# Inclusive Growth and Sustainable Development of Coconut Industry in India

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Coconut, *Cocos nucifera L*, known to have been used in Ayurveda dates back to 4000 years. Coconut formed a rich source of health food for the people of Polynacian Island. The natural beauty of Polynacian women in those days was attributed to coconut. Coconut is known as Tree of Life, since every part of coconut is being used as medicine. It is also known as Nature's Super Market and Tree of Abundance. More than 100 products are being produced using various parts of coconut having day today utility to human life. It is therefore called as Kalpavriksha and Tree of Heaven. Coconut plays a significant role in the agrarian economy of not only India but also the whole of Asia -Pacific countries. Apart from the importance of coconut oil which is widely used in the manufacture of soaps, hair oil, cosmetics and other industrial products, the husk is a source of fibre which supports a sizable coir industry. The tender nut supplies coconut water, a popular thirst quencher of health and hygienic value. Coconut is grown in more than 80 countries of the world. India occupies a predominant position in respect of production of coconut in the world.

Traditional areas of coconut in India are the states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Orissa, West Bengal, Pondicherry, Maharashtra and Islands of Lakshadweep and Andaman and Nicobar. Non-traditional areas are the states of Assam, Gujarat, Madhya Pradesh, Rajasthan, Bihar, Tripura, Manipur and Arunachal Pradesh. Four southern states viz., Kerala, Tamil Nadu, Karnataka, Andhra Pradesh contribute maximum (Table 1). Coconut is a crop of small and marginal farmers since 98% of about five million coconut holdings in the country are less than two hectares. In the west coast of India, the palm is an essential component in the homestead system of farming where it is grown as rainfed.

The progress of the Indian Coconut Sector during the last two decades can be classified into three distinct categories. First is the progress achieved in extending the cultivation of the crop in more areas both in traditional and non-traditional areas. Second is the increase in area, production and productivity of coconut in the country with the regress in the consumption of coconut oil in both edible and non-edible sectors which warranted the need for the development of broad based processing technologies for the sustainable growth of the industry. Third is the problems of low income from the coconut holdings due to price fluctuations, decline in the prices of coconut and its

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Table 1. Area and production of coconut in different states

| States /Union Territories | 2007-2008 Area ('000 ha) | 2007-2008 Production (Million nuts) | 2007-2008 Productivity (Nuts/ha) | 2008-2009 Area ('000 ha) | 2008-2009 Production (Million nuts) | 2008-2009 Productivity (Nuts/ha) |
|---|---|---|---|---|---|---|
| *Andhra Pradesh* | *101.32* | *1119.26* | *11047* | *104.00* | *970.00* | *9327* |
| Assam | 19.00 | 136.00 | 7158 | 18.80 | 147.10 | 7824 |
| Goa | 25.50 | 127.60 | 5004 | 25.61 | 128.18 | 5005 |
| Gujarat | 16.40 | 138.30 | 8433 | 15.98 | 157.42 | 9851 |
| *Karnataka* | *405.00* | *1635.00* | *4037* | *419.00* | *2176.00* | *5193* |
| *Kerala* | *818.80* | *5641.00* | *6889* | *787.77* | *5802.00* | *7365* |
| Maharashtra | 21.00 | 175.10 | 8338 | 21.00 | 175.10 | 8338 |
| Nagaland | 0.90 | 0.20 | 222 | 0.92 | 0.55 | 598 |
| Orissa | 51.00 | 275.80 | 5408 | 51.00 | 275.80 | 5408 |
| *Tamil Nadu* | *383.37* | *4968.20* | *12959* | *389.60* | *5365.00* | *13771* |
| Tripura | 5.80 | 11.40 | 1966 | 5.80 | 11.40 | 1966 |
| West Bengal | 28.60 | 355.50 | 12430 | 28.60 | 355.50 | 12430 |
| A & N Islands | 21.60 | 80.60 | 3731 | 21.69 | 82.00 | 3781 |
| Lakshadweep | 2.70 | 53.00 | 19630 | 2.70 | 53.00 | 19630 |
| Pondicherry | 2.20 | 26.60 | 12091 | 2.10 | 30.70 | 14619 |
| All India | 1903.19 | 14743.56 | 7747 | 1894.57 | 15729.75 | 8303 |

Source: Coconut Development Board; Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India.

products which necessitated the need for the development of appropriate coconut based farming systems to enhance the farm level income. The stiff import duties imposed on the edible oils and restricted import of the coconut products played an important role in keeping the domestic price high. Hence the structural rigidities in the coconut industry have been keeping a hold on its performance. The industry has not been able to unleash its true potential mainly because of its oil driven market. However, by realizing the imperative need to become competitive, the industry is now undergoing modernization, product diversification and byproduct utilization and restructuring process. Consumer demands for varied high value coconut products are tremendously increasing and hence the domestic industries have become vibrant. This in turn would help make the industry globally competitive.

In the era of trade liberalization and globalization, it is now important for the coconut industry to become competitive. The trend of coconut to copra and coconut oil has slowly changed in the recent past but it is not that fast to make the industry competitive. Having known that the coconut products like coconut water, cream, milk powder, desiccated coconut, coco jaggary etc are getting higher price than coconut oil, it is time for the industry to go for value addition and product diversification producing high value products including virgin coconut oil. Instead of coconut oil deciding the coconut price, it should be changed to a situation that the price of coconut products should decide the farm gate price of coconut .

## Global Scenario of Coconut Industry

Coconut is grown in more than 93 countries in the world in an area of 12.19 million ha with an annual production of 61,165 million nuts or 13.59 million t of copra equivalent. Indonesia is the largest coconut producing country, with an area of 3.8 million ha and 3.77 million t of copra equivalent, followed by the Philippines with an area of 3.3 million ha and production of 2.49 million t of copra equivalent. India with 1.9 million ha and production of 2.74 million t copra equivalent per year, occupies third place. The production increase in coconut is mainly due to area increase over the years. But the productivity remained almost static, i.e., around 1.0 t copra equivalent per ha per year. This is the major set back, which needs to be addressed by every coconut growing country (Rethinam, 2004a).

Global export of coconut products exceeds US$ 1.2 billion annually. Even though more than 50 products of coconut are being exported, only 10 products *viz.*, copra, coconut oil, desiccated coconut, coconut milk, milk powder, cream, coco chemicals, shell charcoal, activated charcoal and coir based products are being exported on a larger scale. Philippines is the largest exporter of coconut products which earn US$ 841 million per year, followed by Indonesia, Sri Lanka, Malaysia, India and Thailand. Indian exports are mainly coir and coir products including geo-textiles, coir pith compost and grow bags.

Among the products exported, coconut oil remains as the largest quantity (1.8 million t). But in terms of growth rate it is fluctuating. The copra export reduced considerably, because the copra producing countries have started processing coconut oil and other value-added products. Global export of desiccated coconut increased from 127,000 t to 280,000 t in the last 25 years. India imports desiccated coconut from Sri Lanka. In the last 15 years, coco chemicals export increased from 17,389 t to 59,400 t, activated carbon from 22,147 t to 110,500 t and coir products from 108,200 t to 250,745 t. India and Sri Lanka are the major coco fibre producing countries (Rethinam, 2004a, b&C and Rethinam, 2005a&b).

Now let us look at the international prices for coconut products. Global Coconut oil price is highly fluctuating. In November 2005 the price was US$ 650/t. Indian Coconut Oil price was US$ 1200/t. Coconut water, which is being wasted by us mostly, fetched US$ 800/t, the price for coconut milk was US$ 800 /t, milk powder US$ 2800 /t, fatty alcohol US$ 1125 /t, coir bristle fibre US$ 460/t and activated carbon US$ 945/t.

## Emerging New Applications

### *Organic foods*

Health conscious people in Europe and United States of America specifically, and in general world over, prefer their food to be free from pesticides, and chemicals. Organic foods are niche products, which come from certified organic farms, processed according to authorized norms and certified by state registered certification bodies.

The largest organic markets in terms of global revenue distribution are EU (53% market share) and North America (40%). In United States, the growth rate for the sale of organic products is 17% to the present level of US$ 12.7 billion compared to 3% annual sales growth for the US food industry as a whole. Organic products account for 2.3% of total food sales in US. World consumption of organic oil is 95,000 t which is only 0.1% of the total oil consumption. Compared to other oils, organic coconut oil and organic virgin coconut oil can easily be produced since the bulk of coconut plantings are managed without the application of inorganic fertilizers and pesticides (Rethinam, 2004d).

### *Virgin coconut oil*

Now, virgin coconut oil (VCO) processed using coconut kernel and coconut milk with very low free fatty acid (FFA) is gaining popularity as a healthy nutritive oil, with potential for wider use in pharmaceuticals, nutriceuticals and cosmoceuticals. Natural VCO and organic all-natural VCO may be exploited in niche health markets with premium prices. A large number of small scale units of Virgin coconut oil has been set up in many countries using different methods. It is all the more necessary to strictly follow quality standards in order to sustain demand. The market seems to be fast growing for functional foods, like pharmaceutical, nutriceutical and cosmoceutical products.

Export quantity of VCO from Philippines has increased significantly over time. In 2001, the total export of the country was only 1.8 t to USA and Hawaii. The export jumped to 176.6 t in 2004 to countries such as USA, Korea, Japan, Netherlands, Singapore, Malaysia, South Africa, and Australia. For the first quarter of the year 2005, the Philippines exported VCO amounting to 159.32 t. Countries in Pacific region like Fiji and Samoa are also exporting VCO to Australia. Indonesia is also producing VCO and the domestic demand for this commodity is booming now. There are about 200 small and medium VCO manufacturers in the country. While most of the production went to the domestic market some of the manufacturers are exporting to the world market such as Malaysia and Singapore.

The export value to all markets of VCO of Philippines was about US $553,469 in 2004 which was significantly up from only US $19,810 in 2001. The export value for period

January-March in 2005 was US $504,377 which was 24.05% increase over the export value of the whole year of 2003 and about 91.1% of the total export value of previous year. The estimated export value for 2005 was US $2.0 million (Rethinam and Amrizal, 2005a&b).

*Functional foods*

The market is attracting health conscious groups with functional food buzz words like designer foods, medical foods, longevity foods, hyper nutritional foods, super foods, pharma foods, perspective foods, phyto foods, therapeutic foods and others. They contain biologically active components thought to enhance health and wellness. While the conventional food sector has an expected growth rate of 1-3%, functional foods are catching up with growth rate of 7-8%. Between 1998 and 2003, global value sales of functional foods increased by almost 60% and are further set to rise by 40% by 2008, says Global Market Analyst Euromonitor. By 2010, the most industrial countries, Western Europe (34%), US (34%) and Japan (25%) will account for 90% of total estimated market size.

A high level of new product activities is continuing to stimulate growth in the global confectionery market (worth US$ 95 billion in 2002) with a total volume of 15 million tonnes. The per capita consumption is 17 kg/year in Denmark, 16 kg in Sweden, 13kg in Norway and in Europe and North America (8.8 kg-10.7 kg). It is a fast growing market. Coconut milk, milk powder and desiccated coconut provide lauric acid which can help to build up resistance/ immunity against viral, fungal and bacterial diseases. Coconut oil and its medium chain fatty acid derivatives have a greater role to play in the fast developing functional foods particularly baby foods, nutriceuticals, and pharmaceuticals.

*Functional drinks from coconut*

This is an area for concentrating efforts on value added products. The functional drink market continues to be healthy; the sports drink, energy drink, wellness drink, and welcome drink markets are continuously growing. Beverages showed strong growth between 1998 and 2003, expanding by a Compound Annual Growth Rate of almost 11%. Functional juices also showed good growth with value-added sales up by an estimated 73% between 2003 and 2008. One reason behind the success of functional beverages is convenience; they can be consumed on the move and therefore tap into a key consumer demand pattern of health, convenience and portability. The global functional food drinks market, defined as "soft drink with added health benefits", was valued at US$ 13.86 billion in 2000. This was expected to double to US$ 24 billion by 2005 (global). Sports drink is mainly isotonic and hypotonic, based with leading brand names. Energy drink, including glucose based products had a market value of US$ 3.5 billion in 2000. Most of the energy drinks contain caffeine, vitamins and minerals, but caffeine is problematic in some countries.

Young coconut water (tender-nut water) and mature coconut water in pure form and also with various added minerals and vitamins could have a wider market both domestic and international with well-directed marketing.

Coconut nectar juice is another product as health drink can be promoted. This product is known as *neera* in the fresh form and toddy in the fermented form. The *neera* is used as a health and nutritive drink. The Government of Kerala, India has recently launched a mega project to popularize coconut nectar juice.

There is increasing demand for the coconut drink in the European Union Countries and American Countries. Proper packaging, labeling with good shelf life will definitely increase the demand in the world market. A good publicity has to be done to popularize this drink.

*Cosmoceuticals*

Production of cosmetics and personal products in Asia and Pacific countries is just developing with emerging popularity of skin whitening products. With growth of 10% for cosmetics and personal care products, and 5-19% for soap in Asia and Pacific, the requirement is enormous. Many of the Pacific Countries are importing all products. Coconut oil, rich as it is in C12 and C14 fatty acids(lauric and myristic), is good for skin care applied pure and also for manufactured cleaning products that have wide acceptance.

*Oleochemicals*

The long term trend for oleochemicals is favourable with world capacity expected to rise to 12 million t and production to 10.8 million t by 2010. Consumer trend is increasing towards application of oleochemicals in detergent, soap and personal care products and hence there is good scope for coconut based oleochemicals.

*Bio-fuel / bio-lubricants*

Energy security perspectives have become a driving force for the use of vegetable oil based bio -diesel fuels. Numerous countries are in the process of making bio-fuel. Three challenges the bio- fuel sector must overcome are price considerations, lack of awareness of the fuel and negative impact on the glycerine supply to exisiting markets.

Bio-lubricants are functional fluids made from vegetable oils and down-stream esters. Coconut oil as a bio-lubricant has been used even in India for three wheelers. Overall global usage of renewable raw material in lubricants and related functional fluid applications is about 250,000 t comprising about 0.7% of the total lubricant marketed and 0.25% of total annual oils and fats produced. Philippines is moving forward followed by Thailand, Vanuatu, and Marshall Islands. Marshall Islands uses the double filtered coconut oil directly to run the car, fishing boat, trucks, etc. Philippines is using a mixture of diesel and methyl ester from CNO at 99:1 ratio and planning to increase to 95:5.

*Biomass as alternative source for fuel*

Coconut biomass like coconut shell and coconut petioles can be used for producing alternative sources of energy. Coconut shell based gasifiers are now becoming popular. The leaf petiole biomass along with other biomasses are being used for generating energy in the recent times.

*Premium grade monolaurin and HIV/AIDS remedies*

Over a period of 22 years, 42 million people in the world have been affected by HIV/AIDS. This virus disease affects 7.2 million people in Asian and Pacific countries, while India is reported to have 3.5-5.0 million sufferers. Coconut oil, with 48% lauric acid, is a potential source for producing monolaurin (lauricidin) which has been experimentally found to reduce the virus. Dr. Jon Kabara, a US scientist has done preliminary work. However, pilot scale testing with a large number of AIDS patients has to be done. Philippines has done some basic studies and would like to expand the effort. If a small amount of donor funds, which are received for the Global AIDS Awareness campaign could be spent on this research, it should be possible to develop a cost effective control measure. If this happens, then the coconut produced now in the world may not be adequate to meet the needs of all sufferers.

*Coir and Coir Pith*

1. For environment friendliness, cost factor and reduction of weight, natural fibres are now considered to be important.
2. Natural fibres as reinforcements in industrial products have made considerable inroads in automotive interiors especially in Europe for reducing cost and weight. Several European firms are testing whether coir can play a role in the growing automotive market for "bio- composites" or as thermal insulation in home construction. It is also used as filler to replace talc and calcium carbonate.
3. Coir fibre matting products for soil protection along roadside cuttings and bare patches have been shown effective and are becoming popular under the label "Geotextile".
4. In the horticulture sector, natural fibre pith can play a vital role with short life, reasonable strength and disposability for transporting flowers, vegetables, fruits and in potting mixtures.
5. Netherlands produces about 1,850 million pots consuming about 30,000 t of synthetic plastics. Bio-degradable pots using natural fibres can be produced replacing synthetic plastics.
6. Rubberized coir used to be the material of choice for car seats, but largely lost out to competition from synthetic foams. Yet, the remaining use of coir in several up-market European car models is an example of how natural fibre products can stay competitive and possibly regain ground. Even when compared to high end foams, seat covers from rubberized coir provide better feel and support. Manufacturing these covers used to be a multi step labor intensive process, but in 2000/2001 two major German automotive suppliers jointly developed a novel one-step injection

process offering shorter cycling times, higher productivity, more consistent quality and, ultimately, lower production cost. The process requires that the used twisted coir fibre is virtually free of pith and very consistent in the weight per unit length of twisted strand.

7. Low cost wall panels from blast furnace slag cement using coir fibres have been developed in Brazil as a low cost environmental sensitive technology. This technology is available in the Institute de Pesquisas Technologie do Estado de Sao Paulo S.A., Brazil.
8. High-tech products of industrial textiles are possible using friction spinning which needs to be exploited by importing coir fibres.

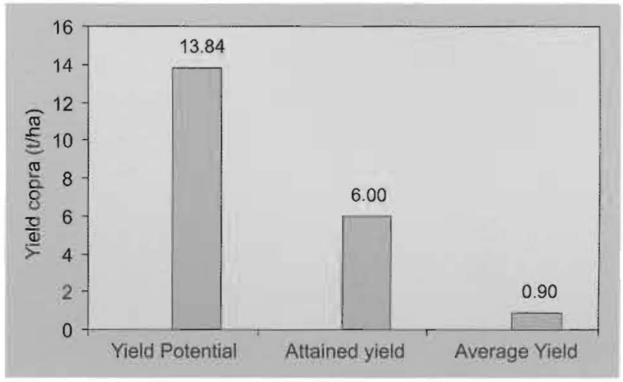
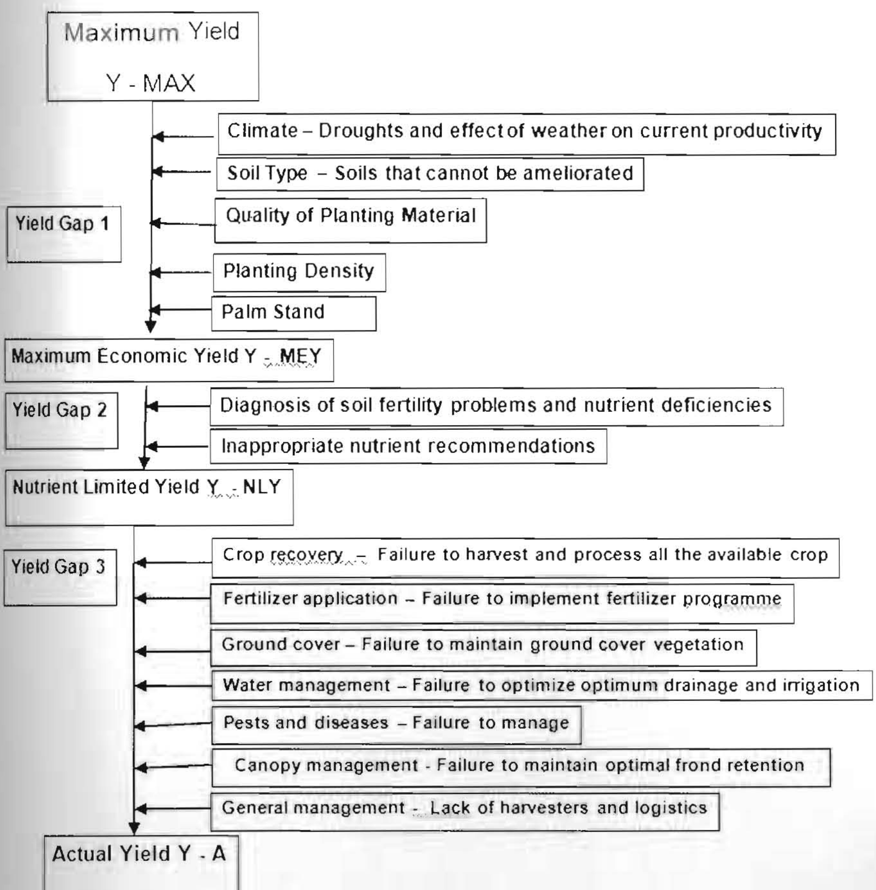



*Fig. 1. Yield Gaps in Coconut*

## Yield Gap in Coconut

A maximum yield of 480 nuts/palm/year was observed in a palm in Thazhava, Kerala with an estimated yield of 13.84 t copra/year. However, attained yield of 6 t copra/year was recorded with the high yielding hybrids and varieties in farmers fields in the specific coconut growing areas. A yield level of 3 to 4 t/ha of copra for hybrid varieties with the application of desired input management practices has been achieved at research institutes around the world. All these indicate that there is ample scope for increasing the productivity (Fig 1).

Yield gap and factors are depicted in the Fig 2. Most of the natural factors cannot be altered but many soil and plant factors could be managed by proper selection and management.




*(Adopted from Fairhust and Griffiths, 2006)*

### 4. Productivity Increase is a Must at Farm Level

Productivity increase is a must to ensure both economic and ecological access to food and nutrition security. It is important to achieve high profitability and reduce poverty besides decreasing the cost of production and ensuring the availability of raw material to meet the growing demand for the processing industries to produce value added and niche products like coconut milk powder, desiccated coconut, virgin coconut oil, biofuel, activated charcoal, coir based products etc. As on date there exists only the under utilization of processing capacity both coconut based food and non-food processing industries, for want of raw material or increase in the cost of raw material. Above all, productivity increase is important to remain competitive and take full advantage of globalization and trade liberalization and be prepared for the WTO regime (Foale, 2003; Rethinam and Amrizal Idroes, 2005).

Though copra was the 'King of oil seeds' and known as 'Green Gold' during the beginning of 20th century, it was dethroned from the position held internationally at the end of 20th century. And now it is again emerging as Sun Rise industry with the value added and niche products which are playing key role in the functional foods, functional drinks, infant foods, pharmaceuticals, nutraceuticals etc., for which the productivity increase is a must to remain competitive.

## Strategic Solutions for increasing Production

Higher production can be achieved through area expansion and productivity increase. Area has increased over a period of time and further increase has only limited scope as land has become a scarce commodity due to diversified uses linked to urbanization and industrialization.

### Integrated Approach to Increase Productivity

Over a period of time, the research conducted in different coconut growing countries has helped to develop high yileidng varieties and hybrids, identify pre-potent talls and dwarfs and input management technologies including organic recycling and low cost technologies to enrich the soil fertility, manage pests and diseases, conserve soil moisture to overcome drought and moisture deficit, promote integrated farming systems to increase farm income and coconut productivity and farm level processing technologies to increase the income and employment (Rognon, 2004).

### High yielding varieties and hybrids

No doubt that the high yielding varieties and hybrids have yielded more when properly managed. The Central Plantation Crops Research Institute ( CPCRI )has the world's largest repository of coconut germplasam with 398 accessions (consisting 266 indigenous and 132 exotic genotypes from 26 countries). Intensive breeding programme resulted in five coconut hybrids involving Talls and Dwarfs as parents and eight high yielding varieties which have been released for commercial cultivation. These hybrids and varieties are capable of yielding 1.62 to 4.07 tonnes of oil /ha annually. At present eighteen varieties and fifteen hybrids suitable for different parts of the country are available in coconut. The variety Pratap from Konkan region yielded 150 nuts per palm per year and another variety ALR 1 from Tamil Nadu recorded yield level of 126 nuts per palm per year. Kerachandra, Kalpa Dhenu, Kamrupa, Kera Keralam and Kera Bastar have yielded nuts above hundred per palm per year. The copra yield of coconut varieties is in the range of 96.3 g/nut (Kalpa Sree) to 256 g/nut (Kalpa Pratibha) and oil content varies between 59.0% (Pratap) and 70.0%(Chandra Kalpa). In case of hybrids, annual nut yield per palm ranges from 84 (Kalpa Sankara) to 156 in VHC-3 from Tamil Nadu. Copra yield (g/nut) varies from 135 (VHC-1) to 216 in Kera Sree and Ananda Ganga. Oil content is in the range of 64.5% to 70.0% in hybrids. Chowghat Orange Dwarf is suitable for tender coconut.

Similarly, Indonesia has released nine hybrids, six talls and four dwarfs. The studies on the performance of these hybrids have shown the yield levels of 3.88 t to 4.66 t copra/ha/year (Table 2). The PB hybrids in Ivory Coast (Cote de Ivoire) have yielded 3.15 t to 4.80 t copra/ha/year (Table 3). The hybrid evaluation in Malaysia has shown the copra yield level of 2.68 t to 4.52 t copra/ha/year (Table 4). Similarly many countries have shown that the yield levels are higher in hybrids and selected talls. With the selected talls, many of the farmers in Andhra Pradesh and Tamil Nadu, India are getting above 200 to 250 nuts/palm/year.

Table 2. Performance of Indonesian intervarietal hybrids (Davis *et al.*, 1985)

| Intervarietal Hybrids | Copra/nut (g) | Copra yield (t/ha) |
|---|---|---|
| Khina - 1 | 253 | Over 4 |
| Khina - 2 | 296 | Over 4 |
| Khina - 3 | 254 | Over 4 |
| KB 1 | 330 | 3.88 |
| KB 2 | 301 | 4.49 |
| KB 3 | 305 | 4.66 |
| KB 4 | 288 | 4.07 |

Table 3. Performance of hybrids from Ivory Coast (Bourdeix *et al*, 1993)

| Hybrids | Copra/nut (g) | Copra yield (t/ha) |
|---|---|---|
| PB 213 | 311 | 4.26 |
| PB 214 | 212 | 3.15 |
| PB 121 | 247 | 3.67 |
| PB 132 | 282 | 3.88 |
| PM 122 | 253 | 3.80 |
| PB 123 | 289 | 4.80 |
| PB 111 | 240 | 4.35 |

Table 4. Performance of hybrids from Malaysia (Chan, 1983)

| Hybrids | Copra/palm (kg) | Copra yield (t/ha) |
|---|---|---|
| MRD X WAT | 25.8 | 4.52 |
| MYD X WAT | 25.0 | 4.38 |
| MRD X MLT | 17.15 | 3.01 |
| MYD X MLT | 17.15 | 3.01 |
| MRD X RLT | 15.33 | 2.68 |
| MYD X RLT | 16.80 | 2.94 |

## Nutrients removal by coconut

Coconut being a perennial crop producing leaves and nuts every month requires nutrients continuously. One hectare of coconut with 150 palms producing 12 to 14 leaves and 100 nuts/palm/year in the harvested matured bunches contain 49 kg N, 16 kg $P_2O_5$, 165 kg $K_2O$, 5 kg Ca, 8 kg, Mg, 11 kg Na, 64 kg Cl, and 4 kg S. The husk contains 60% of the $K_2O$, 18% N and 26% of Mg removed in the harvest. It is therefore recommended that the wastes such as coconut husks and fronds be left in the field to undergo decomposition and mineralization so that nutrients eventually returned to the soil. The nutrient uptake/ exhaust of nutrients by coconut estimated by various authors have been given in Table 5. When this much quantity of nutrients are being removed every year, it is necessary to replenish the soil with nutrients for better production.

## Integrated nutrients and water management

Coconut, a monocot crop responds well to input management. The Table 11 shows that while no manure and no tillage crop yielding 8 nuts, it is possible to increase to 110 nuts/palm/year through application of organic and inorganic manures coupled with tillage.

It was also found out by research in India that the neglected coconut plantations can be revived with the application of double the recommended dose in the first year and the recommended dose from second year of management (Table 6). The recommended dose of fertilizers is 500 g N, 320 g P2O5 and 1200 g K2O/palm/

Table 5. Nutrient uptake/exhaust of nutrients by coconut (International Fertilizer Industry Association, 1992)

| Yield | Source | kg/ha | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | Mg | Ca | S | Na | Cl |
| 1.5 t copra | Copeland, 1931 | 93 | 41 | 138 | - | 17 | - | - | - |
| 25 nuts/palm | Cooke, 1950 | 29 | 9 | 26 | - | - | - | - | - |
| 60 nuts/palm | Nathaniel, 1969 | 72 | 39 | 108 | - | - | - | - | - |
| 100 nuts/palm | Khanna and Nair, 1977 | 120 | 18 | 85 | - | - | - | - | - |
| 100 nuts/palm | Ouvier & Ochs, 1978 | 49 | 16 | 115 | 8 | 5 | 4 | 11 | 64 |
| 6.71 t copra: | Ouvier & Ochs, 1978 | 108174 | 3946 | 232299 | 1539 | 970 | 930 | 2054 | 125249 |
| 1 t copra | Ashgar, 1988 | 16.2 | 5 | 36 | 2 | 1.4 | 1.3 | 2.5 | 19.7 |

year applied in two split doses (Table 8). The full response of coconut to manuring is observed at the end of third year eventhough slight incremental effect will be felt in the first year.

Table6. Response of West Coast Tall palms to different management practices in India (Nair,2000)

| Treatments | No. of nuts/ palm/year |
|---|---|
| Organic manure + inorganic manure + tillage | 110 |
| Inorganic manure + tillage | 97 |
| Inorganic manure + forking basin | 91 |
| Tillage only | 53 |
| Weed control using herbicide | 27 |
| No manure, no tillage | 8 |

Table 7. Response of WCT palms grown under neglect (Laterite soil) to fertilizers (Nair, 2000)

| Treatments | Cumulative yield of nuts/ palm/year (five years) |
|---|---|
| T1. Farmers ' practice (Neglected conditions) | 101 |
| T2. 1/3 dose Ist year and 2/3 of recommended dose afterwards | 179 |
| T3. 50% dose 1st year and full dose afterwards | 231 |
| T4 Recommended dose* | 221 |
| T5. Double the recommended dose Ist year and the recommended dose in subsequent years | 265 |

* Recommended dose: 500g N, 320g $P_2O_5$, 1200g $K_2O$/palm/year

Table 8. Fertilizer recommendation (g/palm/year) for west coast of India (Nair, 2000)

| Age | May-June | | | Sept-Oct | | |
|---|---|---|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ |
| First year | – | – | – | 50 | 40 | 135 |
| Second year | 50 | 40 | 135 | 110 | 80 | 270 |
| Third year | 110 | 80 | 270 | 220 | 160 | 540 |
| Fourth year | 170 | 120 | 400 | 330 | 200 | 800 |

## Low Cost Input Management

Many cost effective input management technologies have been developed for easy adoption by the farmers. The low cost input management includes organic recycling of biomass obtained from coconut plantations, weeds, green manures, green leaves etc., either through composting or direct application. Composting can be done by vermicomposting methods using earthworms or composting with appropriate bioinoculants (Rethinam, 2006).

## Coconut biomass

In the pure coconut plantations, the biomass, which are available, are coconut leaves, coconut shedding, coir pith etc. The nutrient contents of coconut usufructs are given in Table 9.

Table 9. Nutrient content of coconut usufructs (Biddappa *et al.*, 1996)

| Source | N | P | K | Fe | Mn | Zn | Cu |
|---|---|---|---|---|---|---|---|
| | | % | | | ppm | | |
| Coir pith | 0.28 | 0.03 | 1.03 | 1164 | 53 | 194 | 3.8 |
| Coconut leaves | 0.89 | 0.06 | 0.45 | 917 | 464 | 38 | 3.5 |
| Coconut sheddings | 0.66 | 0.10 | 0.50 | 781 | 94 | 25 | 5.0 |

## Vermicomposting

Vermicomposting is the digestion of organic materials by earthworms, which produce excreta known as casts. Vermicomposting differs from conventional composting because the organic material is processed by the digestive systems of worms. The excreted casts can be used to improve the fertility and physical characteristics of soil and potting media. Vermicomposting is the simplest method now being adopted by the coconut farmers in India. All the available organic wastes are composted using earthworms at I kg/ t of biomass addition. The earthworm composting may take 45-60 days and in a year 4 to 6 vermicomposted manure can be obtained and can be used for coconut and inter/ mixed crops. Earthworms once introduced can be multiplied using cowdung and farm wastes.

## Growing green manure and green leaf manure crops and incorporation

Green manure/green leaf manure crops are used primarily as a soil amendment and as a nutrient source for the crops (Drinkwater *et al.*, 1998; Subramanian *et al.*, 2005; Cherr *et al.*, 2006). Growing green manure and incorporation in the field improve economic viability, while reducing the environmental impacts of agriculture. Growing green manure crops like sunnhemp, Sesbania and green leaf manure crops like *Glyricidia* sp. etc, in the plantation will provide green leaves as well as nitrogen fixed from atmosphere through root nodules. The nutrient contents of a few green and green leaf manure crops are depicted in Table 10. The biomass production and nutrient addition through green manure/pulse crops are given in Table 11. These pulse/green manure crops can also be used for getting green vegetables. Green manure cover crops like *Calapogonium* sp, *Mimosa invisa*, *Pueraria* sp etc grown in the basins can add 25-27 kg biomass in littoral sand and 15-19 kg/basin in sandy soils which can add considerable quantities of nutrients.

Table 10. Nutrient content of important green manure and green leaf manure crops

| Crops | Nutrient content (% on dry weight basis) | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| Green manuring | | | |
| *Sesbania aculeata* | 3.3 | 0.7 | 1.3 |
| *Crotalaria juncea* | 2.6 | 0.6 | 2.0 |
| *Seabania speciosa* | 2.7 | 0.5 | 2.2 |
| *Tephrosia purpurea* | 2.4 | 0.3 | 0.8 |
| *Phaseolus trilobus* | 2.1 | 0.5 | - |
| Green leaf manure | | | |
| *Pongamia glabra* | 3.2 | 0.3 | 1.3 |
| *Glyricidia maculata* | 2.9 | 0.5 | 2.8 |
| *Azadirachta indica* | 2.8 | 0.3 | 0.4 |
| *Calotropis gigantea* | 2.1 | 0.7 | 3.6 |

Table 11. Nutrient potential of green manure/pulse crops

| Green manure crops incorporation (kg/ha) | Biomass (t/ha) | N |
|---|---|---|
| Daincha *(Sesbania aculeata)* | 22.5 | 125 |
| *S. rostrata* | 20.1 | 146 |
| Sunn hemp *(Crotalaria juncea)* | 18.4 | 113 |
| Wild Indigo *(Tephrosia purpurea)* | 6.8 | 6 |
| Green gram *(Vigna radiata)* | 6.5 | 60 |
| Black gram *(Vigna mungo)* | 5.1 | 51 |
| Cow pea *(Vigna unguiculata)* | 7.2 | 63 |

### Soil moisture conservation

The success of coconut growing depends a great deal on adequate water supply throughout the year. Where rainfall is not well spread throughout the year, and where there is no supplementary water source, soil water conservation is a very important cultural practice. Soil water conservation not only provides the palm with water for a longer time, but also with nutrients dissolved in the water. Adequate weed control may reduce soil-water losses during the dry season. There are various methods of moisture conservation, such as contour planting, contour tillage and trenching on sloping land; mulching; increasing the soil organic matter content and cover cropping. Coconut plantations in many countries are grown as rainfed crop. Inadequate rainfall distribution or rainfall deficit over long periods will deplete the soil moisture and cause palms to suffer due to drought. Soil moisture conservation is a must both in the rainfed as well as in neglected coconut plantations.

### Drought management

Drought is a common phenomenon in many coconut growing countries affecting the coconut production and productivity. Conservation of available soil moisture and effective utilization of water resources are important requirements for sustaining optimum productivity. Mulching with coconut leaves, coir pith, green manures and green leaf manures, organic recycling techniques such as husk burial, cultural practices like deep planting, wrapping the seedlings by tying, drip/fertigation, etc. are useful agronomic measures for soil moisture conservation. These practices will help to overcome the impact of drought to certain extent.

### Drip irrigation

Drip irrigation is an efficient water and nutrient use method (Dhanapal *et al.*, 2004). In places where ground water or irrigation water is inadequate, drip irrigation system could be adopted. This system is not only economic but also increases the efficiency of water in addition to increasing the productivity of coconut palms as could be seen in Table 12.

Table 12. Comparative economics of irrigation and fertilizers in coconut gardens

| Particulars | Yield (nuts/palm) | Yield (nuts/ha) | Gross returns (Rs/ha) | Annual cost (Rs/ha) | Gross margin (Rs/ha) |
|---|---|---|---|---|---|
| Irrigation only | 73 | 12775 | 38325 | 14200 | 24215 |
| Fertilized without irrigation | 91 | 15925 | 47775 | 13200 | 34575 |
| Fertilized with irrigation | 128 | 22400 | 67200 | 18200 | 49000 |

Source: Unpublished data, CPCRI Annual Reports.

### Soil mulching

Mulch is a cover on the soil surface. Reduction in soil water loss occurs not only because the mulch acts as a barrier preventing loss, but also because of alteration in the soil radiation balance and its thermal regime, thus influencing the evaporation rate at the surface. Fallen coconut leaves, husks, coir dust etc could be used for mulching coconut basins. Mulching can be done with slashed weeds from the inter-row, coconut husk and coir dust, or any organic material that can be found in and around the plantation. A 50% yield increase after incorporating coconut husk as mulch in the basin of coconut palms has been reported (Das *et al.*, 1991). The effect of the husk lasted for 6 years. Coir dust can also be used for mulching (Uthaiah *et al.*, 1989). Coir dust is a by-product of coir fibre production, which is an important industry in most countries where coconuts are grown. One of the most important attributes of coir dust is it's ease of wetting. Coir dust remains relatively hydrophylic (water attracting) even when it is air dry. This property impacts on water and fertilizer use efficiency and on plant quality. Perennial intercrops provide shade and also ameliorate the microclimate at soil level. The leaves falling from these crops may provide additional mulch. Cutting off old coconut leaves to reduce evapotranspiration may even be considered. Rao (1989) observed that During the dry season in Kerala, India, some farmers cut off mature lower leaves of the canopy to minimize the transpiration loss and stimulate the growth of younger leaves. They must have found that this method has some advantages (Rao, 1989). The yields were not significantly affected by leaf pruning, leaving as few as 13 leaves in the crown (Magat and Habana, 1991).

### Coconut and mixed crop biomass

Coconut and cocoa is the common crop mix in most of the coconut growing regions. The single hedgerow planting of cocoa has been found to add about 818 kg of dry matter of leaves while that of double hedge system added 1785 kg/ha. With this sort of biomass addition through cocoa leaf fall in double hedge system it was possible to add 59 kg of N, 11 kg $P_2O_5$, and 36 kg $K_2O$/ha (Table 13). Coconut, pepper, pineapple, banana, turmeric, elephant foot yam, Colocasia, have added 209.8 kg of N, 22.54 kg of $P_2O_5$ and 57.6 kg of $K_2O$/ha.

### Increasing Productivity of Coconut through Inter/Mixed/ Multiple Cropping and Integrated Farming Systems

Coconut being a widely spaced crop utilizing only 22% of space provides ample scope for growing inter/mixed/ multiple/multistoreyed cropping and farming systems (Nelliat *et al.*, 1974: Nair, 1979; Rethinam *et al.*, 2001; Sivaraman *et al.*, 2002; Rethinam, 2002). These cropping

Table 13. Yield of coconut and cocoa in the mixed cropping system at CPCRI, India (Nair, 1979)

| Cropping pattern | Number of plants/ha | | Annual yield of coconut (nuts/palm) | | | Annual increase in Productivity/ha | |
|---|---|---|---|---|---|---|---|
| | Coconut | Cacao | Before Plantg. cacao (1) | After Plantg. cacao (2) | Increase | Coconut (no. of nuts) | Cacao (kgdry beans) |
| Coconut alone | 175 | - | 77.4 | 130.8 | 53.4 | 9,345 | - |
| Coconut + singlehedge cocoa | 175 | 350 | 65.4 | 139.3 | 73.9 | 12,932 | 300 |
| Coconut+ doublehedge cocoa | 175 | 650 | 49.8 | 117.9 | 68.1 | 11,917 | 400 |

and farming systems will add considerable quantities of biomass to the soil. This will help to increase the physical, chemical and biological properties of soil and add nutrients ultimately resulting in increased productivity. The crops have to be carefully selected and properly planted to have complementary effect.

Intercropping in coconut gardens has resulted in the increase of nut yield as a result of improvement in soil organic matter status and soil life. The research carried out in Sri Lanka by Linayage and Gunathilake (1997) has shown that 16 to 53% increase in yield could be obtained as could be seen in Table 14.

(HDMCS) also resulted in the addition of large quantity of biomass to soil. The combination of various crops in the system has reduced the fertilizer requirement of coconut to 1/3 of recommended dose. Even in the root (wilt) disease affected area the HDMCS has increased the productivity of palms (Table 18). Integrated farming system with animals in coconut gardens not only increase the income and employment of the farmer but also enhances the productivity of even old coconut palms. The cow dung and urine can be used to produce biogas, which can be used for cooking as well as lighting in the farmhouse.

Table 14. Effect of multiple cropping on coconut yield

| Crop model | Agro climatic zone | Mean yield (nuts/palm/year) | | |
|---|---|---|---|---|
| | | Monoculture | Cropping system | % increase |
| Coconut-pepper-coffee-ginger | Wet zone | 6406 | 7427 | 16.0 |
| Coconut-pepper-cocoa-ginger | | 5738 | 6657 | 16.0 |
| Coconut-pepper-coffee-gliricidia | Intermediate zone | 4541 | 6970 | 53.5 |
| Coconut-mango-lime-banana | | 6688 | 6934 | 3.7 |
| Coconut cashew -banana | | 4617 | 6794 | 32.0 |

Table 15. Average yield of coconut/palm in different blocks of spice crops, Ratnagiri, Maharashtra, India

| Block/ Particulars/ yield | Cinnamon block | Clove block | Nutmeg block | Allspice block | Garcinia block | Black Pepper block | Control block |
|---|---|---|---|---|---|---|---|
| Average yield before planting spices | 69.25 | 47.08 | 70.56 | 49.15 | 63.67 | 82.87 | 75.94 |
| Average yield after planting spices 1989 to 2000 | 120.57 | 91.25 | 120.34 | 88.63 | 93.24 | 102.23 | – |
| Percent increase | 74.11 | 93.82 | 70.55 | 80.33 | 46.44 | 23.36 | – |

Source: Unpublished data, CPCRI Annual Reports

Similar increase of nut yield in palms has been observed under mixed cropping system with clove, nutmeg, cinnamon, all spice and garcinia as component crops (Table 15). In the same way, the multistoreyed cropping system carried out from 1985-88 has increased the nut yield from 45.3 to 115 nuts/palm/year (Table 16 and 17). The high density multispecies cropping system

Table 16. Yield of crops in multistoreyed cropping systems (1985-88) (Nair and Gopalasundaram, 1990)

| Crop | Unit | Yield |
|---|---|---|
| Coconut* | Nuts (No./palm/year) | 115.0 |
| Pepper | Dry berries (kg/palm/year) | 0.86 |
| Cocoa | Pods (No./tree/year) | 33.0 |

* Pre experimental yield of coconut - 45.3 nuts/palm/year

Table 17. Yield of coconut and cocoa in the mixed cropping system at CPCRI, India (Nair, 1979)

| Cropping pattern | Number ofplants/ha | | Annual yield of coconut (nuts/palm) | | | Annual increase in Productivity/ha | |
|---|---|---|---|---|---|---|---|
| | Coconut (kgdry beans) | Cacao Before | Plantg. cacao (1) | After Plantg.cacao (2) | Increase | Coconut (no. of nuts) | Cacao |
| Coconut alone | 175 | - | 77.4 | 130.8 | 53.4 | 9,345 | - |
| Coconut + singlehedge cocoa | 175 | 350 | 65.4 | 139.3 | 73.9 | 12,932 | 300 |
| Coconut+ doublehedge cocoa | 175 | 650 | 49.8 | 117.9 | 68.1 | 11,917 | 400 |

Table 18. Summary observations in the high density multispecies cropping systems (Bavappa *et al.*, 1986)

| Observations made | 1983 84 | 1984 85 | 1985 86 |
|---|---|---|---|
| Yield of coconut (No. of nuts/ha) | | | |
| Full dose | 9,719 | 9,344 | 27,097 |
| 2/3 F | 11,029 | 11,778 | 25,912 |
| 1/3 F | 10,374 | 8,908 | 29,141 |
| Air space utilisation (%) | 32.4 | 31.00 | 30.9 |
| Biomass coconut (t/ha) | 35.1 | 37.9 | 50.1 |
| Other crops (t/ha) | 7.0 | 7 - 0 | 7.4 |

Table 19. Yield of coconut and component crops in HDMSCS from 1.0 ha area over the years (Maheswarappa *et al.*, 2003)

| Year | Coconut (nuts/year) | Banana (kg) | Pepper (kg) | Pineapple (kg) | Nutmeg (kg) | | Amorph (kg) | Dioscorea (kg) | Colocasia (kg) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mace | Nutmeg | | | |
| 1993-94 | 6149 | 975 | - | - | - | - | 280 | 310 | 205 |
| 1994-95 | 6225 | 823 | - | 280 | - | - | 310 | 285 | 235 |
| 1995-96 | 6115 | 912 | 25 | 385 | - | - | 230 | 260 | - |
| 1996-97 | 6364 | 876 | 26 | 288 | - | - | 390 | 237 | 230 |
| 1997-98 | 6053 | 660 | 28 | 320 | 5 | 8 | 350 | 260 | - |
| 1998-99 | 4848 | 1339 | 32 | 298 | 8 | 13 | 360 | 289 | 187 |
| 1999-00 | 6042 | 1102 | 28 | 315 | 12 | 20 | 355 | 305 | - |
| 2000-01 | 8486 | 1030 | 26 | 268 | 14 | 23 | 302 | 387 | - |

Table 20. Nut and copra yield over the years as influenced by integrated management practices and high-density multispecies cropping system (HDMSCS)

| Disease category | Average nut yield (Nuts/palm/year) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre-expl. (1991-02) | 1997-98 | 1998-99 | 1999-00 | 2000-01 | 2001-02 | Average of 1997-02 | Copra content (g/nut) (2001-02) | Copra outturn (kg/palm) (2001-02) |
| Apparently healthy | 44 | 48 | 53 | 64 | 88 | 87 | 68.0 | 179.3 | 15.6 |
| Disease early | 40 | 45 | 42 | 59 | 84 | 74 | 60.8 | 182.4 | 13.5 |
| Disease middle | 36 | 42 | 41 | 55 | 74 | 55 | 53.4 | 181.7 | 10.0 |
| Disease advanced | 21 | 29 | 28 | 30 | 35 | 26 | 29.6 | 180.6 | 4.7 |

Source: Unpublished data, CPCRI Annual Reports

### Why Productivity Increase is Necessary?

For coconut industry to become competitive the productivity from a unit holding has to increase on a sustainable basis. This will help generate consistent supplies of raw material for the processing industries at cost effective prices. It will also greatly help to reduce poverty among coconut growers.

### Strategies for Increasing Productivity

Short, medium and long-term strategies need to be followed for increasing the productivity of coconut in the Asian and Pacific countries on a mission mode approach.

### Short-term strategies

#### Adoption of proper harvesting methods and collection of all fallen nuts

Harvesting is done basically by professional climbers by climbing on the trees, by using trained monkeys as in Thailand, and by using long lanceolate aluminum poles attached with a sickle or a long bamboo pole with a sickle as in many of the coconut growing areas. In case of some countries where nobody climbs and harvests tall palms, the nuts which fall on maturity should be collected properly. In many Pacific countries the fallen nuts are not being collected by the contracted labour and thus there are coconut forests instead of plantations. By proper harvesting and picking up nuts at least 10 - 15 % more nuts could be obtained from such gardens.

#### Adoption of low cost technologies

Since small holders of coconuts are resource poor, low cost technologies like on-farm organic recycling, weed suppression, growing of green manure crops and application of green leaf manure in the basins may be practised on a regular basis.

Many of the island countries are land locked and almost at sea level. Instead of using inorganic fertilizers, the farmers shall be advised to make use of all biomass in the plantation for proper recycling. This will also help to reduce pollution due to chemical fertilizers.

#### Effective transfer of technologies

The farmers are to be encouraged to adopt the input management technologies covering nutrient and water management, pest management, soil moisture conservation etc. This should be done on war footing on a community or group or network basis.

### Medium term strategies

Medium term strategies include group farming or cluster farming approach, adoption of inter/mixed/multi storeyed / high density multi-species cropping system and integrated farming system, developing farmers' organizations and other agri-business organizations / stake holders to adopt modern practices by establishing a network system among farmers.

### Long term strategies

Rejuvenating and consolidating coconut area into manageable units for developing integrated coconut industry, forming a road map for 2025 for coconut development, starting replanting/under planting process in a sequential manner, consolidation of existing plantations, production and supply of quality planting materials of known high yielding varieties/hybrids as well as dwarf, encouraging community nurseries, besides government nurseries, promoting planting of coconut in the backyards of houses as well as in the city housing compounds, encouraging public private farmer partnership etc will go a long way in increasing productivity and making coconut industry competitive.

Effective Transfer of Technology

Organizing demonstrations, training the farmers and house wives in cultivation and primary farm level processing and providing microfinance will further help to boost the productivity.

## Conculsion

To conclude, for sustainable and competitive development of coconut industry, there is urgent need to increase the productivity by adopting integrated management practices including organic recycling in a cluster / group approach coupled with effective transfer of technology through Farmers' Field Schools spread all over the country. This will help to make available raw materials at competitive rates. Other strategic requirements shall encompass coconut product diversification and byproduct utilization, effective marketing support including market promotional activites and adherence to international quality standards for the products marketed and standard packaging with brand name ad labeling.If Public Private Partnership (PPP) mode is encouraged it will further enhance sustainability.

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