa markets and price volatility

The econometric studies ensure the presence of spatial price integration among the regional cocoa markets in India and also its integration with world cocoa markets. The presence of co-integration between the pairs of cocoa price series of both regional and world market confirms that there is a co-movement of prices and thus they are integrated markets in nature (Figure 48). This gives an important insight that the price fluctuations in the world market will be transmitted to the domestic market and can affect the domestic price since they are integrated. Following liberalization of cocoa marketing systems in the nineties, farm gate prices in most cocoa producing countries are now largely determined by international prices. As a result, farm gate prices have shown greater fluctuations in most cocoa producing countries. The comparative price fluctuation of cocoa over various periods is illustrated in Figure 49. Studies also indicate that the trend in cocoa production

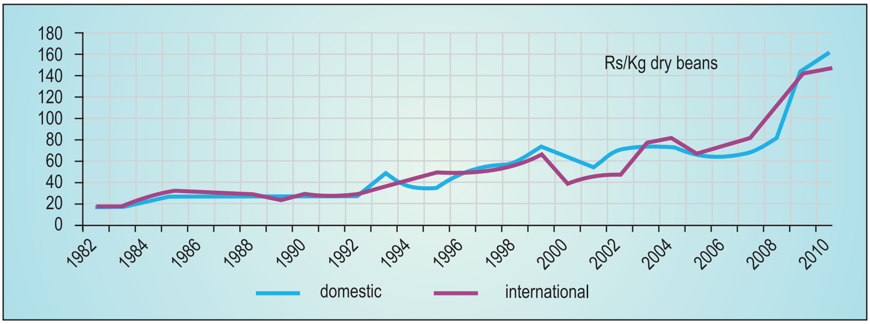

Figure 48. Movement of international and domestic cocoa prices
Source:uncomtrade

remains strongly linked to the financial capability of cocoa farmers to invest in yield improvement. This may result in supply shocks because the major share of cocoa is produced by West African countries and a surplus/deficit in production in these regions will be reflected straight away in the international prices. Above all cocoa beans are heavily traded in two world exchanges: London (NYSE LIFFE) and New York (ICE) and cocoa futures contracts are the benchmark global price quote for cocoa.

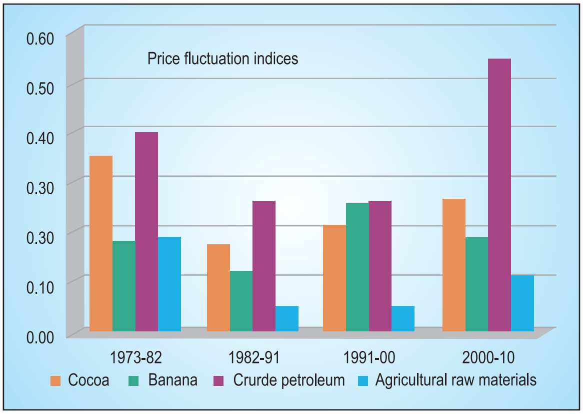

Figure 49. Price fluctuation indices of cocoa in comparison with other commodities

In the evolving liberalization regime, the market integration is becoming an inevitable event. There is an urgent need to come up with a clear market intelligent mechanism which could provide price signalling in advance. Cocoa is an important commodity traded in the international stock exchanges. In the domestic level, we may formulate a producer consortium to facilitate the futures trading and stock investment of cocoa beans, and there by combat the speculative price movements to a large extent. Risk aversion mechanisms should be adequately taken while advising the area expansion programmes on cocoa wherein we should discourage the monocropping of cocoa.

3.3.2.4. Domestic supply chain of cocoa

Domestic supply chain of cocoa in India is still in rudimentary stages. CAMPCO and Cadbury India Ltd (now Mondelez India) are the major procuring agencies in India, who are directly procuring the cocoa beans from farmers. The value share of the producer/farmer is a meagre 32% because most of the farmers sell the produce as wet beans, even without doing minimal processing. Drying yards, primary processing facilities, and storage facilities are lacking in the case of most of the cocoa farmers. Since the stringent food safety standards and trace back systems are evolving in international arena, it is a real challenge to establish robust procuring system in the upstream end of the cocoa value chain in the country.

Urgent steps should be taken to establish village level primary processing units and capacity building for fermentation and drying of cocoa beans with the formation of strong farmer aggregates, women SHG's and rural youth. Development of exclusive market yards and assembling places for cocoa beans along with the adoption of high quality food safety standards would be a pro-active step for better realization of bean prices. Assured buy-back systems developed in the frame of contract farming under the stake of government (tripartite arrangement) can help the growth of the sector. State machinery should go for Memorandum of Understanding with the leading chocolate manufacturers for appropriate marketing arrangements and supply chain development.

Sustainable cocoa production wherein cocoa is produced without chemicals and devoid of child labour is gaining popularity all over the world. We may explore this opportunity because India is one among the few countries where cocoa is produced without engaging child labour and moreover, a major cocoa growing district in Kerala (Kasaragod) is declared as an organic district. On a pilot basis, we may explore this opportunity by popularizing the organic cocoa and may endeavour for organic/sustainable certification.

To make cocoa farming more profitable, farmers need to produce more cocoa. Average productivity increases when entrepreneurial farmers are trained to use inputs such as fertilizer and better cocoa varieties. Corporate investments in training and distribution networks for fertilizer and seedlings play a crucial role in helping farmers become more prosperous. To attain the projected bean surplus, it is essential to focus on partnership building and reinforced capacities across the cocoa sector. Meaningful partnerships should be evolved between all stakeholders, namely governments, cocoa farmers, and the cocoa industry to boost productivity and strengthen the cocoa community development in the country.

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Epilogue

Although through this sectoral document we have attempted to view the sectoral nuances of coconut, arecanut and cocoa sectors, it reflects umpteen discussion points which are common to all the plantation crops. The Indian plantation sector has inherent strength of varied agro-climatic conditions, huge domestic demand, highest productivity, strong research and development, and technology dissemination systems. However, so far, the sector has not effectively utilized the possible linkage between them for increasing the production and marketing efficiencies. Inclusive growth and sustainability of plantation economy could be achieved through integrated development of cultivation and industry coupled with a stable market. The programmes, which has taken a shift in strategy like aggregation of farmers for group activities, collaborative research for production of high yielding and hybrid seedlings, creating more skilled labourers for farming, harvesting and processing operations along with the objective of triggering production, processing and value addition, will place the coconut, arecanut and cocoa sectors at forefront in the world. Apart from these, since food safety standards are becoming more stringent in the world, to be competitive in the trade we must give adequate importance to the Good Management Practices (GMP) in the plantation sector. There is an urgent need to realign the production structure of plantation crops in accordance to the international and domestic price signals. Crop wise in-depth sectoral studies assume paramount importance and the sectoral views should be ploughed back into the research and developmental agenda of the institutions.

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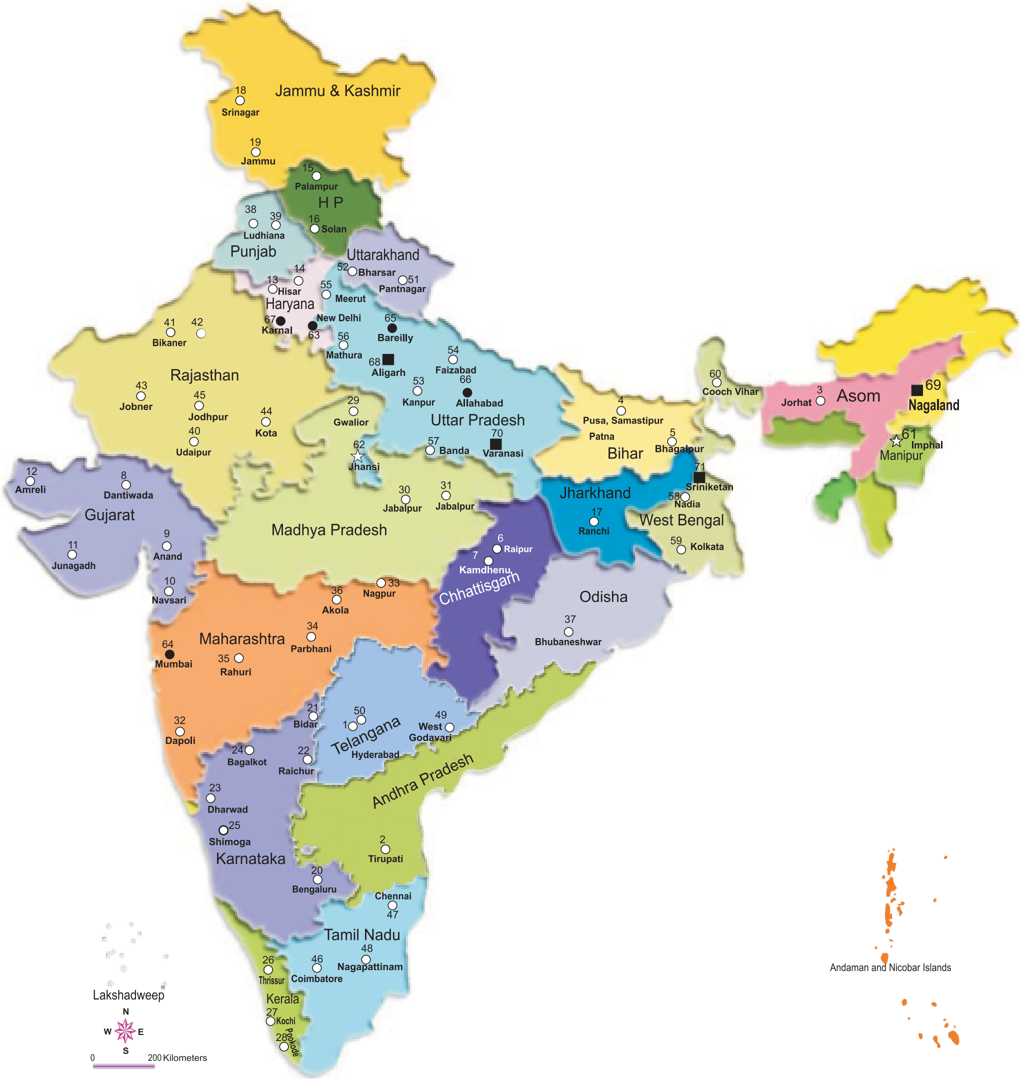

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