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Ministry of Agriculture &
Farmers Welfare

Report of the Committee for Doubling Farmers' Income

Volume VIII

"Production Enhancement through Productivity Gains"

Production & Productivity is linked to Market Inputs, Field Inputs, Farming Practices and Directly Impacts on the Value Realised

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Document prepared by the Committee for Doubling Farmers' Income,
Department of Agriculture, Cooperation and Farmers' Welfare,
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Foreword

The country has witnessed a series of concerted discussions dealing with the subject of agriculture. In 1926, the Royal Commission of Agriculture was set up to examine and report the status of India's agricultural and rural economy. The Commission made comprehensive recommendations, in its report submitted in 1928, for the improvement of agrarian economy as the basis for the welfare and prosperity of India's rural population. The urban population was about 11 per cent of the whole, and demand from towns was small in comparison. The Commission notes, that communication and physical connectivity were sparse and most villages functioned as self-contained units. The Commission encompassed review of agriculture in areas which are now part of Pakistan, Bangladesh and Myanmar. The net sown area in erstwhile British India was reported as 91.85 million hectares and cattle including buffaloes numbered 151 million. Almost 75 per cent of the cultivated area was under cereals and pulses, with rice and wheat occupying 46 per cent of the net sown area. The area under fruits and vegetables was about 2.5 per cent and that under oilseeds and non-food crops was about 20 per cent. In the ensuing years, as well known, the country underwent vast changes in its political, economic and social spheres.

Almost 40 years later, free India appointed the National Commission on Agriculture in 1970, to review the progress of agriculture in the country and make recommendations for its improvement and modernisation. This Commission released its final report in 1976. It refers to agriculture as a comprehensive term, which includes crop production together with land and water management, animal husbandry, fishery and forestry. Agriculture, in 1970 provided employment to nearly 70 per cent of the working population. The role of agriculture in the country's economic development and the principle of growth with social justice, were core to the discussions. The country was then facing a high population growth rate. After impressive increase in agricultural production in the first two Five Year Plans, a period of stagnancy set in and the country suffered a food crisis in the mid-1960s. The report in fifteen parts, suggested ample focus on increased application of science and technology to enhance production.

Thirty years hence, the National Commission for Farmers was constituted in 2004 to suggest methods for faster and more inclusive growth for farmers. The Commission made comprehensive recommendations covering land reforms, soil testing, augmenting water availability, agriculture productivity, credit and insurance, food security and farmers competitiveness. In its final report of October 2006, the Commission noted upon ten major goals which included a minimum net income to farmers, mainstreaming the human and gender dimension, attention to sustainable livelihoods, fostering youth participation in farming and post-harvest activities, and brought focus on livelihood security of farmers. The need for a single market in India to promote farmer-friendly home markets was also emphasised.

The now constituted DFI (Doubling Farmers' Income) Committee besides all these broad sectoral aspects, invites farmers' income into the core of its deliberations and incorporates it as the fulcrum of its strategy. Agriculture in India today is described by a net sown area of 141 million hectares, with field crops continuing to dominate, as exemplified by 55 per cent of the area under cereals. However, agriculture has been diversifying over the decades. Horticulture now accounts for 16 per cent of net sown area. The nation's livestock population counts at more than 512 million. However, economic indicators do not show equitable and egalitarian growth in income of the farmers. The human factor behind agriculture, the farmers, remain in

frequent distress, despite higher productivity and production. The demand for income growth from farming activity, has also translated into demand for government to procure and provide suitable returns. In a reorientation of the approach, this Committee suggests self-sustainable models empowered with improved market linkage as the basis for income growth of farmers.

India today is not only self-sufficient in respect of demand for food, but is also a net exporter of agri-products occupying seventh position globally. It is one of the top producers of cereals (wheat & rice), pulses, fruits, vegetables, milk, meat and marine fish. However, there remain some chinks in the production armoury, when evaluated against nutritional security that is so important from the perspective of harvesting the demographic dividend of the country. The country faces deficit of pulses & oilseeds. The availability of fruits & vegetables and milk & meat & fish has increased, thanks to production gains over the decades, but affordability to a vast majority, including large number of farmers too, remains a question mark.

The impressive agricultural growth and gains since 1947 stand as a tribute to the farmers' resilience to multiple challenges and to their grit & determination to serve and secure the nation's demand for food and raw material for its agro-industries.

It is an irony, that the very same farmer is now caught in the vortex of more serious challenges. The average income of an agricultural household during July 2012 to June 2013 was as low as Rs.6,426, as against its average monthly consumption expenditure of Rs.6,223. As many as 22.50 per cent of the farmers live below official poverty line. Large tracts of arable land have turned problem soils, becoming acidic, alkaline & saline physico-chemically. Another primary factor of production, namely, water is also under stress. Climate change is beginning to challenge the farmer's ability to adopt coping and adaptation measures that are warranted. Technology fatigue is manifesting in the form of yield plateaus. India's yield averages for most crops at global level do not compare favourably. The costs of cultivation are rising. The magnitude of food loss and food waste is alarming. The markets do not assure the farmer of remunerative returns on his produce. In short, sustainability of agricultural growth faces serious doubt, and agrarian challenge even in the midst of surpluses has emerged as a core concern.

Farmers own land. Land is a powerful asset. And, that such an asset owning class of citizens has remained poor is a paradox. They face the twin vulnerabilities of risks & uncertainties of production environment and unpredictability of market forces. Low and fluctuating incomes are a natural corollary of a farmer under such debilitating circumstances. While cultivation is boundarised by the land, market need not have such bounds.

Agriculture is the largest enterprise in the country. An enterprise can survive only if it can grow consistently. And, growth is incumbent upon savings & investment, both of which are a function of positive net returns from the enterprise. The net returns determine the level of income of an entrepreneur, farmer in this case.

This explains the rationale behind adopting income enhancement approach to farmers' welfare. It is hoped, that the answer to agrarian challenges and realization of the aim of farmers' welfare lies in higher and steady incomes. It is in this context, that the Hon'ble Prime Minister shared the vision of doubling farmers' income with the nation at his Bareilly address on 28th February, 2016. Further, recognizing the urgent need for a quick and time-bound transformation of the

vision into reality, a time frame of six years (2016-17 to 2022-23) was delineated as the period for implementation of a new strategy.

At the basic level, agriculture when defined as an enterprise comprises two segments – production and post-production. The success of production as of now amounts to half success, and is therefore not sustainable. Recent agitations of farmers (June-July 2017) in certain parts of the country demanding higher prices on their produce following record output or scenes of farmers dumping tractor loads of tomatoes & onions onto the roads or emptying canisters of milk into drains exemplify neglect of other half segment of agriculture.

No nation can afford to compromise with its farming and farmers. And much less India, wherein the absolute number of households engaged in agriculture in 2011 (119 million) outpaced those in 1951 (70 million).Then, there are the landless agricultural labour who numbered 144.30 million in 2011 as against 27.30 million in 1951. The welfare of this elephantine size of India's population is predicated upon a robust agricultural growth strategy, that is guided by an income enhancement approach.

This Committee on Doubling Farmers' Income (DFI) draws its official members from various Ministries / Departments of Government of India, representing the panoply of the complexities that impact the agricultural system. Members drawn from the civil society with interest in agriculture and concern for the farmers were appointed by the Government as non-official members. The DFI Committee has co-opted more than 100 resource persons from across the country to help it in drafting the Report. These members hail from the world of research, academics, non-government organizations, farmers' organizations, professional associations, trade, industry, commerce, consultancy bodies, policy makers at central & state levels and many more of various domain strengths. Such a vast canvas as expected has brought in a kaleidoscope of knowledge, information, wisdom, experience, analysis and unconventionality to the treatment of the subject. The Committee over the last more than a year since its constitution vide Government O.M. No. 15-3/2016-FW dated 13th April, 2016 has held countless number of internal meetings, multiple stakeholder meetings, several conferences & workshops across the country and benefitted from many such deliberations organized by others, as also field visits. The call of the Hon'ble Prime Minister to double farmers' income has generated so much of positive buzz around the subject, that no day goes without someone calling on to make a presentation and share views on income doubling strategy. The Committee has been, therefore, lucky to be fed pro-bono service and advice. To help collage, analyse and interpret such a cornucopia of inputs, the Committee has adopted three institutes, namely, NIAP, NCAER and NCCD. The Committee recognizes the services of all these individuals, institutions & organisations and places on record their service.

Following the declaration of his vision, the Hon'ble Prime Minister also shaped it by articulating 'Seven Point Agenda', and these have offered the much needed hand holding to the DFI Committee.

The Committee has adopted a basic equation of Economics to draw up its strategy, which says that net return is a function of gross return minus the cost of production. This throws up three (3) variables, namely, productivity gains, reduction in cost of cultivation and remunerative price, on which the Committee has worked its strategy. In doing so, it has drawn lessons from the past and been influenced by the challenges of the present & the future.

In consequence, the strategy platform is built by the following four (4) concerns:

- Sustainability of production
- Monetisation of farmers' produce
- Re-strengthening of extension services
- Recognizing agriculture as an enterprise and enabling it to operate as such, by addressing various structural weaknesses.

Notwithstanding the many faces of challenges, India's agriculture has demonstrated remarkable progress. It has been principally a contribution of the biological scientists, supplemented by an incentivizing policy framework. This Committee recognizes their valuable service in the cause of the farmers. It is now time, and brooks no further delay, for the new breed of researchers & policy makers with expertise in post-production technology, organization and management to take over the baton from the biological scientists, and let the pressure off them. This will free the resources, as also time for the biological scientists to focus on new science and technology, that will shift production onto a higher trajectory - one that is defined by benchmark productivities & sustainability. However, henceforth both production & marketing shall march together hand in hand, unlike in the past when their role was thought to be sequential.

This Report is structured through 14 volumes and the layout, as the readers will appreciate, is a break from the past. It prioritizes post-production interventions inclusive of agri-logistics (Vol. III) and agricultural marketing (Vol-IV), as also sustainability issues (Vol-V & VI) over production strategy (Vol. VIII).The readers will, for sure value the layout format as they study the Report with keenness and diligence. And all other volumes including the one on Extension and ICT (Vol. XI), that connect the source and sink of technology and knowledge have been positioned along a particular logic.

The Committee benefited immensely from the DFI Strategy Report of NITI Aayog. Prof. Ramesh Chand identified seven sources of growth and estimated the desired rates of growth to achieve the target by 2022-23. The DFI Committee has relied upon these recommendations in its Report.

There is so much to explain, that not even the license of prose can capture adequately, all that needs to be said about the complexity & challenges of agriculture and the nuances of an appropriate strategy for realizing the vision of doubling farmers' income by the year of India's 75th Independence Day celebrations.

The Committee remains grateful to the Government for trusting it with such an onerous responsibility. The Committee has been working as per the sound advice and counsel of the Hon'ble Minister for Agriculture and Farmers' Welfare, Shri Radha Mohan Singh and Dr. S.K. Pattanayak, IAS, Secretary of the Department of Agriculture, Cooperation and Farmers' Welfare. It also hopes, that the Report will serve the purpose for which it was constituted.

12th August, 2017

Ashok Dalwai
Chairman, Committee on
Doubling Farmers' Income

About Volume VIII

The eighth volume of the Report of the Committee on Doubling Farmers' Income (DFI) examines productivity led production growth, keeping mindful that farmers must be able to benefit from technologies and practices that allow them to create value in a more optimal manner. Production enhancement, as a result of productivity gains, optimises on resources deployed, minimises ecological stresses and also reduces per unit cost of production.

This volume discusses these various aspects for the major agricultural sectors. Productivity on crops comes about from changed cultivation practices, i.e., selection of appropriate planting material, applying optimal inputs for soil and plant health, efficiencies during irrigation and tending phase, suitable staggering of sowing and harvest, inter-cropping and enhancing the cropping intensity on land. To achieve this, a wide variety of technology, information, tools and scientific practices are brought into use. In case of livestock and fisheries sectors, productivity enhancement can come from breeding, feeding, health care and other application of animal sciences. The result of such efforts is that the production is optimal to the effort and resources used.

Productivity enhancement not only adds to production, but can also contribute to release farmers' time, land and other resources, freeing these for other productive activities. Consequently this in turn, can offer the farming enterprise the option to diversify into other activities in the supply chain. Farm level productivity therefore, can bring additional gains by allowing the farmers' enterprise to partake in the marketing and other allied activities and capture value from a market led agricultural value system. These secondary, off-field or near-farm activities are also explained in Volume-III. The important aspects on input management are detailed in Volume-VII which also relate to sustainability, which is discussed earlier in Volumes V and VI. Productivity is therefore, intrinsically linked with the earlier volumes, and the consequent gains in production has to be directly co-related to marketing and monetisation.

This volume touches upon the selected agricultural sectors and examines aspects related to cereals, pulses, oilseeds, horticulture, livestock & fishery, sericulture and some commercial crops. The following Volume-IX will take the discussion forward on Secondary Agricultural activities.

Ashok Dalwai

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Doubling Farmers' Income

Volume VIII

"Production Enhancement through Productivity Gains"

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Setting the Context

Redesigning crop geometry & commodity matrix

Production is the final output resulted from the efforts of farmers. The produce is the fungible material that a farmer seeks to monetise, for generating returns on the efforts and costs undertaken. The value realised depends not only on the market demand but also on the productivity achieved in the course of production. Productivity allows for production at lower per unit cost, and is critical to farmers' income.

0.1 Background

Assets, tools, labour and capital are the key elements that take material inputs and convert into agricultural output. Land is the primary asset in case of all terrain-based farming, for field crops, orchards, plantations, aquaculture, livestock, etc. However, in case of marine fishing, the primary asset is the maritime ecosystem and the vessels that harvest the produce. The tools vary across sectors, from simpler hand held implements to industrial scale equipment and high technology systems like sonars, radar, humidity controllers and sensor based equipment.

Labour includes the individual enterprise dedicated to the core farming activities, by the farmer and the farming workers. Human capital in agriculture is involved in controls and decision making and as labour in the activities undertaken. The financial capital cuts across the operations and plays a critical role in the physical capacity to deploy appropriate tools and manpower, as well in the necessary inputs that go into farming. The inputs, such as planting material, water, fertilizer, animal feed, knowledge, etc. are linked to the initial capital available and the capital generated from monetising the output.

The drivers of income growth for farmers are diversification of farm activities towards high-value produce, technology up-gradation and modernisation, knowledge based enterprise development, irrigation (micro-irrigation), each having a multiplier effect in production and productivity. Value chain optimisation at every level in the integrated supply chain, in producing and moving the produce from farm to consumers, optimal price realisation for farmers through competitive markets and improvement in terms of trade are the other factors that ensure that the productivity at field translates into gainful productivity at income level.

The efficiencies achieved from the synergistic exploitation of all of above, is decisive in the productivity achieved at farm level. These efficiencies underpin the final cost of production, the total production achieved, and the reduced stress on man, assets and the ecology. From the farmers' perspective, the cost and volume produced are most critical, as this is the wealth that he/she creates. This wealth is thereafter available to the farmers, to be monetised at prices that are directly linked to demand. The exchange transacted is the final value realised by the farmer, and the productivity impacts on the net income achieved.

0.2 Mandate of Agriculture

At Independence, India's urban population was estimated at 6 crores, and by its 75th anniversary it is expected to be about 48 crores. With such urbanisation, the ratio of urban population in the total population has shifted from 15 per cent to nearly 35 per cent. The

dependency load on the agricultural sector for food and other materials has, at a minimum, more than doubled. This has to happen from a fixed land area and depleting resources. Reports also indicate that by 2030 the urban population may touch 50 per cent. This only reflects that agriculture, is increasingly and acutely linked to the sustenance and survival of the urban population. However, this awareness is yet to be fully appreciated by the dependent population.

The globally accepted goal from agriculture, has been to produce more to assure food security. However, food that contains toxins is not food secure, neither is production that is harming the ecology sensible. It is time to go beyond the conventional terms of food security and ensure that food security includes not such quantity but quality of nutrition and quality of production system. Agriculture, in today's world, is not just with purpose to produce to sustain life; it has to produce more from less and in safe manner. In modern day context, the agricultural mandate needs redefining, entailing food and nutritional security, along with sustainability, thereby expanding upon the erstwhile production centric mandate.

i. Agriculture has the moral responsibility of meeting food and nutritional security in consonance with the agro ecological backdrop.
ii. It has to generate gainful employment resulting in income gains to make the farmers more economically secure.
iii. It has to generate raw material that will directly support agro-processing of food and non-food products to support secondary agriculture.
iv. It has to support agro-processing industry to produce primary and intermediate goods, which will feed the manufacturing sector.
v. Agricultural practices need to be on a sustainable basis.

Agriculture has to generate both food and raw material to meet the requirement of modern society for feed, fibre, fuel and other industrial uses, and in a manner that is sustainable.

0.3 Changing Farmers' Income from Seasonal to Perennial

Concentration on few cereal crops has reduced profitability, distracted investment, and dampened growth in the agricultural sector. Agricultural diversification can help to reverse these trends by making the sector more profitable as it becomes flexible in meeting the local and international demands and enables poor people to do something new and remunerative yet within their sphere of competencies and resources.

Diversification is considered a shift of resources from one crop (or livestock) to a larger mix of crops and livestock, keeping in view the varying nature of risks and expected returns from each crop/livestock activity and adjusting it in such a way that it leads to optimum portfolio of income. Diversified farming activities, instead of concentrating on crops alone, can ensure sustainable income. Agricultural diversification can reduce the risk exposure of farm households by optimizing income from a range of activities, more stable employment for farm workers and resources throughout the year.

Agricultural diversification in India is gradually picking momentum in favour of high value crops/livestock/fishery activities to augment incomes rather than a coping strategy to manage risk and uncertainty. In India, today nearly two-thirds of the total agriculture production today is high value (dairy, horticulture, fish, meat, poultry and spices). This has help farmers to shift to less water-intensive crops, reduce dependence on rain, and ensure that their livelihoods are more sustainable. However, this diversification has been largely driven by a few states like Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra and West Bengal.

Diversification needs to be more geographically widespread and augmented through further thrust on processing of perishables. This highlights the importance of strong policy support for development of agricultural diversification in India so as to enable farmers to capitalize on the opportunities of diversification. Infrastructural bottlenecks remain a major obstacle for poor farmers to participate in and profit from agricultural diversification due to limited ability to get their produce to markets, limited ability to add value to their produce and also due to lack of market knowledge. Policies are needed to help theses growers by strengthening their marketing skills, providing market access, both on local and national levels and improving market and transport infrastructure.

Also the lack of resources in terms of credit, training and exposure are major constraints for farmers wanting to venture into new lines of production. Restructuring of existing extension systems toward more participatory methods and provision of small term loans in terms of micro-finance options has been found to be an effective means of strengthening the linkages between farmers and the research community. Also, cooperation with local NGOs and producer group with regards to extension work has proved very beneficial so as to fulfil the needs of women, small and marginal farmers.

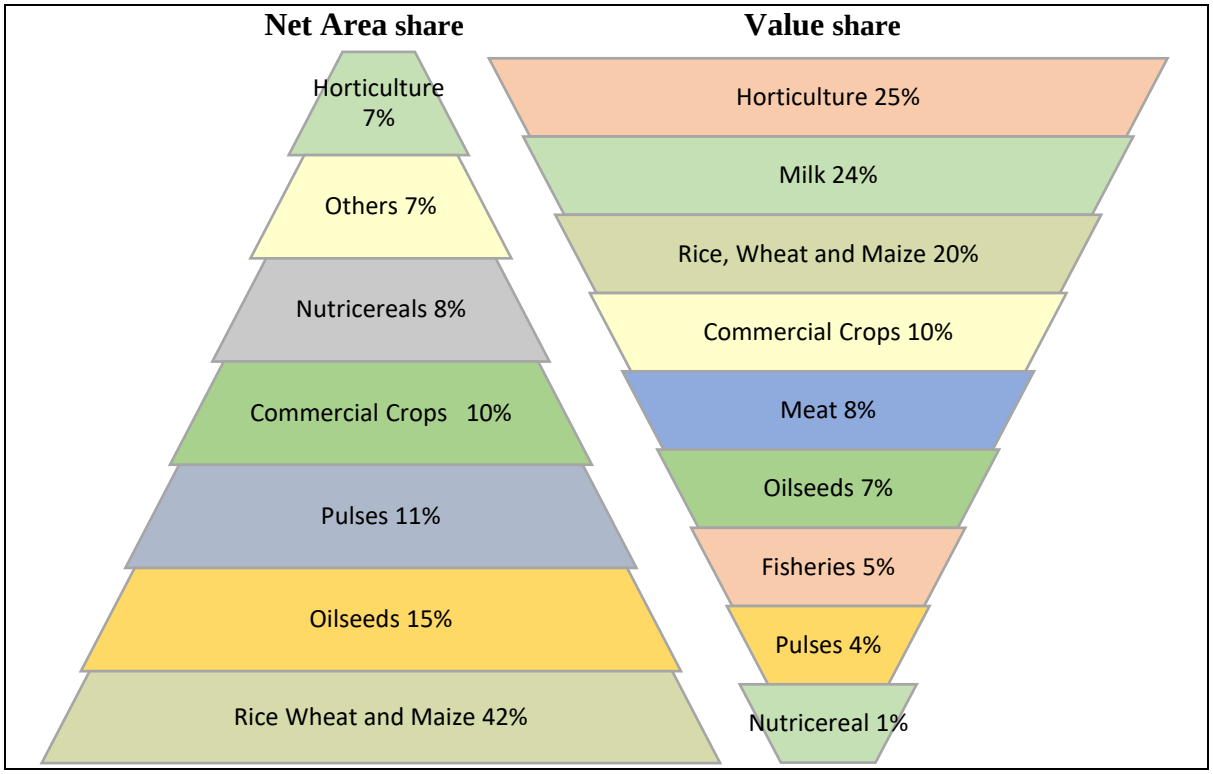
Regional and international networking and contractual research are considered important to quickly resolve a wide variety of constraints in diversification that differs from region to region. The training of farmers in new technologies and processes involved in diversification will improve their technical ability to engage in diversification. There is the need for enabling the establishment of fruitful corporations between native entrepreneurs and foreign businesses and by serving local businesses to upgrade their standards so as to conform to international quality requirements. But for all this to be successful farmers need assistance in acquiring the technical knowledge of these arrangements and assistance in accessing related markets.

0.4 Area and value pyramid

Farmers' income security is as important as nation's food and nutritional security. Agriculture has met the goal of food security with surplus foodgrain production; however, there is a need to assure the nutritional security, along with the gains in farmers' income. Value is important for generating high income of farmers, but as seen in DFI Volume I, no direct correlation among area and value is observed.

The value of any agricultural produce depends on a number of factors. In some cases, the factors include demand linked to administered and allocated values, and in some cases the terms of trade many not be so favourable, despite untapped demand, such as in case of nutri-cereals. It would be worthwhile to evaluate the relationship between acreage and value and use this to plan future actions, to make the most of agricultural assets, outputs and markets. Certainly, there is need to change the crop cafeteria to suit the ecology and the consumers' preference, hence ensuring that value is captured across all areas of concern.

Figure 0.1 Area and Value Pyramid



Source: DFI Committee

In case of field crops, it is observed that 42 per cent of the area is under major cereal crops (rice, wheat and maize) contributing only 20 per cent in the value of output, and just 7 per cent area is under horticultural crops but contributes 25 per cent to the value (Figure 0.1). Thus, a shift in area under cereals to other high value and nutritional commodities like horticulture, pulses, nutri-cereals as per the agro-climatic condition of the regions can may lead to demand fulfilment and income enhancement can also be achieved.

The DFI Committee felt the need for States to undertake comprehensive district level planning, to bring about a shift in area under cereals to other high value and nutritional commodities like horticulture, pulses, nutri-cereals as per the agro-climatic condition of regions, so that along with demand fulfilment, income enhancement can also be achieved.

Unless the concerns on profitability of crops are addressed immediately, it may be difficult to liberate agriculture from its current growth trends. The country has the ability to to meet the food and nutritional demands of its population. However, before initiating a shift in the crop

geometry, there will be need to ensure that food security is not disrupted. This can happen through special focus on productivity enhancement.

Except wheat, productivity of other crops in the country is below world average and much lower than agriculturally advanced countries (Chand, 2017). Technology adoption, minimizing yield gaps, better and sustainable irrigation practices etc. are few areas that need attention for enhancing the productivity growth in crops.

0.5 Commodity matrix and Supply Demand balance

Owing to increasing population over the years, demand for food will naturally show an associated increase. Further, socio-economic changes will also influence the trends on overall demand for food. NCAP Vision 2050 and a study by Kumar et al 2016, showed that the demand for fruits and vegetables will surpass the demand for cereals in the years to come.

Table 0.1 Projected Demand for major food commodities in India

Commodity	Current Production (~mill tons)	Projected Demand (mill tons)		Growth in Demand between 2030 to 2050
		2030*	2050**	
Cereals	**250**	284	359	**26.4%**
Pulses	**22**	26.6	46	**72.9%**
Edible Oils	**8**	21.3	39	**83.1%**
Vegetables	**175**	192	342	**78.1%**
Fruits	**93**	103	305	**196.1%**
Milk	**160**	170.4	401	**135.3%**
Sugar	**20**	39.2	58	**48.0%**
Meat	**7**	9.2	14	**52.2%**
Egg	**4**	5.8	10	**72.4%**
Fish	**11**	11.1	22	**98.2%**

Source : **Kumar et al. (2016) for projected demand in 2030*
***NCAP Vision 2050 for projected demand in 2050*

To meet this variation in demand, there will be need to **diversify and shift existing areas into crops where demand is expected to grow at a higher pace**. Looking at the food grain production scenario, country is self-sufficient or rather surplus in food grain requirement thus; we need to assess whether India needs this much of foodgrains? There is a possibility to shift some area to other crops which are high in both nutrition and in value. This will necessitate undertaking important changes in the current agriculture scenario and offers high potential in achieving doubling of farmers' income.

Farmers' income is directly related to both production and the marketing of the produce. There is need to grasp the gains in form of income enhancement along with maintaining the production balance in commodity status. Moreover, moving to sync with changes in the consumer preference for specific commodities and for better quality will also foster trade across the nation, which will further increase the share from farming income and allied activities.
Following table provides an insight from productivity gains from major food commodities and resultant production in 2022-23.

Table 0.2 Current and Projected Output of Agriculture Sector

Crop/ Livestock category	Production, 2015-16 (million tonnes)	Projected Production, 2022-23 (million tonnes)		
		Business as Usual Based on output growth between 2000-15 (% growth)	Accelerated growth scenario	Assumptions
Cereals	235.2	275.7 (2.29)	295.8	No area change, based on productivity growth of 3.1%
Pulses	16.3	20.8 (3.50)	21.9	No area change, based on productivity growth of 3.1%
Oilseeds	25.3	32.9 (3.88)	35.1	No area change, based on productivity growth of 3.1%
Horticulture	286.2	425.3 (5.80)	451.5	Area growth of 2.8%, productivity growth of 3.1%
Milk	151.0	204.0 (5.36)	205.6	Based on output growth of 4.5%
Meat	7.0	14.6 (11.02)	14.6	Based on output growth of 11%

Source: DFI Committee Estimates

It can be clearly noticed that despite no change in acreage under crops, an enhancement in productivity by 3.1 per cent will not only realise desired gains to the farmers in 2022-23 but also increase the nutritional availability. The country faces a deficit in pulses & oilseeds.

It is to note that current outputs can easily outpace the requirements in some sectors. One can naturally expect that the rising food demand will be accompanied by increasing demand for its safety and quality owing to rising health consciousness. Thus, the main challenge will be to develop technologies, practices, varieties and breeds that are high yielding as well as safe to human health. This will need to be accompanied with safe and secure post-harvest management and delivery systems. Together, this will make India's agricultural sectors future ready.

It has also assessed that irrigation management can be a game changer in productivity enhancement by bringing substantial growth in output. It has been established that micro-irrigation can bring substantial increase in productivity and result in water saving (Government of India, 2009). The average productivity of fruits and vegetables has increased about 42.3 and 52.8 per cent, respectively mainly because of judicious use of water. This was met with equal consumer demand and the overall benefits from the micro irrigation system are reflected in the income enhancement of these farmers. In addition to productivity increase and resource conservation, a major advantage of micro-irrigation in the rain-fed areas is to help reduce fluctuations in output under deficit rainfall conditions and hence reduce vulnerability.

Apart from above mentioned indicators for diversifying and to take a productivity approach, major requirement will be to evaluate and sync with the agro-climatic conditions. The crop matrix should be developed in agro-ecological consonance. An overall shift from being

production centric to productivity centric approach is the need of the hour to overcome both nutritional requirement and value gains.

0.6 Yield gaps

India is largest producer of pulses in the world whereas the second largest producer of paddy, wheat and sugarcane. India is also an important producer of commercial crops like cotton, sugarcane and tobacco. But in most of the cases the productivity of various crops in India are lower than those in the US, Europe and China, because in most of these countries crops are largely grown in high input management conditions with considerably long growing periods. A measure of the degree of crop yield potential, the attainable yield and the corresponding yield gap (the difference between attainable yield and actual yields) is crucial so as to suggest appropriate policy measures.

There always exists a gap between what is projected as the potential yield of any crop variety at a research station, and what is produced by the farmers themselves. Several factors are responsible for theses yield gaps such as physical, biological, socio-economic and institutional constraints which can be effectively improved through participatory research and government attention. Thus, it is important to revisit yield gaps in various production systems in India to estimate existing yield potential across various agro-climatic zones in India.

The clear objective is to ensure that the maximum potential of any crop variety is harvested at the farmers' field. Significant yield gaps exist across various crops through different states as well as within states. Bridging these yield gaps will not only increase crop production but also helps to improve the efficiency of land and labour use, reduce production cost and add to food security. The current yield gaps show a lack of transfer of technology, adoption and knowhow to farmers.

Improving farm yields is important as it can also release land for other productive uses, such as diversifying into added high value commodities and allow farmers to scale up integrated farming practices. If a farmer can generate the current output, of say wheat, from lesser share of his land, some of the same land can be used to take up horticulture or add mushroom, sericulture, beekeeping or other secondary agricultural activities.

Productivity enhancement requires yield gap minimization between district to state, state to state and state to nation. These variations in crop yields are related to market accessibility, purchasing power/income, agricultural work force, and terrain factors, besides water and fertilizer management. However, closing yield gaps will enhance food self-sufficiency and enable food security at local, regional, and global scales.

There is immense yield potential at every level which needs to be assessed to minimise these yield leakages through better technology adoption, increased participation in FLD (front line demonstration), better irrigation practices, soil health card and other schemes.

Table 0.3 presents the yield gaps across major states producing cereals crops in India. Yield for rice ranges from a maximum of 3.8 tonnes per hectare in Punjab to lowest of 2.0 in case of Odisha, indicating a yield gap of more than 47 percent. The information highlights that crop yields vary across regions, even within the same climatic zones.

Table 0.3 Cereals- Inter-state and Intra-state Yield Gap (2014-15)

Interstate Yield Gap			**Intrastate Yield Gap**				
State	Yield of Major States (ton/Ha)	Percentage Yield Gap with Maximum Yield State	Best Yield District (ton/Ha)	Lowest Yield District (ton/Ha)	Yield range within State (ton/Ha)	Gap in max yield district and Min yield district (%)	Gap in State Avg Yield and Min Yield district (%)
Rice	Best Yield Punjab 3.8						
West Bengal	2.7	28.9	Maldah (3.5)	Darjeeling (2.1)	1.4	40.0	22.2
Uttar Pradesh	2.1	44.7	Auraiya (3.2)	Lalitpur (0.8)	2.4	75.0	61.9
Punjab	3.8	0.0	Sangrur (4.7)	Pathankot (2.5)	2.2	46.8	34.2
Odisha	2.0	47.4	Sonepur (3.4)	Jharsuguda (1.4)	2.0	57.9	29.0
Andhra Pradesh	3.0	21.1	SPSR Nellore (4.0)	Visakhapatanam (1.7)	2.3	57.5	43.3
All India	***2.4***	***36.8***					
Wheat	Best Yield Punjab 4.3						
Uttar Pradesh	2.3	46.5	Baghpat (3.4)	Banda (0.9)	2.5	73.5	60.9
Madhya Pradesh	2.9	32.6	Hoshangabad (4.8)	Dindori (1.3)	3.5	72.9	55.2
Punjab	4.3	0.0	Faridkot (4.8)	Pathankot (2.7)	2.1	43.8	37.2
Haryana	4.0	7.0	*				
Rajasthan	3.0	30.2	Jhunjhunu (4)	Jaisalmer (1)	3.1	75	66.7
All India	***2.8***	***34.9***					
Maize	Best Yield Tamil Nadu 6.4						
Karnataka	3.2	50.0	Kodagu (5.1)	Bidar (1.8)	3.3	64.7	43.8
Madhya Pradesh	1.9	70.3	Seoni (3.6)	Sidhi (1.3)	2.3	63.9	31.6
Bihar	3.3	48.4	Katihar (6.5)	Kaimur (Bhabua) (1.2)	5.3	81.5	63.6
Tamil Nadu	6.4	0.0	Perambalur (11.0)	Tuticorin (5.2)	5.8	52.7	18.8
Telangana	3.3	48.4	Karimnagar (5.0)	Medak (1.8)	3.2	64.0	45.5
All India	***2.6***	***59.4***					

Source: DFI Committee Estimates based on data compiled from DACNET

*District -wise data not available for the year 2014-15

In case of wheat, the yield varies from a high of 4.3 tonnes per hectare in Punjab to a low of 2.3 in Uttar Pradesh. The yield gap in case of major cereals is maximum in case of maize where

more than 70 percent difference is seen between the states having the lowest and the highest yield. The table also highlighted large yield gap among the districts in specific states, thus there is considerable yield gap within states, indicating the scope to increase the yield in future, in the districts having comparatively lower yields.

Considerable yield gap also exist between major states producing coarse cereals like Jowar and Bajra where it is more than 64 per cent and as much as 68 per cent respectively.

Table 0.4 Coarse Cereals: inter-state and intra-state Yield Gap (2014-15)

Interstate Yield Gap			**Intrastate Yield Gap**					
State	Yield of Major States (ton/Ha)	Percentage Yield Gap with Maximum Yield State	Best Yield District (ton/Ha)	Lowest Yield District (ton/Ha)	Yield Range within State (ton/Ha)	Gap in Max yield district and Min yield district (%)	Gap in Max District Yield and Avg State Yield (%)	Gap in State Avg Yield and Min Yield district (%)
Jowar	**Jowar: Best Yield Madhya Pradesh 1.7**							
Maharashtra	0.6	64.7	*					
Karnataka	1.1	35.3	Davangere (2.1)	Chamarajanagar (0.4)	1.7	81.0	47.6	63.6
Tamil Nadu	1.5	11.8	Tirunelveli (4.7)	Tiruppur (0.3)	4.4	93.6	68.1	80.0
Rajasthan	0.8	52.9	Rajsamand (2.1)	Jaisalmer (0.1)	2.0	95.2	61.9	87.5
Madhya Pradesh	1.7	0.0	Barwani (3.3)	Rewa (0.9)	2.4	72.7	48.5	47.1
All India	***0.9***	***47.1***						
Bajra	**Best Yield Uttar Pradesh 1.9**							
Rajasthan	1.1	42.1	Dholpur (2.1)	Jaisalmer (0.1)	2.0	95.2	47.6	90.9
Uttar Pradesh	1.9	0.0	Kasganj (3.3)	Allahabad (0.7)	2.6	78.8	42.4	63.2
Gujarat	1.7	10.5	*					
Haryana	1.7	10.5	*					
Maharashtra	0.6	68.4	Jalgaon (1.2)	Parbhani (0.1)	1.1	91.8	50.8	83.3
All India	***1.3***	***31.6***						

Source: DFI Committee Estimates based on data compiled from DACNET

*District -wise data not available for the year 2014-15

District wise yield gap in maximum in Rajasthan both in case of Jowar and Bajra where it is around 88 percent in case of Jowar and more than 90 percent in Bajra. Thus there are serious gaps both at the state level and at the district level which highlights the importance of increasing yield potential, which if addressed properly could help in achieving the target of increasing farmers income.

There exists significant yield gap in case of pulse also, for example in case of Tur (Arhar) the yield ranges from a high of 1.1 (tonnes/hectare) to a low of 0.6 in case of Maharashtra. Same

is the case with Gram and Lentil (Masur) where the yield gap is considerable with more than 36 percent in case of Gram and around 50 percent in case of Lentil (Masur).

Table 0.5 Pulses- Inter-state and Intra-state Yield Gap (2014-15)

Interstate Yield Gap			Intrastate Yield Gap					
State	Yield of Major States (ton/ Ha)	Percentage Yield Gap with Maximum Yield State	Best Yield District (ton/Ha)	Lowest Yield District (ton/Ha)	Yield Range within State (ton/ Ha)	Gap in Max yield district and Min yield district (%)	Gap in Max District Yield and Avg State Yield (%)	Gap in State Avg Yield and Min Yield district (%)
Tur (Arhar)	**Best Yield Gujarat 1.1**							
Maharashtra	0.6	45.5	Jalgaon (0.5)	Beed (0.2)	0.3	60.0	40.0	33.3
Madhya Pradesh	1.0	0.0	Damoh (1.5)	Khargone (0.5)	1.0	66.7	33.3	50.0
Karnataka	0.7	0.0	Hassan (1.5)	Tumkur (0.2)	1.3	86.7	53.3	71.4
Gujarat	1.1	0.0	*					
Jharkhand	1.0	0.0	*					
All-India	***0.7***	***0.0***						
Gram	**Best Yield Uttar Pradesh 1.1**							
Madhya Pradesh	1.0	9.1	Shajapur (1.8)	tikamgarh (0.4)	1.4	77.8	44.4	60.0
Maharashtra	0.8	27.3	Hingoli (2.9)	Jalna (0.3)	2.6	89.7	72.4	62.5
Rajasthan	0.7	36.4	Sawaimadhopur (1.4)	Churu (0.3)	1.1	78.6	50.0	57.1
Karnataka	0.7	36.4	Hassan (1.0)	Haveri (0.5)	0.5	50.0	30.0	28.6
Andhra Pradesh	1.1	0.0	Guntur (2.3)	Anantapur (0.1)	0.6	95.7	52.2	90.9
All-India	***0.9***	***18.2***						
Lentil (Masur)	**Best Yield West Bihar1.0**							
Madhya Pradesh	0.7	30.0	Ratlam (1.0)	Shivpuri (0.3)	0.7	70.0	30.0	57.1
Uttar Pradesh	0.5	50.0	Budaun (1.1)	Banda (0.1)	1.0	90.9	54.5	80.0
Bihar	1.0	0.0	Kaimur (Bhabua) (2.6)	Sitamarhi (0.2)	2.5	93.6	62.0	83.1
West Bengal	1.0	0.0	Medinipur west (1.8)	Coochbehar (0.5)	0.5	70.6	44.9	46.6
Rajasthan	1.0	0.0	Pratapgarh (1.2)	Bhilwara (0.6)	0.6	50.0	16.7	40.0
All-India	***0.71***	***29.5***						

Source: DFI Committee Estimates based on data compiled from DACNET

*District -wise data not available for the year 2014-15

Even at district level across different states, there exists huge yield gap mainly due to different cropping systems, biophysical situations and other attributes of farming systems. This

highlights the need for taking up adaptive research based technology generation and dissemination in case of major pulses producing states.

In last few years India has emerged as the major importer of food oil and pulses in the world. So by increasing the yield of oilseeds we can restrict the additional burden on state exchequer. In case of oilseeds yield gap across major states is maximum (78.6 percent) in case of Groundnut while it is minimum in case of Rapeseed & Mustard. Significant intrastate yield gaps exist. Thus, there is considerable scope for increasing yield for oilseeds in the country.

Table 0.6 Oilseeds - Inter-state and Intra-state Yield Gap (2014-15)

Interstate Yield Gap			**Intrastate Yield Gap**					
	Yield of Major States (ton/Ha)	Percentage Yield Gap with Maximum Yield State	Best Yield District (ton/Ha)	Lowest Yield District (ton/Ha)	Yield Range within State (ton/ Ha)	Gap in Max yield district and Min yield district (%)	Gap in Max District Yield and Avg State Yield (%)	Gap in State Avg Yield and Min Yield district (%)
Rapeseed & Mustard		**Best Yield Haryana 1.4**						
Rajasthan	1.2	14.3	Hanumangarh (1.5)	Jaisalmer (0.6)	0.9	60.0	20.0	50.0
Madhya Pradesh	1.0	28.6	Mandsaur (2.1)	Umaria (0.4)	1.7	81.0	52.4	60.0
Haryana	1.4	0.0	*					
Uttar Pradesh	0.9	35.7	Mainpuri (1.8)	Banda (0.1)	1.7	95.4	48.6	91.1
West Bengal	1.1	21.4	Paraganas north (1.3)	Darjeeling (0.3)	1.0	77.5	19.7	72.0
All-India	***1.1***	***21.4***						
Groundnut	**Best Yield Tamil Nadu 2.8**							
Gujarat*	2.2	21.4	*					
Rajasthan	2.0	28.6	Bikaner (2.4)	Rajsamand (0.8)	1.6	66.7	16.7	60.0
Tamil Nadu	2.8	0.0	Thiruvarur (4.9)	Nilgiris (1.0)	3.9	79.6	44.9	63.0
Karnataka	0.8	71.4	Udupi (2.0)	Bidar (0.3)	1.8	87.2	62.0	66.2
Andhra Pradesh	0.6	78.6	Guntur (4.5)	Anantapur (0.3)	4.2	93.2	87.6	45.6
All-India	***1.6***	***42.9***						
Soyabean	**Best Yield Madhya Pradesh 1.1**							
Madhya Pradesh	1.1	0.0	Betul (2.1)	Burhanpur (0.6)	1.5	71.4	47.6	45.5
Maharashtra	0.7	36.4	Kolhapur (2.2)	Hingoli (0.3)	1.9	86.4	68.2	57.1
Rajasthan	1.0	9.1	Sawai Madhopur (1.4)	Banswara (0.8)	0.6	42.9	28.6	20.0
Karnataka	0.7	36.4	Dharwad (1.0)	Bidar (0.6)	0.5	44.4	27.9	22.8
All-India	***1.0***	***9.1***						

Source: DFI Committee Estimates based on data compiled from DACNET

*District -wise data not available for the year 2014-15

Table 0.7 presents the yield gap across major commercial crops in India. As can be seen from the table, there exists huge yield gap both across different states and within the same state as well. Several spatial and temporal factors are responsible for such variation in productivity across major states. A thorough understanding and quantification of these factors is needed to estimate the scope to increase productivity in various states.

Table 0.7 Commercial Crops - Inter-state and Intra-state Yield Gap (2014-15)

Interstate Yield Gap			**Intrastate Yield Gap**					
	Yield of Major States (ton/Ha)	Percentage Yield Gap with Max Yield State	Best Yield District (ton/Ha)	Lowest Yield District (ton/Ha)	Yield Range within State (ton/Ha)	Gap in Max yield district and Min yield district (%)	Gap in Max District Yield and Avg State Yield (%)	Gap in State Avg Yield and Min Yield district (%)
Cotton	**Best Yield Gujrat 0.6**							
Gujrat	0.6	0.0	Solapur (0.3)	Beed (0.1)	0.2	66.7	51.6	31.1
Maharashtra	0.3	50.0	Khammam (0.5)	Nizamabad (0.2)	0.3	60.0	20.0	50.0
Telangana	0.4	33.3	Guntur (0.9)	Anantapur (0.2)	0.7	77.4	32.3	66.7
Andhra	0.6	0.0	Gulbarga (0.7)	Chamarajanagar (0.2)	0.5	71.4	42.9	50.0
Karnataka	0.5	16.7						
All-India	***0.5***	***16.7***						
Sugarcane	**Best Yield Tamil Nadu 106.8**							
Uttar Pradesh	62.2	41.8	Shamli (78.8)	Lalitpur (40.4)	38.4	48.7	21.1	35.0
Maharashtra	82.2	23.0	Sangli (108.8)	Washim (29.0)	79.8	73.3	24.4	64.7
Karnataka	91.2	14.6	Davangere (128.3)	Ramanagara (65.6)	62.7	48.9	28.9	28.1
Tamil Nadu	106.8	0.0	Namakkal (126.1)	Tirunelveli (78.0)	48.1	38.1	15.3	27.0
Gujarat	68.9	35.5	*					
All-India	***71.5***	***33.1***						
Tobacco	**Best Yield Uttar Pradesh 4.3**							
Andhra	2.6	39.5	Krishna (6.2)	Anantapur (1.9)	4.3	69.4	58.1	26.9
Gujarat	1.4	67.4	*					
Karnataka	0.7	83.7	Belgaum (1.3)	Mysore (0.6)	0.7	53.8	46.2	14.3
Uttar Pradesh	4.3	0.0	Etah (4.7)	Hardoi (2.5)	2.2	46.8	8.5	41.9
Bihar	1.8	58.1	Khagaria (2.0)	Siwan (1.8)	0.2	10.0	10.0	0.0
All-India	***1.6***	***62.8***						

Source: DFI Committee Estimates based on data compiled from DACNET

*District -wise data not available for the year 2014-15

India is the largest milk producer in the world, milk and other dairy products account for around two thirds of the value of the Indian livestock sector and support the livelihoods of nearly half of India's rural households. Table 0.8 shows the yield gap in milk production. Application for

yield gap analyses in dairy sector is significant in context of fact that livestock farming is an important component of smallholder farming systems.

Punjab tops the list for yield across the most categories in the dairy sector owing to various socio-economic reasons. Considerable yield gaps are seen, both across different states and within the states as well.

Table 0.8 Interstate Yield Gap across Major Milk Production States (T.E 2014-15)

Major States	Average daily Productivity (Kg/ Day)	Yield Gap with Maximum Yield State (%)	Major States	Average daily Productivity (Kg/ Day)	Yield Gap with Maximum Yield State (%)
Crossbred	**Best yield Punjab (11.1)**		**Indigenous**	**Best yield Punjab (6.6)**	
Punjab	11.1	0.0	Punjab	6.6	0.0
Chandigarh	9.0	18.4	Haryana	5.2	21.4
Meghalaya	9.0	19.2	Gujarat	4.1	38.7
Gujarat	8.9	19.3	Delhi	4.0	40.2
Kerala	8.8	21.0	Rajasthan	3.7	44.2
All India	***7.0***	***37.0***	***All India***	***2.5***	***62.9***
Buffaloes	**Best yield Punjab (8.7)**		**Goats**	**Best yield Punjab (8.7)**	
Punjab	8.7	0.0	Daman & Diu	1.7	0.0
Haryana	7.6	13.0	Punjab	1.4	18.0
Chandigarh	6.1	29.3	Haryana	0.9	48.9
Jharkhand	5.8	33.2	Uttar Pradesh	0.8	56.2
Delhi	5.8	33.4	Kerala	0.7	62.0
All India	***5.0***	***43.0***	***All India***	***0.4***	***74.3***

Source: Basic Animal Husbandry & Fisheries Statistics 2015, Ministry of Agriculture & Farmers Welfare Department

The dairy sector is only one reflection of India's livestock sector, one of the largest in the world. The socio-economic development and changing lifestyle has resulted in a change in the dietary patterns in India. There has been increased consumption of meat, including poultry and animal-based products.

Also over the last few years, a steep rise in export of bovine meat (carabeef) and this industry has emerged to be significant for providing income and employment in the agricultural sector.

The major states with buffalo meat production centres are Uttar Pradesh, Andhra Pradesh, Maharashtra and Punjab. A significant component of the rural labour force is employed in rearing the livestock and related occupations. There has been sharp rise in the production of animal meat across various states in India but there exists significant yield gap across major meat producing states in India. Table 0.9 provides the yield gap across major meat producing states.

Table 0.9 Interstate Yield Gap across major Meat producing States (2015-16)

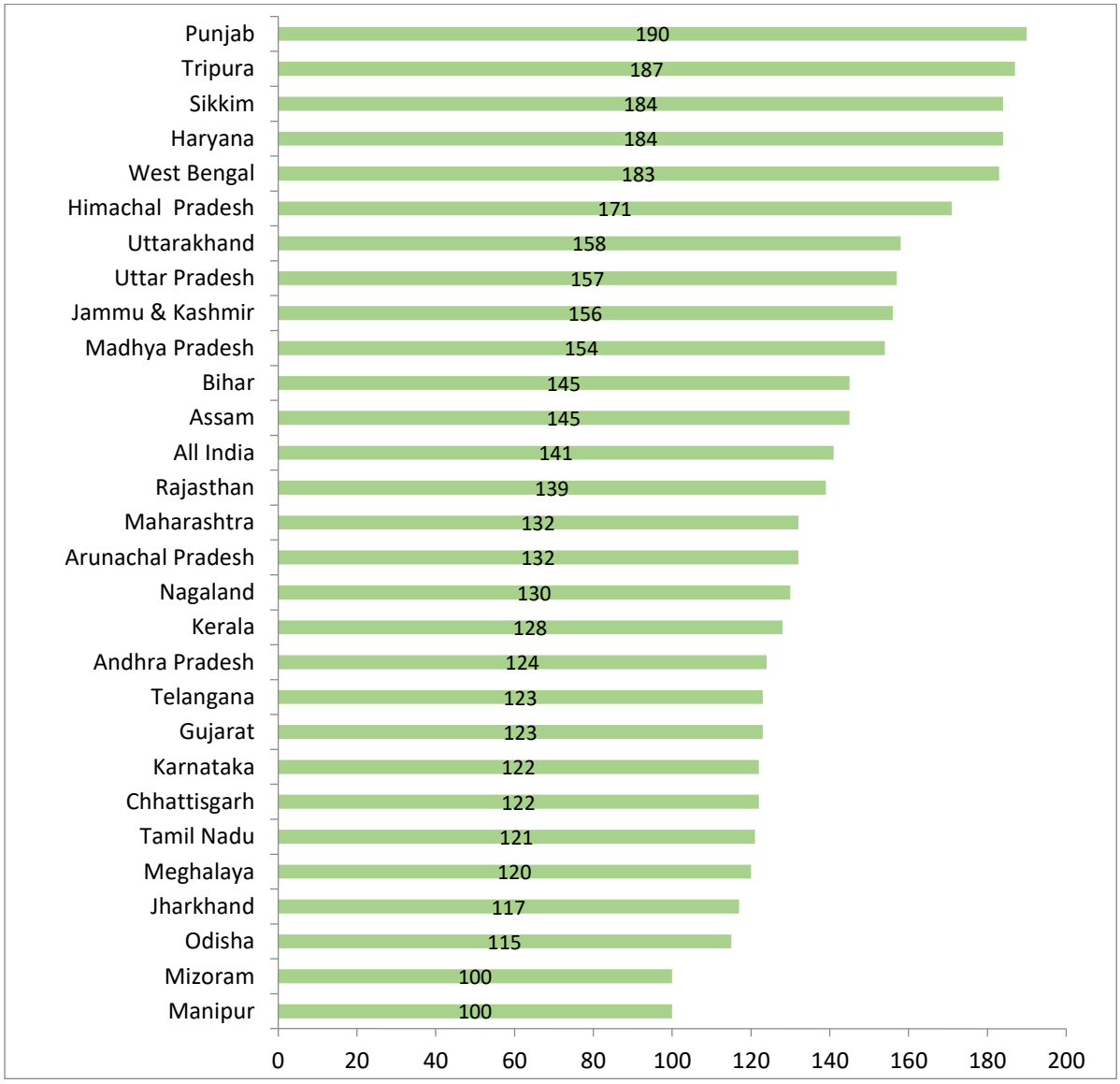
States	Productivity (Kg/animal)	Yield Gap with Maximum Yield State (%)	States	Productivity (Kg/animal)	Yield Gap with Maximum Yield State (%)
Cattle-Adult: Best yield A&N Islands (214.3)			**Cattle-Young: Best yield Kerala (90.1)**		
A&N Islands	214.3	0.0	Kerala	90.1	0.0
Tamil Nadu	147.3	31.3	Tamil Nadu	72.1	19.9
West Bengal	130.8	39.0	Arunachal Pradesh	70.1	22.2
Maharashtra	130.5	39.1	Assam	57.3	36.4
Sikkim	128.4	40.1	Manipur	43.1	52.1
Total	**110.6**	**48.4**	**Total**	**51.0**	**43.3**
Buffalo-Adult: Best yield A&N Islands (240.0)			**Buffalo-Young: Best yield Nagaland (104.7)**		
A&N Islands	240.0	0.0	Nagaland	104.7	0.0
Nagaland	187.4	21.9	Kerala	92.0	12.1
Maharashtra	186.7	22.2	Madhya Pradesh	82.7	21.0
Jammu & Kashmir	168.4	29.8	Maharashtra	81.4	22.2
Delhi	159.9	33.4	Andhra Pradesh	74.4	28.9
Total	**133.9**	**44.2**	**Total**	**63.5**	**39.3**
Sheep-Adult: Best yield Haryana (20.0)			**Sheep-young: Best yield Andhra Pr. (10.7)**		
Haryana	20.0	0.0	Andhra Pradesh	10.7	0.0
Himachal Pradesh	19.3	3.8	Jammu & Kashmir	10.6	1.1
Jammu & Kashmir	16.9	15.7	Rajasthan	10.4	3.2
Karnataka	16.6	17.3	Madhya Pradesh	10.1	5.9
Rajasthan	15.5	22.5	Haryana	9.3	13.6
Total	**13.8**	**31.1**	**Total**	**9.9**	**7.2**
Goat-Adult: Best yield Himachal Pr. (20.2)			**Goat-Young :Best yield Madhya Pr. (12.1)**		
Himachal Pradesh	20.2	0.0	Madhya Pradesh	12.1	0.0
Haryana	19.4	4.0	Jammu & Kashmir	10.7	12.1
Jammu & Kashmir	16.7	17.2	Andhra Pradesh	10.5	13.2
Uttar Pradesh	16.6	17.7	Rajasthan	10.2	16.2
Madhya Pradesh	16.6	18.0	Kerala	9.0	26.2
Total	**11.2**	**44.4**	**Total**	**8.9**	**26.3**
Pig-Adult: Best yield Mizoram (86.9)			**Poultry: Best yield Lakshadweep (3.2)**		
Mizoram	86.9	0.0	Lakshadweep	3.2	0.0
Nagaland	79.4	8.6	Sikkim	2.5	21.1
Kerala	75.0	13.6	West Bengal	2.0	36.7
Rajasthan	60.4	30.5	Manipur	2.0	37.0
Arunachal Pradesh	60.0	30.9	Mizoram	1.9	40.5
Total	**38.0**	**56.3**	**Total**	**1.4**	**57.4**

Source: Basic Animal Husbandry & Fisheries Statistics 2015, Ministry of Agriculture & Farmers Welfare.

0.7 Cropping Intensity

According to the latest available data triennium 2014-15, the index of intensity of cropping for the country as a whole is 141 per cent. It shows great spatial variations with 'higher levels in northern plains and lower levels are found in dry, rain-fed regions of Rajasthan, Gujarat, Maharashtra and Karnataka. Punjab has the highest cropping intensity of 190 per cent, followed by north eastern states of Tripura and Sikkim and Haryana (184 per cent).

Figure 0.2 State-wise cropping intensity (T.E. 2014-15)



Source: DFI Committee - estimates based on data compiled from DACNET.

To fulfil the increasing food demand, intensifying cropping over the existing area is the only viable option we had today. Higher cropping intensity implies higher productivity per unit of arable land during one agricultural year.

The level of cropping intensity is determined by several factors. The most important factor is the availability of water from natural or man-made sources for irrigation purpose. However,

the scope for year round cropping activities in most states of India is severely constrained by the seasonal distribution of rainfall.

So long as this natural constraint is mitigated, by developing irrigation facilities, the level of multiple cropping cannot be improved. Volume I of the DFI reports provides insight on how micro irrigation can benefit famers' income growth.

0.8 The Crop Geometry

Shifting little area from staple to high value in the suitable region (basis agro-climatic condition and availability) can lead to a sizable increase in the returns for farmers. This can be clubbed with crop planning matrix to understand the potential location for area and crop shifting. Diversification towards high value crop needs current attention (NITI Aayog Policy Paper and Volume I and Volume II of DFI Committee Report). High value crops offer comparatively better growth in terms of value of output contribution as compared to the staple crops. Birthal, *et al.* (2013) has also noted that diversification into production of fruits and vegetables, in general, and vegetables, in particular, is likely to benefit the small and marginal farmers more than the medium and large farmers.

Table 0.10 provides the existing crop geometry and shows that in the majority of states, maximum area is occupied under foodgrains, followed by oilseeds. Area under nutri-cereals and horticultural crops is lower despite its potential to generate higher returns.

Table 0.10 Existing crop geometry across states (area share to GCA %)

States	**GCA (000 ha)**	Rice	Wheat	Maize	Nutri cereals	Total Pulses	Total Oilseed	Total Food-grain	Hortic ultural Crops
Andhra Pr	**7909**	29.7	0.1	4.0	3.1	14.7	17.5	51.6	13.7
Arunachal Pr	**293**	43.8	1.1	16.2	8.1	3.5	11.4	72.7	9.3
Assam	**4086**	60.6	0.7	0.6	0.1	3.6	7.5	65.7	12.8
Bihar	**7725**	41.8	27.5	9.2	0.3	6.9	1.6	85.7	6.0
Chhattisgarh	**5705**	66.6	1.8	2.0	2.4	15.6	5.1	88.4	2.6
Gujarat	**12620**	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.8
Haryana	**6461**	19.2	39.2	0.1	7.7	2.1	8.5	68.3	1.1
Himachal Pr	**941**	7.9	8.0	8.1	3.1	8.2	8.4	8.5	14.2
J & K	**1162**	23.2	25.9	26.1	3.5	2.2	5.4	80.9	8.8
Jharkhand	**1628**	65.0	4.2	6.0	0.9	10.2	4.1	88.0	7.4
Karnataka	**12087**	10.9	1.7	11.1	17.5	19.5	11.6	60.7	8.8
Madhya Pr	**23662**	8.4	23.5	4.0	3.1	22.8	31.5	61.9	3.1
Maharashtra	**22915**	6.9	4.3	4.2	17.9	15.5	17.7	48.7	5.5
Manipur	**356**	53.3	0.6	6.7	0.0	8.5	11.0	69.2	14.9
Meghalaya	**342**	32.1	0.1	5.2	0.0	1.4	3.7	39.6	47.5
Mizoram	**125**	24.1		4.7	0.0	3.0	1.7	31.8	65.4
Nagaland	**496**	38.2	0.6	13.9	2.1	7.7	13.1	62.5	20.1
Odisha	**5136**	79.5	0.0	1.7	0.6	14.6	3.7	95.8	0.1

States	GCA (000 ha)	Rice	Wheat	Maize	Nutri cereals	Total Pulses	Total Oilseed	Total Food-grain	Hortic ultural Crops
Punjab	**7858**	36.4	44.7	1.6	0.2	0.7	0.6	83.6	2.3
Rajasthan	**24769**	0.6	12.4	3.8	20.8	14.5	19.7	52.0	4.0
Sikkim	**142**	8.0	0.3	28.1	5.7	4.4	5.7	40.8	48.5
Tamil Nadu	**5677**	29.4		5.6	8.4	13.0	7.1	56.4	12.2
Telangana	**5801**	27.3	0.0	11.6	2.0	9.1	8.0	50.0	4.5
Tripura	**477**	53.5	0.1	0.9	0.0	2.3	1.4	56.7	26.7
Uttarakhand	**1107**	23.4	31.7	2.3	18.6	5.8	2.9	81.9	5.4
Uttar Pradesh	**25955**	22.8	37.8	2.9	4.9	9.0	4.3	77.3	4.6
West Bengal	**9589**	56.8	3.4	1.3	0.2	2.6	7.9	64.3	18.0
All India	**197852**	**22.1**	**15.5**	**4.5**	**8.1**	**12.1**	**13.5**	**62.4**	**6.6**

Source: DFI Committee Estimates based on data compiled from DACNET.

With appropriate infrastructural and logistic support, a chunk of area can be shifted to high value commodities for generating higher returns to farmers.

The change in this existing crop geometry will require investing in tandem to develop strong structural support for these highly perishable produce types. Both central and state assistant is required to build the necessary infrastructural facilities. The current e-NAM scheme can also prove beneficial by providing a trading platform for these commodities.

0.8.1 Changing Crop Geometry

Tables 0.11 provide us a glimpse about future requirement for wheat in India (projected demand based on actual consumption in NSS Family Budget Survey plus average export of wheat for last ten years) based on two scenarios i.e. business as usual and accelerated growth scenario; thus, approximately 2.5 million hectares can be released from wheat cultivation and can be shifted to more required and remunerative crops.

Table 0.11 Estimated land which can be released from Wheat Crop

		Output (Million Tonnes)	Projected Demand (Million Tonnes)	Surplus (Million Tonnes)	Productivity (Tonnes/ Hectare)	*Land to be released (Million Hectare)
2016-17	Existing Status	98.4	91.0	7.4	3.0	2.5
2021-22	#Business as usual	105.0	100.6	4.4	3.5	1.3
2021-23	@Accelerated growth scenario	112.0	100.6	11.4	3.7	3.1

Source: DFI Committee Estimates

Output projected using the productivity growth of 1.9 % per year (last 10 year growth) with area constant at 30.2 Million ha at 2015-16 level.
@Output projected using the productivity growth of 3.1 % per year as given in NITI Policy Paper with area constant at 30.2 Million ha at 2015-16 level.
*Calculated by dividing surplus production divided by the wheat productivity

Many parts of northern India, especially Punjab is facing severe water crisis because of a complicated mix of economic, geographic, and political factors. In global comparison, India

also uses almost twice the amount of water to grow crops as compared to China and United States (Table 0.12). In the past half century, majority of the growth to net irrigated area has come through the assurance of continuous supply of ground water. The primary cause of over-exploitation of ground water has been the rising demand from agricultural sector. In most of the cases, decisions such as cropping pattern and cropping intensity are primarily driven by continuous supply of ground water without caring about negative environmental impact.

Table 0.12 Water use for crop production in different countries (in cubic metres/tonne)

Crops and Crop Products	Average Amount of Water Needed to Grow Crops in			
	Brazil	India	China	United States
Rice	3,082	2,800	1,321	1,275
Sugarcane	155	159	117	103
Wheat	1,616	1,654	690	849
Cotton	2,777	8,264	1,419	2,535

Source: R. Suhag, Overview of Groundwater in India, Tech. Rep. 2016.

Policy measures like power subsidies for agriculture have played a major role in the decline of water levels especially in the northern part of India. Also, even though Minimum Support Prices (MSPs) are currently announced for number of crops, growers of sugarcane, wheat and rice are largely benefitted from this policy. These issues have created highly skewed incentive structures in favor of water intensive crops. Water-intensive crops like sugarcane and paddy are mostly grown in the naturally water-starved areas of the country for instance paddy in Punjab and Sugarcane in Maharashtra with Maharashtra being the second largest grower of sugarcane in India and Punjab being the third largest grower of rice (Agricultural Statistics at a glance 2016). Central Ground Water Board (CGWB, Ministry of Water Resources) used to measure ground water resources in the country at different scales at different time interval at state level and within districts, such as blocks/mandals/talukas/watersheds. Ground water development is a ratio of the annual ground water extraction to the net annual ground water availability. It specifies the quantity of ground water available for use. Table 1.13 illustrates the level of ground water development in the country over the past two decades.

Table 0.13 Ground Water Situation in India (Past 20 Years)

Level of ground water development	Explanation	% of districts in 1995	% of districts in 2004	% of districts in 2009	% of districts in 2011
0-70% (Safe)	Areas which have ground water potential for development	92	73	72	71
70-90% (Semicritical)	Areas where cautious ground water development is recommended	4	9	10	10
90-100% (Critical)	Areas which need intensive monitoring and evaluation for ground water development	1	4	4	4
>100% (Overexploited)	Areas where future ground water development is linked with water conservation measures	3	14	14	15

Source: R. Suhag, Overview of Groundwater in India, Tech. Rep. 2016.

0.8.2 Different scenarios of staple foodgrains production

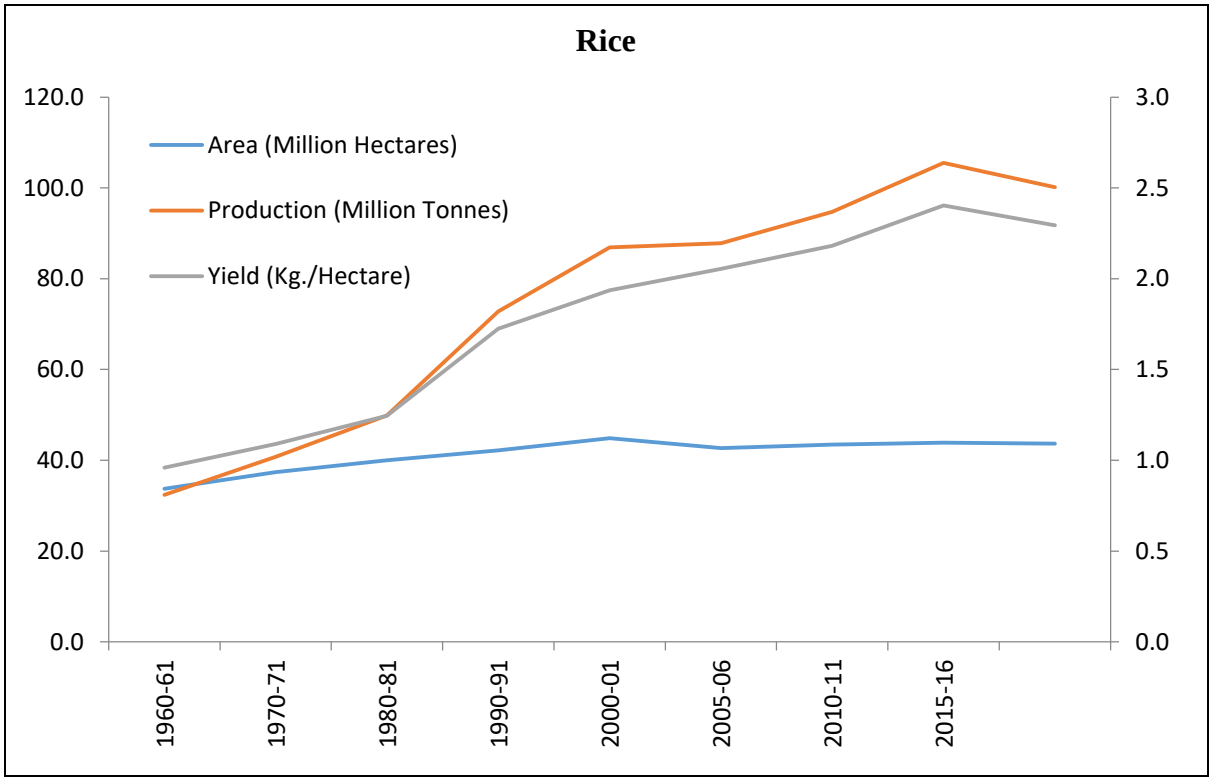
From 1960-61 to 2015-16, rice production increased from around 34 million tonnes to around 44 million tonnes and wheat production increased from 10.4 million tonnes to around 92.0 million tonnes. The yield improved from around 1.0 tonnes per hectare to around 2.4 tonnes per hectare in case of rice and fourfold in case of wheat, from 0.8 to 3.0 tonnes per hectare. Nonetheless, the area under rice cultivation has increased only marginally; it was around 40 million ha in 1980-81 and 44 million ha in the year 2015-16.

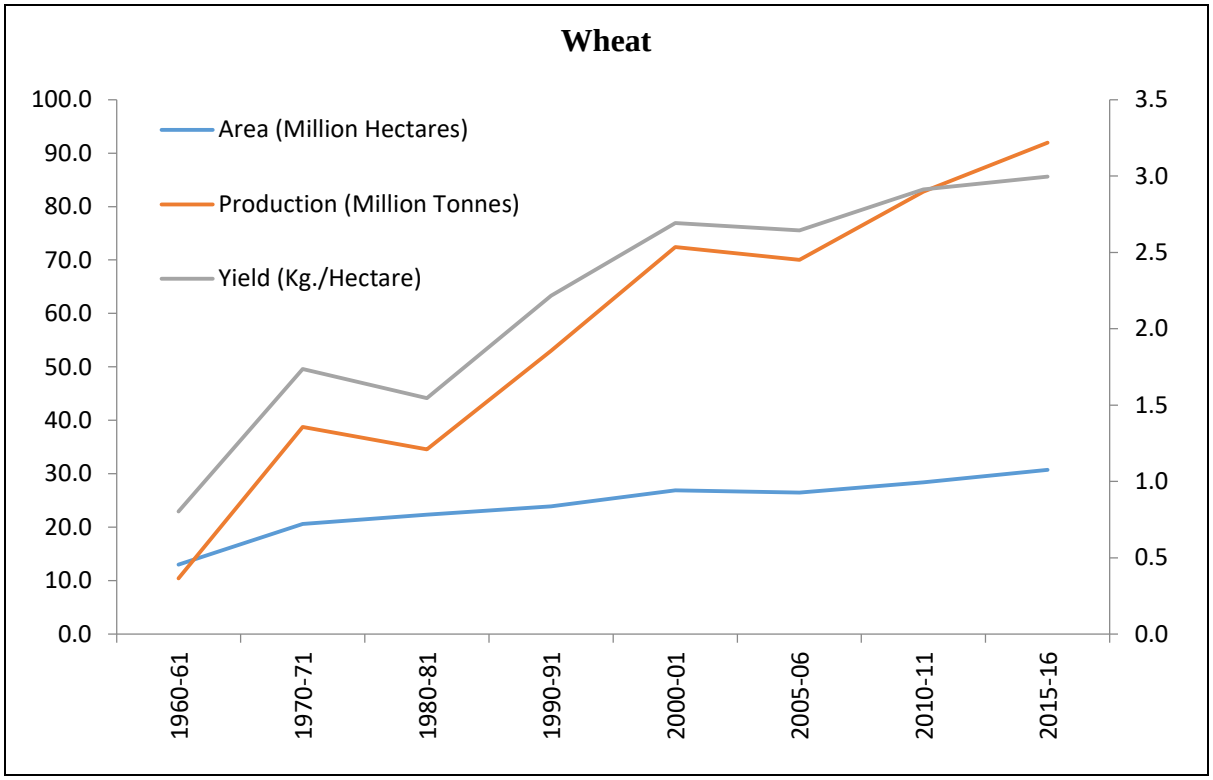
Table 0.14 Rice and Wheat (Area, Production and Yield)

	Rice			Wheat		
Year	Area (mill Hectares)	Production (mill tonnes)	Yield (ton/Ha)	Area (mill Hectares)	Production (mill tonnes)	Yield (ton/Ha)
T.E. 1960-61	33.7	32.4	1.0	13.0	10.4	0.8
T.E. 1970-71	37.4	40.8	1.1	20.6	38.8	1.7
T.E. 1980-81	40.0	49.9	1.2	22.4	34.6	1.5
T.E. 1990-91	42.2	72.8	1.7	23.9	53.0	2.2
T.E. 2000-01	44.9	86.9	1.9	26.9	72.4	2.7
T.E. 2005-06	42.7	87.8	2.1	26.5	70.1	2.6
T.E 2010-11	43.4	94.8	2.2	28.4	82.8	2.9
T.E.2015-16	43.9	105.5	2.4	30.7	92.0	3.0

Source: DFI Committee Estimates based on data available in Agricultural Statistics at a Glance

Figure 0.3 Trends in Area, Production and Yield of Rice and Wheat in India





The trends show that future production of rice may face some stagnation. Various agencies had suggested different growth rate for production of various commodities in India as shown in Table 0.15.

Table 0.15 Average Annual Growth Rate of Production of Selected Food Commodities in India as suggested by different agencies

	Actual Growth Rate	FAO/ OECD	USDA	FAPRI	IGC	NCAER	
						India stand-alone Cosimo Model	Econom-etric Model
	2004-14	**2013-23**	**2013-23**	**2013-21**	**2013-19**	**2015-24**	**2015-23**
Wheat	3.6	1.5	0.8	1.1	1.0	1.2	1.6
Rice	2.0	1.5	0.8	NA	1.9	1.5	2.5
Coarse grains	2.1	1.8	2.3	1.9	1.8	1.5	2.6
Pulses	3.8						1.3
Total oilseeds	1.0	2.6	2.1	0.6	1.3	1.5	4.9

Source: *State of Indian Agriculture 2015-16*

Scenario A: Business as Usual

In the last five years since 2011-12 to 2015-16, in case of rice, the area is almost stagnant at 44 million hectare whereas the production is increasing at a slow rate. Average growth rate for the area between the last ten years (2006-07 to 2015-16) is -0.01 per cent and average growth rate for production comes out as 1.42 per cent.

Table 0.16 Projected Area, Yield and Production for rice and wheat

	Rice*	Wheat#	Demand Supply Projections[1]				
Year	Production-(million tonnes)	Production-(million tonnes)	Commodities	Year	Supply Projection	Demand Projection	Demand supply gap
2016-17	106	96	Rice	2020	108.1	111.8	-3.7
2017-18	107	100		2030	122.1	122.4	-0.3
2018-19	109	103	Wheat	2020	104.2	98.3	5.9
2019-20	110	106		2030	128.8	114.6	14.2
2020-21	112	109					
2021-22	113	113					
2022-23	115	116					

Source: DFI Committee Estimates based on data available in Agricultural Statistics at a Glance

* (Area constant at 43.4 hectares at 2015-16 level and annual production grows at rate of 1.4 percent per year)
# (Area constant at 30.23 hectares at 2015-16 level and annual production grows at rate of 3.2 percent per year)

Using area constant at 43.4 million hectares at 2015-16 level and average annual production growth rate of 1.4, the rice production is projected at 115 million tonnes in 2022-23. In case of wheat average growth rate for the area between the last ten years (2006-07 to 2015-16) is 1.36 whereas average growth rate for production is 3.19. Using the area constant for wheat at 30.23 hectares at 2015-16 level and average production growth rate of 3.19 per cent, wheat production is projected at 116 million tonnes for the year 2022-23.

Scenario B: Optimistic Approach

In this scenario, keeping area under rice constant at 43.4 million hectares, a higher annual growth rate of production at 2.5 per cent is used.

Table 0.17 Optimistic scenario for rice and wheat production

Year	**Rice Area** (mill Hectares)	**Rice Production** (mill tonnes)	**Wheat Area** (mill Hectares)	**Wheat Production** (mill tonnes)
2015-16	43.4	104.3	30.2	93.5
2016-17	43.4	106.9	30.2	96.8
2017-18	43.4	109.6	30.2	100.2
2018-19	43.4	112.3	30.2	103.7
2019-20	43.4	115.1	30.2	107.3
2020-21	43.4	118.0	30.2	111.0
2021-22	43.4	121.0	30.2	114.9
2022-23	43.4	124.0	30.2	119.0

Source: DFI Committee Estimates based on data available in Agricultural Statistics at a Glance

[1] Adapted from Kumar P. et al (2016)

In this case, with higher yield from same area, total supply of rice will be 124 million tonnes in 2022-23. Using the same criteria for wheat with area fixed at 30.23 hectares at 2015-16 level, and a higher annual growth rate of 3.5 per cent, the wheat production will be 119.0 million tonnes in 2022-23.

0.8.3 Specific Case of Punjab

Over 97% of the cultivated area in Punjab is irrigated, the highest in the country though only 25% of the area benefits from canal irrigation the remaining 75% is irrigated using groundwater. Average annual decline in groundwater table in the central Punjab was about 17 cm during the 1980s and about 25 cm during the 1990s, it was alarmingly high at 91 cm per annum during 2000–2005.

Table 0.18 District-Wise Ground Water Assessment for Punjab (as on 31.03.2011)

Area	Total Irrigated Area (Hectares)	Wheat (Hectares)	Percentage of Total Irrigated Area	Level of Exploitation of Groundwater	Yield (Tonnes/ Hectare)
Amritsar	414392	188233	45.42	Over exploited	3.91
Barnala	248570	113785	45.78	Over exploited	4.62
Bathinda	556800	253581	45.54	Semi-Critical	4.80
Faridkot	247996	115607	46.62	Over exploited	4.81
Fatehgarh Sahib	191061	84411	44.18	Over exploited	4.05
Fazilka	475007	206201	43.41	Critical	4.43
Firozepur	415567	188220	45.29	Over exploited	4.66
Gurdaspur	413016	183010	44.31	Critical	3.35
Hoshiarpur	322489	142345	44.14	Semi-Critical	3.60
Jalandhar	412947	167475	40.56	Over exploited	4.10
Kapurthala	267159	110234	41.26	Over exploited	3.90
Ludhiana	592502	252702	42.65	Over exploited	4.46
Mansa	357668	165382	46.24	Over exploited	4.47
Moga	381307	175067	45.91	Over exploited	4.54
Muktsar	446362	208148	46.63	Safe	4.36
Nawanshahr	179612	75234	41.89	Semi-Critical	3.71
Pathankot	55440	22909	41.32	Safe	2.74
Patiala	510722	233229	45.67	Over exploited	4.39
Rupnagar/ Ropar	134508	65673	48.82	Safe	4.03
S.A.S Nagar/ Mohali	104214	50022	48.00	Safe	3.96
Sangrur	635311	284263	44.74	Over exploited	4.81
Tarn Taran	394413	188215	47.72	Over exploited	4.13
Total	7757063	3473946	44.78		4.29

Source: Dynamic Ground Water Resources of Punjab State, Central Ground Water Board, 2013 and Agricultural Statistics at a Glance 2016.

In 22 districts of Punjab water table is declining in 110 blocks due to over-extraction of water than recharge. By 2023, the water table depth in central Punjab is projected to fall below 70 feet in 66% area, below 100 feet in 34% area and below 130 feet in 7% area (Central Ground Water Board 2014-15).

There are districts like Amritsar, Fatehgarh Sahib, Jalandhar, Kapurthala and Tarn Taran, all these districts fall under the over exploited category also their productivity level is low as compared to other districts. Because of the depletion of the groundwater, irrigation cost for wheat crop has increased significantly in these areas; this has resulted in more adverse effect relatively on the small and marginal farmers who lack necessary resources to finance such investments.

This has further contributed to increasing incidence of farmers' indebtedness as a result of increasing cost of well deepening and pump replacement. Thus, these districts may be targeted to release the area from wheat and some other crops may be grown there which are more remunerative.

Similarly, there are several other districts in different states, which have low water table and are struggling with irrigation issues, but traditionally are growing water intensive crops like paddy and sugarcane. These should be marked and specific tailor made policies/programmes should be designed for these districts so as to encourage them to grow crops, which are less water intensive at the same providing higher returns.

The need of the hour is to shift from water guzzling crops of rice, wheat and sugarcane towards less water consuming crops like pulses, coarse cereals, vegetables and fruits. But, it needs several policy measures for encouraging the farmers to make a shift from wheat-rice cycle to other cereals and pulses. Since wheat and rice coupled with other crops are backed by minimum support prices (MSP) and input subsidy (whether water, fertilizer or power) regime, there is a huge enticement for the farmers in some parts of the country to grow these crops.

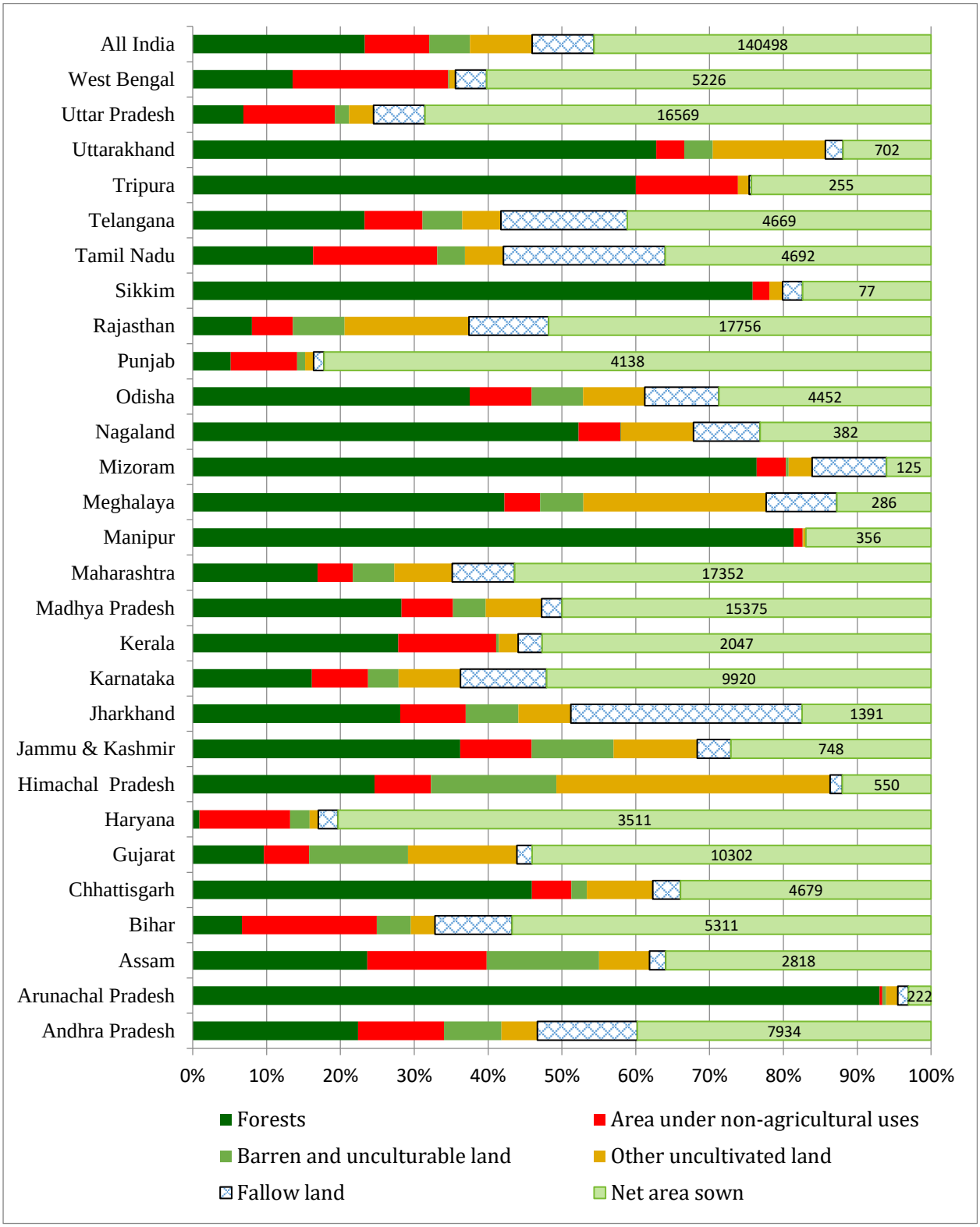
Most of the time major policy response to is problem has always been to disincentivise farmers from growing these crops by making meagre enhancements in the MSP. However, this alone is not sufficient, we need a complete package of agricultural practices that will help the farmers in growing alternative crops for that we required huge investment in public infrastructure. For instance, due to the rice milling industry in Haryana and Punjab, there is now a proper established market in place for different varieties of rice.

Until such a marketplace is available for other crops, farmers are unlikely to make a shift to other crops like pulses. In such a scenario, KVKs can play a key role in sensitizing the farmers towards environmental issues emerging because of consistent growing of crops which are consuming enormous amount of water and benefit of growing alternative crops like pulses, coarse cereals, vegetables and fruits.

0.9 State-wise land use pattern

India's land-use pattern shows total geographical area of 3.28 million square km. As per the land use statistics only 94 per cent of the total geographical area is available for utilisation.

Figure 0.4 State wise land use pattern in India ('000 Hectares, T.E 2014-15)



Source: DFI Committee Estimates based on data compiled from DACNET

Out of this, 45.5 per cent is net sown area, forest cover is 23 per cent, and 5 per cent is current fallow land (Table 0.15). This land-use pattern varies across states.

Every state in the country has significant area under culturable waste, and barren and unculturable land, which comprises 10 per cent as a whole for India. This area can be judiciously brought under cultivation following intense land management practices.

There is scope to bring culturable waste land under agriculture or by altering the area currently not fit for cultivation. The latter comprises of area under non-agricultural use, barren and unculturable land. This land area is unfit for cultivation due to problematic soil conditions like acidic soil, large treks and mainly is rainfed. Such land can be upgraded to support optimal crop production. There is need to follow proper land management practises.

In view of mounting pressure on land for numerous purposes, it is necessary to plan appropriate use of all the available land. This may be done by taking fitting measures to control soil erosion, desertification, improvements made on irrigation and water and soil conservation. Likewise, with the help of up-to-date and scientific methods of farming, productivity of land can also be amplified. All endeavours should be made to strike a balance amongst diverse use of land.

Nutri-cereals are typical to the dry land ecosystem, and play an important role in agricultural value system, the same as rice and wheat in irrigated areas. In the dry land parts of the country, nutri-cereals can play a significant role in doubling the farmers' income while also addressing concerns on nutrition.

Though income generation through enhancement in the productivity gains during green revolution has great significance, however, the dry land crops were not able to reap the same benefit as two staple cereals (rice and wheat).

In case of nutri-cereals productivity enhancement measures must be implemented along with demand enhancement through value addition so as to achieve objectives. Different policy measures are needed in order to enhance the productivity potential of millets in India. Developing innovative supply chain models as market linked value systems, will add to farmers' share in consumers' rupee and increase their income. Creation of farmgate level primary processing clusters for millets will increase the consumption of millets in the production zones. Creation of awareness about the health and environmental benefits associated with consumption of millets will aid demand creation for millets in the country.

Along with doubling farmers' income in various agro-ecological commodities and cropping systems the aspect of imparting nutritional security should also has to be considered.

Table 0.19 State wise land use pattern in India (thousand Hectares, T.E 2014-15)

State/ Union Territory/ Year	Geogra-phical Area	Reporting area for land utilisation statistics	Forests	Not available for cultivation		Other uncultivated land excluding			Fallow Lands		Net area Sown	Gross Cropped Area	Agri. Land (Culti-vable / Cultur-able /Arable)	Cultivated land	Un-cultivable land	Un-cultivated land
						Fallow Land										
				Non-agricultural uses	Barren &unculturable land	Permanent pastures & other grazing lands	Land under misc. tree crops	Culturable waste land	Fallow other than current fallows	Current fallows						
Andhra Pradesh	19934	19934	4461	2324	1550	313	199	457	1087	1609	7934	9823	11285	9542	8649	10391
Arunachal Pradesh	8374	7241	6735	26	38	18	35	63	66	37	222	293	424	259	6817	6982
Assam	7844	7844	1854	1269	1193	170	223	144	86	87	2818	4086	3359	2906	4485	4938
Bihar	9416	9360	622	1711	432	15	247	45	121	856	5311	7677	6580	6167	2780	3192
Chhattisgarh	13519	13790	6333	738	289	877	1	353	259	261	4679	5705	5553	4941	8237	8849
Gujarat	19602	19069	1834	1171	2552	851	4	1960	16	379	10302	12620	12661	10681	6408	8388
Haryana	4421	4371	39	538	115	25	7	20	20	97	3511	6461	3655	3607	717	764
Himachal Pradesh	5567	4576	1126	350	777	1510	64	122	22	54	550	941	812	604	3764	3971
Jammu & Kashmir	22224	9339	1000	267	306	114	63	136	15	111	748	1162	1072	859	2955	3168
Jharkhand	7972	7970	2239	707	569	114	100	352	1074	1424	1391	1628	4341	2815	3630	5155
Karnataka	19179	19051	3073	1447	787	906	280	411	529	1698	9920	12087	12838	11618	6213	7433
Kerala	3886	3886	1082	515	14	0	3	98	56	71	2047	2611	2275	2118	1611	1768
Madhya Pradesh	30825	30756	8693	2146	1363	1293	20	1014	481	371	15375	23662	17261	15746	13495	15010
Maharashtra	30771	30758	5205	1466	1724	1245	250	917	1194	1406	17352	22915	21118	18758	9640	12000
Manipur	2233	2100		26	1	1	6	1	0	0	356	356	363	356	1737	1744
Meghalaya	2243	2242	946	109	131		165	390	155	60	286	342	1056	346	1186	1896

State/ Union Territory/ Year	Geogra-phical Area	Reporting area for land utilisation statistics	Forests	Not available for cultivation		Other uncultivated land excluding			Fallow Lands		Net area Sown	Gross Cropped Area	Agri. Land (Culti-vable / Cultur-able /Arable)	Cultivated land	Un-cultivable land	Un-cultivated land
				Non-agricultural uses	Barren &unculturable land	Fallow Land										
						Permanent pastures & other grazing lands	Land under misc. tree crops	Culturable waste land	Fallow other than current fallows	Current fallows						
Mizoram	2108	2075	1585	82	8	7	52	7	161	48	125	125	393	173	1682	1902
Nagaland	1658	1652	863	93	2		93	69	99	50	382	496	694	432	958	1220
Odisha	15571	15495	5814	1301	1078	528	208	559	641	915	4452	5136	6775	5366	8721	10129
Punjab	5036	5033	259	453	53	5	8	46	6	65	4138	7858	4263	4203	769	829
Rajasthan	34224	34267	2749	1898	2400	1687	25	4064	1980	1709	17756	24769	25534	19465	8734	14802
Sikkim	710	443	336	10			4	4	5	7	77	142	97	84	346	358
Tamil Nadu	13006	13033	2125	2191	489	109	243	327	1716	1141	4692	5677	8119	5833	4914	7200
Telangana	11359	11346	2641	890	611	300	113	180	761	1180	4669	5801	6903	5849	4443	5497
Tripura	1049	1049	629	145		1	12	3	2	1	255	477	273	257	776	793
Uttarakhand	5348	5886	3695	222	228	192	389	316	86	55	702	1107	1548	757	4337	5129
Uttar Pradesh	24093	24170	1658	2988	468	65	327	413	528	1153	16569	25955	18990	17722	5180	6449
West Bengal	8875	8684	1173	1833	12	2	49	20	13	356	5226	9589	5664	5581	3020	3102
All India	328726	307702	71732	26767	17006	10257	3158	12500	10941	14844	140498	197852	181940	155342	125761	152360

Source: DFI Committee Estimates based on data compiled from DACNET

The measures to consider for increasing the production of millets would include bringing more fallow and waste lands under millet cultivation, bridging existing yield gaps and increasing the resource use efficiency. These steps will help in increasing the nationwide availability of nutri-cereals and supplement marginal dry land farmers' income. Development of value added products will help in growing the demand for millets in the country.

Volume VIII-A

Cereals: Staple Crops
Rice, Wheat and Maize
Nutri-Cereals, including Millets
Pulses & Oilseeds

Volume VIII-B

Commercial Crops: Cotton, Sugarcane

Volume VIII-C

Horticulture & Sericulture

Chapter 1
Horticulture - a Sunrise Sector

Horticulture contributes more than a third of the agricultural GDP, though it occupies less than a fifth of the cultivated area. This stems from the fact that there is very high demand and a continued growth in consumption of fresh produce like fruits and vegetables. Floriculture is another growing subsector.

1.1 Introduction

Horticulture, a sub-sector of the larger agricultural sector, comprises a wide array of cultivation systems ranging from the seasonal to the annual, to the perennial. Broadly, the horticultural sector covers six categories, namely pomology (fruits), olericulture (vegetables), floriculture (flowers), plantation crops, spices, aromatics and herbal medicines. On account of their higher monetisable potential relative to field crops like cereals, pulses and oilseeds, horticulture sector is considered as a high value segment. The high value percolates from the higher demand from consumers, and from greater awareness of wholesome nutritional benefits from fresh whole food that horticulture offers. Horticultural crops play a unique role in India's economy by improving the income of the rural populace and provide enormous scope to small and marginal farmers with higher return per unit of land than any other staple crops. They also play an important role in overcoming vitamin and micronutrient deficiencies. Thus, horticulture is emerging as the main growth engine of Indian agriculture.

Larger amounts of labour is needed in the horticulture domain, for operations like preparing planting material, planting, canopy management, staking and in care during cultivation, besides more granular land preparation, and for nutrient & pest management of individual plants. Since, cultivation of horticultural crops is labour intensive, it generates employment opportunities for the rural population. Horticulture also uses high-tech tools and practices and tends to attract rural youth, who generally display a proclivity for technology, as farmers and technology providers. As a result of research, education, technology and policy initiatives, horticulture in India has become a viable option for the small and marginal farmers. This sector has also stared attracting entrepreneurs for commercial ventures in a big way facilitated by technology driven scientific support.

With a surge in the middle and upper income group in the population, demand for fresh fruits and vegetables is bound to increase several fold. In this context, in addition to more food, the young, rich and urban population would demand diversified nutritious and safe food of high quality and as a result of this there will be pressure on supply of horticulture crops like fruits and vegetables. The potential of under-exploited segments of horticulture like dry land horticulture, temperate horticulture and floriculture have to be fully exploited to meet the ever increasing demand.

There is scope for expanding the area under horticulture crops by 4 million hectares and that with an enhanced yields by 60 per cent. This generates 8 million additional employment opportunities in horticulture. For example, an average horticulture nursery producing one lakh plants generates employment of 2160 man-days. It is estimated that average labour requirement for

horticulture crops is 860 person days per hectare compared to 143 days for cereal crops and is as high as 1000 to 2500 days in the case of grapes, flower and other labour intensive crops.

Further, jobs in processing industry is also likely to get added, as processing activity in fruits and vegetables is also expected to go up by ten per cent. With the focus of the government on promoting secondary agriculture through centrally sponsored schemes like the National Mission on Food processing, every one percent increase in processing will demand 2.5 to 3.0 million tonnes of additional fruit and vegetables, that too of processible variety. Export requirements will also pick up and may reach ten percent of the production. The diverse agro-climatic conditions prevalent in India are conducive for cultivating most of the horticultural crops in one area or the other, thereby facilitating almost round the year production and supply. Amid concerns of changing climate, horticulture has demonstrated its resilience to drought and other extreme weather events. Horticulture holds importance for industry as well other than engaging farmers. By way of supplying raw materials it sustains a large number of agro-based industries. These industries also generate large number of employment opportunities for youth in processing and marketing of horticultural products. The horticulture sector continues to be a fundamental source of employment and income generation in India. Hence, improvements in horticultural sector can provide significant scope to absorb a work force, and there is vast scope for the growth of this sector within agriculture for farmers to look forward.

1.1.1 Horticulture for Nutritional Security

Maximum population lives in rural areas. Hunger and malnutrition are often linked to poverty. Providing economic opportunities through horticultural production will not only help in providing promising family incomes, but would also address the problem of hunger through food security and nutrition. Many of the horticulture crops and their products find place in our meals and diet. Human body requires vitamins, minerals, proteins, energy etc. for its health. All these are supplied by horticultural crops. India is currently producing about 300 million tonnes of horticulture produce. It has proven beyond doubt that productivity of horticulture crops is much higher compared to productivity of food grains. Per capita availability of fruit to the Indian population is 200 g/ person/ day and has been helping in supplementing nourishment. Per capita availability of vegetables in India is 387 g/person/day, which is helping in fighting malnutrition.

Table 1.1 Per capita availability of Fruits and Vegetables

Projected Population of India in 2016-17 (million)	**1268**
Fruits Production in 2016-17 (thousand tonnes)	92846.0
Vegetables Production in 2016-17 (thousand tonnes)	175007.9
Per Capita Availability of Fruits (g/person/day)	200.6
Per Capita Availability of Vegetables (g/person/day)	378.13

Source: Population Projections for India and States, 2001-2026 Report, Office of Registrar General of India (RGI)

The general recommendation for intake of fruit and vegetable is at least 400 grams per person per day (five serving of 80 g each day). Numerous Indians are still unable to avail the targeted daily dietary allowances and thus the Human Development Index (As of 2016, HDI for India stood at 0.624) is very low resulting into a considerable gap between gross food production and net availability.

Iron deficiency is one of the major concerns in Indian population and the richest sources of iron are green leafy vegetables like spinach, amaranth, pomegranate figs and apple. Fruits in diet help in combating iron deficiency anaemia. By introducing these fruits and vegetables in diet help in reducing the iron deficiency anaemia. Training women to produce and market horticultural crops can also be helpful in nutrition security of India as well as in reducing burden of various nutritional deficiency diseases and can go a long way in improving the overall health scenario in India.

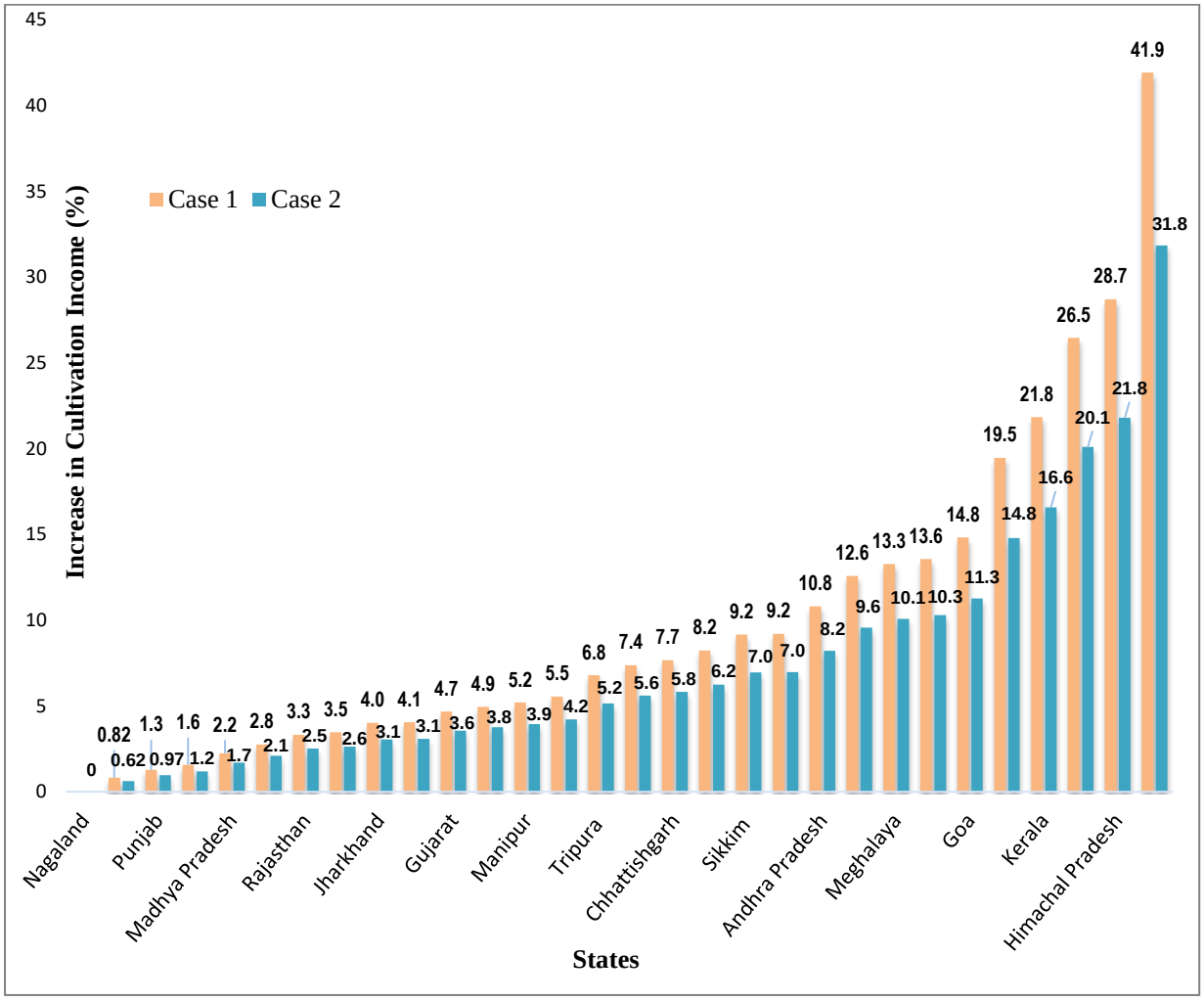
1.2 Income level of farmers and horticulture as an option

Horticulture is seen as optimal option for crop diversification in agriculture. The per unit earning capacity of farmers is much higher than in case of foodgrains and it also addresses environmental concerns. Nevertheless, most horticultural output requires specialised market linkages and connectivity and to make this sector more remunerative, there is a need to address the constraints involved.

In 2012-13, an average Indian farmer's monthly income was Rs 6,426 per hectare. Punjab's farmers had the highest income at Rs 18,059, followed by those in Haryana (Rs 14,434), Jammu & Kashmir (Rs 12,683) and Kerala (Rs 11,888). Bihar's farmers earned the least, with their monthly incomes averaging Rs 3,558. The CAGR of farmers' nominal incomes between 2002-03 and 2012-13 was 11.8 per cent at an all-India level. The CAGR of real income rose at a national average of only 3.5 per cent only during the same period. There are case studies brought to notice of this committee where farmers in Haryana diverted a portion of land from the wheat/rice cropping cycle into horticulture and more than doubled their total income from farming. While the foodgrains allowed for a more assured income through state procurement system, the horticultural crops provided opportunity to tap into a more profitable trade.

Chapter 4 of Volume II of the DFI Report, discusses the opportunity for farmers from diversifying into horticulture. The scope for income growth from each 1 per cent shift of area into horticultural crops, state-wise, is provided in Table 4.2 in Volume-II of DFI Report. In addition, two broad based case scenarios were discussed to highlight income growth from diversifying from staple crops into horticultural crops. The key findings for the two case examples, showing the resulting increase in income that can arise from diversifying into horticulture, are repeated in the figure on the following page.

Figure 1.1 Increase in Income (at 2015-16 prices) from diversifying into horticulture [1] (%)



Source: DFI-Vol-II

[1)] Crop diversification through shift in area in favour of horticulture (by reducing equal area under staple crops). States are arranged in the ascending order of percentage increase in income from cultivation in Case 1.

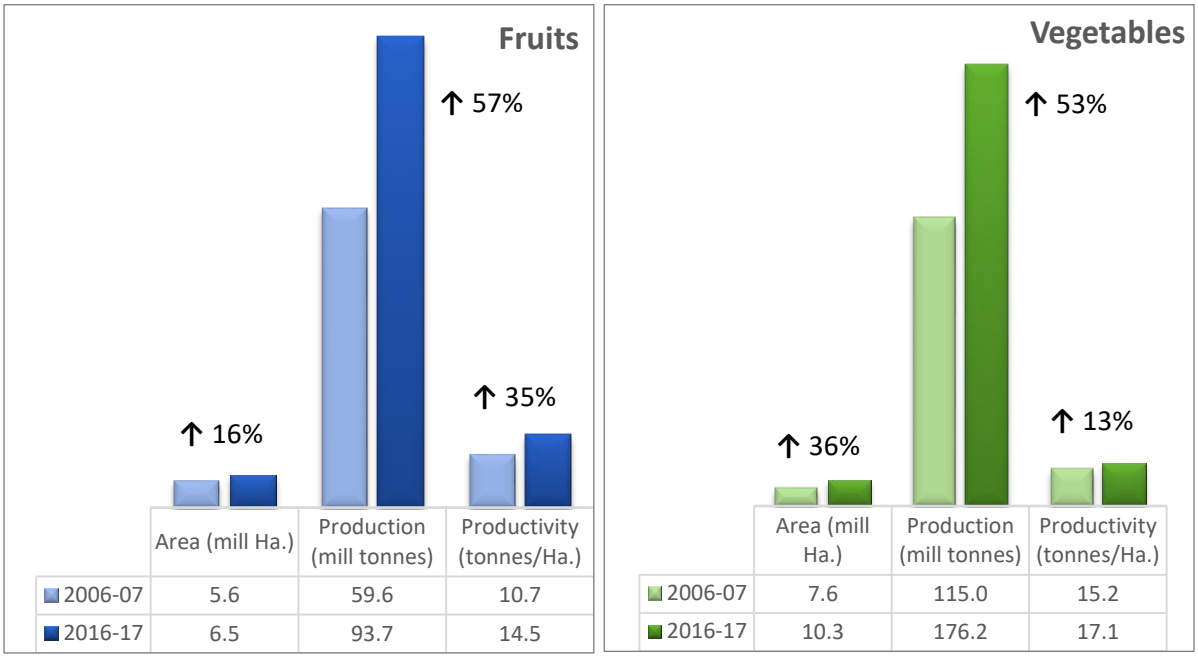
Case 1: Shift of area in favour of horticulture at 4 per cent per annum for 7 years, that is, till 2022-23.
Case 2: Shift of area in favour of horticulture at 2 per cent per annum for the first three years and thereafter at 4 per cent per annum for the next four years (2018-19 to 2022-23).

1.3 Status of Horticulture

India's horticultural production has surpassed that of all other agricultural sub-sectors, since 2012-13. It is no gain saying that that productivity of horticultural crops is much higher compared to productivity of foodgrains.

As more farmers diversified into horticulture, the area under horticulture increased 34 per cent in 10 years, from 18.7 million ha in 2006-07 to 25.1 million ha in 2016- 17. In the same period, horticultural production increased 56 per cent from 191.8 million tonnes in 2006-07 to 299.8 million tonnes by 2016-17. The growth in production and productivty of frtuits and vegetables in last ten years is represented below.

Figure 1.2 Growth in fruits & vegetables in previous 10 year



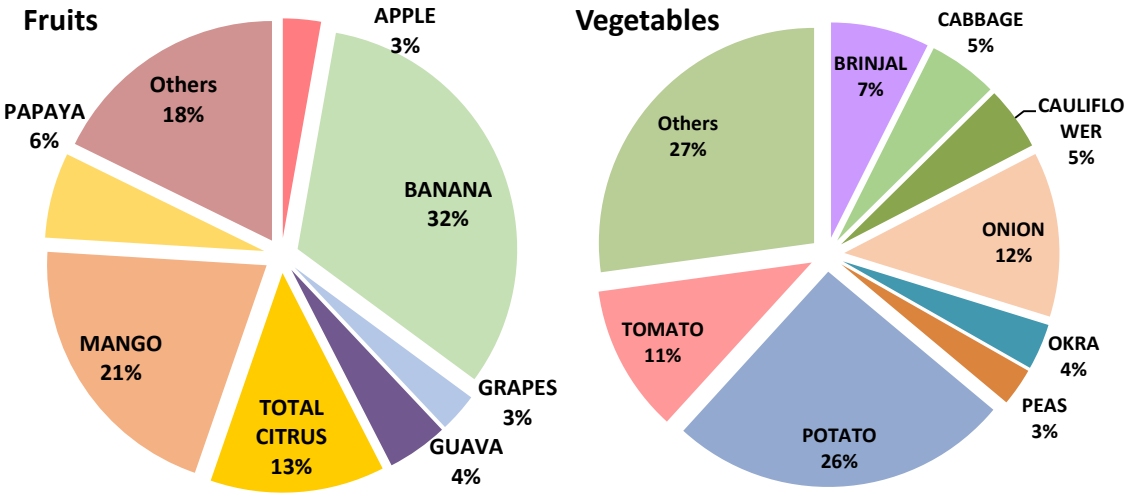
Fruits	Area (mill Ha.)	Production (mill tonnes)	Productivity (tonnes/Ha.)
2006-07	5.6	59.6	10.7
2016-17	6.5	93.7	14.5

Vegetables	Area (mill Ha.)	Production (mill tonnes)	Productivity (tonnes/Ha.)
2006-07	7.6	115.0	15.2
2016-17	10.3	176.2	17.1

India is the second largest producer of fruits and vegetables globally. The country is a world leader in production of mango, banana, papaya, pomegranate, sapota, litchi, ginger acid lime, aonla, peas, guava, jackfruit and okra. Besides, India occupies the second position in production of brinjal, cabbage, cauliflower, onion, peanut, sugarcane and third in coconut, lettuce, potato and tomato in the world.

The production permits the population a per capita availability of more than 190 gm/day of fruits and 357 gm/day for vegetables. India is also the largest producer and exporter of spices in the world. Noticeable advancement has been made in recent years in flower production, particularly, cut flowers, which contains vast potential for exports. The venn diagram below depicts the commodity composition status of fruits and vegetables.

Figure 1.3 Fruit & Vegetable Snapshot



The special thrust given to the sector, especially after introduction of the National Horticulture Mission in 2005 and the revamped Mission for Integrated Development of Horticulture (MIDH), has borne positive results. MIDH rolled out in 2014 and it subsumed all erstwhile horticultural programmes.

Table 1.2 Area, Production & Productivity in Horticulture (2016-17)

SN	Crop category	2016-17 (3rd Estimate)		
		Area ('000 Ha)	Production ('000 tons)	Productivity (tons / Ha)
1.	Fruits	6457	93707	14.51
2.	Vegetables	10295	176177	17.11
3.	Flowers	328	2277	6.94
4.	Plantation crops	3659	18353	5.01
5.	Spices	3705	8202	2.21
6.	Aromatic	665	1042	1.56
7.	Honey	-	95	-
Totals		**25,109**	**299,853**	

The growth strategy under MIDH is raising of productivity by supporting high density plantations, protected cultivation, micro-irrigation, quality planting material, rejuvenation of senile orchards, and directing this productivity into income by bringing primary thrust on post-harvest management and marketing. Since most of the horticultural output is perishable in nature, the post-production facilitation and market linkage becomes most important. For this purpose, horticultural producing regions need to take up creation of PRAMs (Primary Rural Agri-Markets) on priority. The PRAM is detailed in DFI Volume IV.

1.3.1 Productivity status in horticulture

Though India is second largest producer of fruits and vegetables in the world, comparing the field productivity with different countries exhibits the scope that exists for improvement.

Table 1.3 Productivities of fruits and vegetables in different countries

Countries	Productivity (tonnes/ha)	
	Fruits	Vegetables
China	11.6	23.6
India	**11.6**	**17.6**
Brazil	16.5	19.0
USA	23.3	32.5
Italy	12.3	27.3
Spain	9.1	39.3
Mexico	12.7	19.9
Turkey	13.6	25.0
Others	9.7	13.7
World	11.3	19.7

- Among fruits, with the exception of banana and papaya, the average productivity is much lower (11.6) in India compared to many leading fruit producing countries U.S.A (23.3), Brazil (16.5), Turkey (13.6), Italy (12.3).
- In case of vegetables, the productivity in India is around 17.6 which is much below the productivity of several leading vegetable producing countries [Spain (39.3) U.S.A (32.5), Italy (27.3), Turkey (25.0), Mexico (19.9).

The productivity is measured on the basis of tons of output per unit of land. Within the country, there is large variation across the states, with large regional spread in productivity.

Table 1.4 Fruit crops productivity in different states

Productivity (t/ha)	States
25-30	Madhya Pradesh
20-25	Gujarat, Punjab, TN, UP
15-20	AP, Karnataka, Rajasthan
10-15	Assam, Bihar, Chhattisgarh, Haryana, Kerala, Maharashtra, Meghalaya, Nagaland, Telangana, Tripura,WB
< 10	Arunachal Pradesh, Delhi, Goa, HP, J&K, Jharkhand, Manipur, Mizoram, Odisha, Uttarakhand

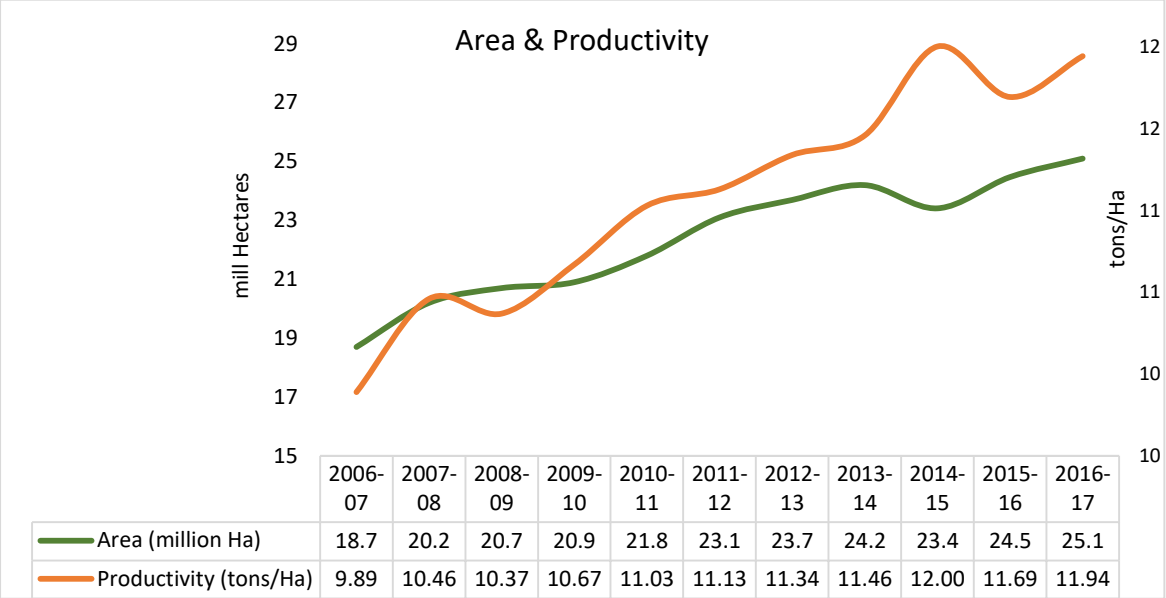
Table 1.5 Vegetable crops productivity in different states

Productivity (t/ha)	States
25-30	Tamil Nadu
20-25	Kerala, J&K, UP, Punjab
15-20	Karnataka, West Bengal, HP, AP, Gujarat, Bihar, Delhi, Jharkhand
10-15	Tripura, Odisha, Haryana, MP, Chhattisgarh, Maharashtra, Uttarakhand, Assam, Manipur, Goa
< 10	Arunachal Pradesh, Meghalaya, Nagaland, Mizoram, Rajasthan, Sikkim

Although the states of North Eastern Region have huge potential, the productivity as of now is low because of factors like lower entrepreneur interest which could be due to land ownership issues, lower credit off take and poor infrastructure in the region.

In the period of last five years, horticulture has witnessed higher yield-led growth for different fruits and vegetables. Overall, fruits and vegetables together registered a growth of 6.34 per cent in production and 4.7 per cent in area. However, the growth in productivity over the past decade was a meagre 1.57 per cent per annum.

Figure 1.4 Horticulture - Area & Productivity Trends



	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Area (million Ha)	18.7	20.2	20.7	20.9	21.8	23.1	23.7	24.2	23.4	24.5	25.1
Productivity (tons/Ha)	9.89	10.46	10.37	10.67	11.03	11.13	11.34	11.46	12.00	11.69	11.94

The cumulative production has grown 56 per cent over the last 10 years. The year-on-year trends continue to indicate growth, but show variations in growth rates which can be linked to weather as well to the associated development in cold-chain for perishable crops.

Table 1.6 Growth rates in Horticulture in last five years (2011-12 to 2015-16)

Crops	Area (A)	Production (P)	Yield (Y)	Remarks
Fruits	-1.14	4.59	5.83	P & Y led growth, negative A growth
Vegetables	1.59	1.61	0.02	A & P led growth
F&V	0.45	2.61	2.15	P & Y led growth
Flowers	-1.07	-2.57* (7.4**)	-	
Horticulture	0.53	2.44	1.76	P & Y led growth

Note: * loose flower, ** cut flower

The prime reasons for the low productivity are non-availability of quality planting material, dwindling status of natural resources, resource poor farmers and low adoption of modern technologies. The challenge is to enhance productivity by increasing the factor productivity of all the horticultural production inputs, and at the same time sustaining it by adoption of good practices and precision farming principles. As most horticultural produce is perishable, high output without the appropriate cold-chain connectivity results in higher losses and can dissuade production, despite high consumer demand.

Productivity gains in fruits has however been comparatively higher, where under, notwithstanding in many cases a reduction in area, the output has kept pace or has been higher.

Table 1.7 Growth rates in major fruits – 2011-12 to 2015-16

Fruit Crops	A	P	Y	Remarks
Apple	-0.62	6.85	7.70	P & Y led growth, negative A growth
Mango	-1.52	3.77	5.42	P & Y led growth, negative A growth
Banana	1.53	0.58	-0.99	A led growth, negative Y growth
Citrus	0.54	9.80	9.04	P & Y led growth
Grapes	1.06	3.99	2.88	A, P & Y led growth
Guava	3.67	12.67	8.67	A, P & Y led growth
Papaya	3.17	6.34	3.02	A, P & Y led growth
Litchi	2.57	0.82	-1.92	A led growth, negative Y growth
Pineapple	1.81	6.97	5.05	A, P & Y led growth
Sapota	-10.25	-2.55	8.60	Y led growth, negative A & P growth
Fruits	-1.14	4.59	5.83	P & Y led growth, negative A growth

A, P and Y stands for area, production and yield led growth

Table 1.8 Growth in major vegetables – 2011-12 to 2015-16

Vegetable Crops	A	P	Y	Remarks
Brinjal	-1.01	-0.16	0.81	Negative A growth
Tomato	-4.33	-0.34	4.11	Y led growth, negative A growth
Onion	3.03	4.64	1.52	A, P & Y led growth
Okra	-1.65	-3.15	-1.48	Negative A, P & Y growth
Potato	2.85	1.35	-1.53	A &P led growth, negative Y growth
Peas	5.04	6.48	1.33	A, P & Y led growth
Cabbage	-0.10	1.00	1.14	P & Y led growth
Cauliflower	2.18	2.77	0.53	A& P led growth
Sweet Potato	4.26	8.22	3.89	A, P & Y led growth
Tapioca	-2.60	-15.05	-12.82	Negative growth in A, P & Y
Vegetables	1.59	1.61	0.02	A&P led growth

A, P and Y stands for area, production and yield led growth

1.4 Challenges in horticulture

Even though, India has the highest productivity with respect to some horticultural crops like grape and banana, much needs to be done for rest of the horticultural crops, due to increasing urbanisation and industrialization the land resources available are shrinking day by day for agricultural related activities.

The capital output ratio, which is the amount of capital needed to produce one unit of output, is comparatively higher in case of horticulture. However, this also evidences much higher levels of output per unit of agricultural land. Occupying only about 14 per cent of agricultural land, horticulture contributes more than 33 per cent to the agricultural GVA.

In case of certain crops like guava, apples, etc., the first output or fruit is a few years after initial planting. However, in case of most horticultural crops, the sowing to harvest cycles are shorter and offer more frequent marketing opportunities. Horticultural crops have options in open field, protected cultivation and orchard based farming systems. Many other new farming technologies are focused on horticulture, such as vertical farming, hydroponics, aeroponics, etc. The main challenges facing those wishing to start work in horticulture sector are access to capital, technology and the initial learning curve to develop the required skills.

- High cost of inputs that burdens the farmers.
- Low benchmark productivity adds to unit cost of produce.
- Large scale prevalence of old and senile orchards impacts productivity. Majority of the orchards also have low planting density.
- Availability of quality seed and planting material impacts quality of produce.
- Poor tree canopy management.
- Rainfed cultivation, with majority of the horticultural cultivation having no access to irrigation.
- Initial cost constraints in adoption of improved technologies.
- Facilities for post-harvest management have not kept pace with production growth.
- Unorganised supply chain, not suitably integrated for managing perishable produce.
- Lack of appropriately trained extension services for horticulture.

Based on a filed survey, it is found that the major problems faced by horticulture farmers are finance, marketing, labour, storage, maintenance, education etc.

Table 1.9 Major Problems of the horticulture farmers

SN	Problems	Number and Percentage of respondents
1	Marketing	61(30.5%)
2	Labour	36 (18%)
3	Storage	30 (15%)
4	Finance	62 (31%)
5	Others	11 (5.5%)
6	**Total**	**200 (100%)**

Better market price realisation, is a factor of various issues and a necessary consideration to mitigate most of the above listed issues. In current scenario, the gap between demand and supply is largely due to ineffective market links, poor handling and lack of consolidation on both the demand-side and supply-side. On the supply-side, the government has the agenda to promote modern cultivation practices and collaborative farming. However, the logistics linkage

between cultivating zones and consumption zones is yet to find appropriate focus. Marketing of horticultural crops is a matter has great urgency if horticulture sector has to grow on a commercial basis.

The marketing is quite complex and risky due to the perishable nature of the produce, seasonal production and bulkiness. These features make the marketing system of fruits and vegetables to differ from other agricultural commodities, particularly in providing time, form and space utilities. In the case of peri-urban clusters, and where the product selling cycle is less than 48 hours (peri-urban supply), aggregation and staging platforms are to be developed at village level. The intention is to create nodal points where individual farmers can collect small loads so as to consolidate into viable truck loads. The total load size can be in the range of 2 to 10 tons depending on terrain and distance from urban centre.

Productivity Gaps-Extension is one of the indicators that highlight the role of extension in horticulture sector. It is related to the flow of new technical information and to the existing state of unadopted technology. Person-to-person communication has traditionally been the most important form of information transfer in horticulture sector. However, there is need to look at alternative ways as this approach is rather expensive and impracticable considering the number of farm holdings in the country. The lack of a close working relationship between national agricultural research and extension organizations, and with different categories of farmers and farm organizations, is one of the most difficult institutional problems. There is the need to move towards specialisation and new professionalism in horticulture advisory services.

Today, it would be difficult to imagine horticulture extension without modern information and communication technologies. Intensifying efforts of imparting of training to the farmers, unemployed youth, and officers of Govt. departments of horticulture using modern ICT tools and empowering farmers to organise themselves. Supporting KisanMelas, Agri-fest, farmer's fair and arrangement of the exhibitions of departmental activities. Frontline demonstrations of improved varieties and technologies of fruits and vegetable adaptive trials on farmer's fields, are to be conducted. Mobile advisory service/ ICT based/ e-extension based activities are to be strengthened. Virtual linkages are to be established for bringing research and extension together. Programmes like "virtual gardens" and "virtual farms" on the World-Wide-Web needs more encouragement. Horticulture in class room program for rural youth and farmers at their convenience should be a national program to pave way for integrated learning and discovery across disciplines, through active and engaging real-world experiences.

As the expectations with regard to extension personnel role are increasing, more robust non-traditional strategies be evolved. This include, but not limited to establishment of plant and pest diagnostic clinics in line with veterinary clinics where in staff can diagnose plant health problems caused by diseases, insects or the environment and offer the best course of action. Commodity Based Extension is another approach which can be implemented on cluster basis for strengthening the production of a particular commodity with commercial or export potential.

Extension as a Commercial Service is a rather recent phenomenon and is being offered by many private institutions which is picking up and needs to be promoted since, the idea of extension as a free public service is no longer being generally accepted. In the case of commercial input suppliers, the costs of extension are included in the product price, as are the costs for advertisement. Private extension services does not aim at substituting private sector for public extension service but complement the efforts of public sector involving private corporate firms, credit institutions, farmer's associations, non-governmental organizations and media organizations. Client-Based and Client-Controlled Extension is another concept in which extension work is done through farmers' associations it is to utilise the potential of local extension knowledge of and the self-help potential of rural groups. It can not only be effective but also cost saving. Interaction with the groups can also help in understanding their problems and finding suitable solutions.

Strengthening agricultural extension brings incredible opportunities and has the potential of enabling the empowerment of farming communities. Information technology can support better crop, fertilizer and pesticide use planning as well as disease monitoring and prevention, both in crops and animal husbandry, besides improving farmers' operational and financial management and to effectively connect them with the markets for better price realisation.

1.4.1 Thrust areas for horticulture development

- Cluster approach linked with post-harvest management and marketing
- Close gaps in post-harvest handling and integrated cold chains
- Market intelligence to promote market led production
- Quality seeds and planting material
- Capacity building programmes on latest technologies at farmers field
- Adoption of improved varieties and rejuvenation with improved cultivars
- Hi-tech horticulture and Precision farming
- High Density plantations
- Enhanced water use efficiency (micro-irrigation and fertigation)
- Horticulture based cropping system
- Protected cultivation and use of plastics in horticulture
- Mechanisation and semi-mechanised implements
- Extension on integrated nutrient management and plant health management
- Promotion of bee-keeping for effective crop pollination
- Promotion of mushroom cultivation for additional income
- Recycling of horticultural waste and Organic horticulture
- Enhanced ICT use to add efficiency to input management, knowledge transfer etc.

1.5 Annotation

Horticulture has emerged as a core sector of agriculture over the past decade, growing steadily in annual area coverage and output. In the year 2016-17, horticulture stood at nearly 25 million ha and production was at a record 299.8 million tonnes of which 269.9 million tonnes was in fruits and vegetables alone. The cultivation of horticultural crops, especially fruits and vegetables, plays a vital role in the prosperity of the farmers and is directly linked with the nutritional health of consumers. Fruits and vegetables are a rich source of vitamins, minerals, and carbohydrates and are referred to as protective foods and therefore assume great importance in the country's nutritional security.

The importance of horticulture can be corroborated with its benefits like high returns per unit area, high export value, higher productivity compared to other crops , best utilization of wasteland/undulating lands, source of raw materials for industries, whole engagement by a grower/labourer, production of more food energy per unit area than that of field crops, and women's empowerment by providing employment opportunities through processing, floriculture, seed production, mushroom cultivation, nursery activities, etc.

Key Extracts

- The technology led gains in the productivity of horticultural crops have given the farmers an opportunity to diversify from food and other crops to horticulture which are more remunerative.
- Assessment of land suitability and potential productivity has to be made in relation to certain production conditions.
- The impact of irrigation, better agronomic practices and improved varieties has been reflected very well in the robust growth of horticultural output.
- Horticulture sector has also demonstrated its resilience to drought by producing more.
- 6.5 lakh ha of additional area will be brought under horticulture crops through area expansion by 2022 and 1.75 lakh ha of additional area will be brought under protected cultivation by 2022.

Chapter 2
Horticulture - Sources of Growth in

The seven sources of growth in income, defined in DFI Volume-II, are discussed in context of horticulture. India has a wide range of agro-climatic zones that allow for all types of horticultural output all through the year, and this can be suitably exploited with post-production market linkage.

2.1 Interventions for income growth

The higher income opportunity for farmers, through horticulture, is buttressed by the fact that by the dietary patterns, which indicate that by volume, the bulk of the food consumed is vegetarian with animal foods occupying a small share of the consumers' plate. This is further supplemented with increasing demand for fresh vegetables and fruits. Trends in consumption indicate that the growth in demand in this sector will surpass all other agricultural sectors. However, the horticultural sector also faces the highest food loss between farm to fork, due to its relatively higher perishability and lack of suitable development in its market linked logistics.

India can boast of a wide variety of climatic systems, where temperature conditions range from cold, temperate, sub-temperate, tropical, sub-tropical and even equatorial conditions. In soil and humidity terms an variety of conditions are also categorised. The Planning Commission, for resource development reasons, divided the country in 1988 into fifteen agricultural zones based on agro-climatic features such as soil type, climate including temperature and rainfall and its variation, and water resources availability. The country was also divided into 127 agro-climatic sub-zones by the National Agricultural Research Project (NARP) of ICAR on the basis of agro-ecological conditions and cropping patterns. The country's climatic regions have also been classified broadly into 6 types ranging from arid to per-humid zones and 5 thermal efficiency types. It suffices to say, that there always exists a favourable condition for some form of horticultural cultivation in the country.

The sources of income growth in horticulture can be categorised as follows:

i. Increasing the output through higher productivity
ii. Increasing the output through area expansion.
iii. Resource use efficiency or savings in cost of production
iv. Increase in cropping intensity
v. Diversification towards high value crops within horticulture
vi. Improvement in the market access and marketing system
vii. Creation of near-farm occupations in post-harvest handling facilities

These aspects in relation these factors are discussed in following sections and chapters.

2.2 Key Interventions to improve productivity

2.2.1 Hybrid technology for high productivity and quality

The hybrid technology has capacity to revolutionise the production of vegetable crops and demand for hybrid seeds is continuously increasing. Hybrids of tomato, chilli, cucumber and muskmelon are being produced at several locations in the country. ICAR has so far recommended the cultivation of more than 50 hybrids. Besides, many hybrids of vegetable crops, developed and marketed by the private sector are also available to the farmers.

At present, the area under vegetable hybrids accounts for 10 per cent of the total area. Area under high yielding F_1 hybrids in important vegetable crops have been developed in tomato, cabbage and brinjal and the area under hybrid capsicum and chilli is on the increase. High production, earliness, superior quality, uniform produce and resistance to biotic and abiotic stresses are the main advantages of F_1 hybrids. Apart of adoption of hybrids in vegetables, papaya hybrids (Red Lady 786, Taiyung 1 &2) and tuberose (Prajwala) are very popular and has potential of diversification for enhancing the income.

Adoption of hybrid varieties can increase 1.5-3 times more yields which mean more income from increased output from same area.

Table 2.1 Comparison of Efficiency Measures (Hybrid vs. Local)

Vegetable	Net Return (Rs per Ha)		Extent of Income gain	Income per rupee of investment		Rate of Return (%)	
	Local	Hyb	Hyb	Local	Hyb	Local	Hyb
Cabbage	9000	50400	41400 (460)	1.43	2.86	143	286
Cauliflower	10500	64200	53700 (510)	1.53	3.34	153	334
Brinjal	10800	54000	43200 (400)	2.20	3.00	220	300
Tomato	30000	105000	75000 (250)	1.40	1.88	140	188
Cucumber	9000	39000	30000 (330)	1.60	1.87	160	187

Note: Figures in the parentheses indicate percentage (*Tuhin Narayan Roy et al, 2015*)

Table 2.2 Higher yield potential of tuberose, hybrid Arka Prajwal vs. local

Items	Local	A.Prajwal
Yield (kg/ha)	14,550	20,000
Cost of cultivation (Rs/ha)	4,56,689	5,62,265
Gross returns (Rs/ha)	7,85,700	12,99,857
Net returns (Rs/ha)	3,29,011	7,37,592
BCR	1.72	2.31

2.2.2 Rootstocks for production and profitability

Appropriately selected rootstocks have potential to modify the architecture of plants for efficient utilisation of resources. It can ameliorate the soil, enhance nutrient and water use. Therefore, rootstocks have become integrated in the production system of grapes, citrus, apple and many fruit crops for successful production. Citrus rootstock, *Rangpur lime* can adapt to water stress, calcareous soils and resist *Phytophthora*.

The use of rootstock in grape cultivation has gained popularity, and almost all newer vineyards are planted on stress tolerant rootstocks only. The popular rootstocks for grape are Dog ridge B-2/56 and 110R, which can sustain abiotic stresses like drought and soil salinity, and provide vigour of vine needed for production. In sapota, *Khirni (Maninkar hexandra)* has proved drought tolerant and productive in marginal soil.

Table 2.3 Propagation Method and Rootstock of Important Fruit Crops

Fruit Crop	Method of Propagation	Rootstocks Used
Apple	Grafting	Crab apple (seedling rootstock); M 27 (ultra-dwarf),M 9, M 26 (dwarf), MM106 (semi-dwarfing), MM111 (vigorous)
Citrus	T-budding	Rough lemon, Rangpur lemon, Pectinifera, Cleopatra mandarin, Sour orange, Poncirus trifoliata, Carrizo citrange, Dragon Fly, Severinia buxifolia
Grapes	Cutting, budding	Dogridge, 110 R, St. George, 1616, 1613, SO4, Teleki
Guava	lnarching, patch budding, wedge grafting	L-49, Pusa Srijan (dwarfing)
Mango	lnarching, wedge grafting, side grafting, veener grafting	Desi mango seedling, Vellaicollumban, Olour, Pahutan, Goa, Kurrukan (polyembryonic)
Peach	Grafting	Sharbati, Florda Guard
Pear	Grafting	Kainth (*Pyrus pashia*), Wild pear (*Pyrus serotine*), Quince

Genetically dwarf scion cultivars and rootstocks suit high density planting system for accommodating more plants, increasing output and income (see Tables below).

Table 2.4 Use of genetically dwarf cultivars

Crop	Genetically dwarf cultivars	Desirable features
Mango	Amrapali	Precocious and tend to bear regularly
Papaya	Pusa Nanha & Pusa dwarf	Dwarf and tend to bear at lower height
Banana	Dwarf Cavendish (AAA)	High yielding with dwarf stature
Sapota	PKM -1 & PKM-3	Columner tree shape Dwarf tree stature

Table 2.5 Use of dwarfing rootstock

Crop	Dwarfing rootstock
Ber	Zizyphus rotundifolia
Citrus	Thomasville, Cintrangequat, Feronia and *Severinia buxifolia*
Guava	P. pumilum, Chinese guava (P. friedrichsthalianum), Pusa Shirni
Mango	Villaikullumban

Root stock technology has capacity to double the production and even make it possible to grow fruit crops under stress conditions with drought hardy root stocks. Success story of grapes grown with root stocks and their impact analysis is given in following tables.

Table 2.6 Grapes root stock for production and profitability

Crop	Technological Intervention suggested	Present Productivity	Expected Productivity	Present Income (Gross)	Expected Income (Gross)
Grapes	Use of "Dogridge" root stock, training on Y- trellis, development of sub canes and use of growth regulators	9 to 10 t/ha	11 to 12 t/ha	Rs.2,70,000 to Rs. 300,000	Rs. 3,33,000 to Rs.3,60,000

Table 2.7 Economic impact due to adoption of root stock in grapes

Particular	Impact of Root Stock technology adoption							
	Domestic Sales		Export sales		Raisin making		For Wine making	
Due to	Root Stock	Own Root	RS	OR	RS	OR	RS	OR
Cost of cultivation (Rs/acre)	49292	52120	74456	85626	53736	56500	50728	52000
Change due to Root Stock (%)	-5.43		-13.04		-4.891		-2.45	
Yield (t/acre)	10.98	10.4	9.73	6.5	3.58	2.895	6.31	6.6
Change due to RS (%)	5.58		49.62		23.66		-4.39	
Price	18	18	41.5	35	77.85	64	33.6	30
Change due to RS (%)	0.000		18.57		21.63		12.000	
Average Gross return	197640	187200	403587	227500	278685	185280	212016	198000
Net return	148348	135080	329132	141874	224949	128780	161288	146000
Change due to RS (%)	9.82		131.99		74.68		10.47	

2.2.3 Quality planting material and seed production

There have been technological changes in seed production, techniques for production of hybrid seeds, using of cytoplasmic male sterile lines (CMS), technologies for vegetative methods of propagation, now in *vitro* propagation technologies- these are a success story in banana, potato and citrus. Knowledge has also improved about the diseases being transmitted through the vegetative propagation chain, and now diagnostic technologies are available for early detection. Enabling policies have also facilitated the availability of the best materials to the farmers.

Use of good quality seed and planting material is a prerequisite for the production of high yields. High quality seeds and planting material help to increase agricultural productivity; improve food security; lower money spent on food purchases and imports and raise domestic economic activity. The projected demand for nursery plants and seeds indicates demand for establishment of more number of accredited nurseries and seed & planting material production system.

Table 2.8 Projected demand of nursery plants of major fruit crops in India

Fruit Plant	Area '000 ha		Increase per annum (%)	Area under fruits projected ('000 ha after years)			Projected Demand of Nursery Plants	
	2006-07	2015-16		5 years 20-21	10 years 25-26	15 years 30-31	2025-26 (crore)	2030-31 (crore)
Apple	252	314	2.5	355	400	452	3.46	5.53
Citrus	798	970	2.2	1079	1201	1336	6.34	10.06
Grapes	65	122	8.8	186	283	430	35.69	68.48
Guava	176	248	4.1	303	370	453	3.36	5.62
Mango	2164	2243	0.4	2284	2326	2369	1.04	1.58
Papaya	72	124	7.2	176	249	353	38.59	70.65
Pomegranate	117	190	6.2	257	348	471	9.88	17.56

A total of 1256 High Yielding Varieties and hybrids of horticultural crops (fruits – 134, vegetables – 485, ornamental plants – 115, plantation and spices – 467, medicinal and aromatic plants – 50 and mushrooms – 5) were developed by Indian Council of Agricultural Science (ICAR). Additionally a large number of varieties and hybrids are being made available by private sector especially in vegetable and ornamental crops. Availability of quality planting material is a prerequisite for the success of horticultural development initiatives.

Role of nurseries in horticulture include production of genetically pure nursery stock, export of nursery stock and employment generation. A nursery is a place where plants are propagated and grown to usable size nurtured and sold out. The nursery provides employment to skilled and unskilled personnel. Creation, modernisation and accreditation of nurseries is supported under the Mission for Integrated Development of Horticulture.

Table 2.9 Estimated vegetable seed requirement and production in India

Crop	Seed Demand (tonnes)	Production from Organised sector (tonnes)	Production from Un-organised sector (tonnes)	Shortage (tonnes)
Tomato	360	190	80	90
Brinjal	465	85	50	330
Chilli	200	68	80	52
Cauliflower	260	130	35	115
Cucumber	70	37	20	13
Muskmelon	110	37	40	33
Watermelon	320	135	100	85
Bottle gourd	615	105	100	410
Onion	1,200	200	400	600
Okra	4,250	1,350	800	2,100
Radish	650	300	200	150
Carrot	700	200	250	250
Beat root	400	100	120	180
Peas	6,000	1,500	2,000	2,500
Cabbage	200	80	60	60

However, seed supply chains that address the production of nucleus, foundation and certified seeds are weak. Management of quality and health of plants needs upgradation, in order to ensure quality seeds and healthy planting material. Therefore, it is essential that the dynamics of technologies and policies are analysed in perspective to address the challenges of the future, because appropriate seeds and planting material hold the key to success in horticulture.

Various diagnostic methods for instance ELISA, Polymerase Chain Reaction (PCR), multiplex PCR, Real Time PCR are available for different viruses, bacteria and fungi. PCR-based diagnostic protocol has been developed for rapid detection of viruses and *Phytophthora* in citrus, banana, potato, coconut and tuber crops.

To improve the profitability from the nursery business, nursery clusters can be promoted in the lines of special economic zone (SEZ) the areas in which business and trade laws are different from rest of the country. They may be located in each of the state or agro climatic regions with an aim to increased planting / seed material production, increased investment, quality infrastructure, job creation and effective administration. These units can have common resources, including mother plant blocks. It is expected that this initiative will trigger a large flow of investment, infrastructure build-up and productive capacity, leading to generation of high quality planting material and lead to traceability of nursery plants which is the need of the time. Further, such units can boost mechanisation as large scale operations can be carried out involving machinery.

Nurseries operate in clean environments with very controlled and discriminate use of pesticides or fertilizers. Such units can be setup along rivers, as part of the initiative to clean the rivers, while keeping the more intensive agriculture activity away from proximity of river banks.

2.2.4 High density planting system

High density planting technology has been standardised for many crops and also adopted by many fruit growers in India. High density orchards have not only provided a higher yield and net economic returns per unit area in the initial years, but also facilitated more efficient use of inputs. It has become a success story in banana, pineapple, guava, papaya, mango and cashew.

Technologies for high density planting, canopy management and rejuvenation of old and senile orchards have been developed and successfully demonstrated at farmers' field. Coconut based high density multi-species cropping system helps to improve soil properties, realised higher and stable farm net income and generates additional employment. Technologies for meadow orcharding in guava are being adopted across the country for higher productivity.

In high density planting, the plants are spaced closer and in case of mango and guava, this has resulted in two and half times more yield than normal spacing.

Table 2.10 Potential technologies Suitable for High Density Planting

Crop	Technological Intervention suggested	Present Productivity	Expected Productivity	Present Income (Gross)	Expected Income (Gross)
Mango (Alphonso)	High density planting, vigour regulating root stock, application of growth retardants & canopy management	3 to 4 t/ha	8 to 9 t/ha	Rs.1,00,000 /ha/year	Rs.2,50,000 /ha/year
Guava Hybrid	Arak Kiran	7-8 t/ha	18-20 t/ha	Rs.50000	Rs.1.20 Lakhs

2.3 Hi-tech horticulture and precision farming

Precision farming calls for efficient resource use through location-specific interventions that encompass micro irrigation, fertigation, protected and greenhouse cultivation, soil and leaf nutrient based fertilizer management, mulching for *in situ* moisture conservation, micro propagation, biotechnology for germplasm, genetically modified crops, use of bio-fertilizers, vermiculture, high-density planting, hi-tech mechanisation, green food, soil-less culture, biological control, etc.

Precision farming application of fertilizers has proved to be profitable along with recommendations based on a package of practices. About 22 Precision Farming Development Centres (PFDC) have been established in different agro-climate regions. Some crops for which

the components of precision farming have been practiced are banana, grape, pomegranate, capsicum, tomato, chilli, cashew and selected flowers. The environmentally controlled structures like poly houses etc. play an important role to minimise the risk of vagaries of climate in adverse conditions and fetch higher return per unit area.

2.4 Protected cultivation

Protected cultivation is a good option for producing quality produce and efficient use of land and other resources in some horticultural crops. It is a cropping technique wherein the micro climate surrounding the plant body is controlled partially or fully as per the requirement of the species grown during their period of growth. Since there is a level of control over plant microclimate, vagaries of extreme weather conditions or climate related risk is minimum with the benefit of alleviating one or more of abiotic stresses for optimum plant growth. This results in crop yields several times higher than those under open field conditions. Efficient use of various inputs like water, fertilizer, seeds and plant protection chemicals helps to achieve 3-5 fold productivity gains. The partially controlled environment can extend the growing period. This adds opportunity for the farmer to supply demand when there is lower supply and capture high market prices.

Good agricultural practices under protected condition and integrated pest, water, nutrient, weed management, pollination, training of crops, harvesting practices, etc. are crop-specific and different than open field conditions. High value crops viz. tomato, coloured capsicums, parthenocarpic cucumber, flowers, strawberries can be successfully cultivated. The example of capsicum, cultivated in open and protected conditions is given in tables below.

Table 2.11 Comparative profitability of capsicum under open vs protected conditions

Capsicum	Open	Protected
Total Cost (Rs/acre)	38884	39455
Total returns (Rs/acre)	73982	154734
Net return	35098	115278
BC Ratio	1.9	3.92
Yield (t/acre)	3.39	5.55
Price Rs/kg	21.85	27.88

Table 2.12 Income earned by farmers from different enterprises under protected conditions

Particulars (n=56)	Unit size (m2)	Net income (Rs/annum)	
		Range	Average
Flower cultivation (carnation and roses)	500	40,000–303,030	164,040
Vegetable cultivation (coloured capsicum, tomato, cucumber)	500	50,000–350,000	117,763

Source: Choudhary A K 2016. Current Science, Vol. 111 (2): 276

Low cost technologies like low tunnels and walking tunnels are now being adopted for raising seedlings and off season vegetable production.

Usually it is mentioned that a key challenge in agriculture is small land holding. However, the example from concerted farming from small plots, as is the case in protected cultivation, shows that small plots can achieve much higher productivity gains. Large scale industrial farming from very large land holdings have shown to be detrimental to the environment, whereas focused attention on individual holding has the ability to enhance productivity while remaining ecologically friendly. Low cost structures are suitable for growing pesticide free green vegetables of high quality for long duration in peri-urban areas of the country to fetch commensurate price of produce.

Protected cultivation can provide near optimal climatic conditions by using different protected structures / methods / devices and increasing the productivity manifold. Protected cultivation is the most contemporary approach for production of crops which is highly productive, efficient and judicious use of water, land and other inputs like pesticides. The high value crops can also be grown round the year, including off-season fetching high market price resulting in increased profitability. Multi-storied vertical farms under protected conditions in the peri-urban areas are catching on in many developed countries, to meet their requirement of fresh produce.

Apart from fresh production, there is a tremendous demand to provide more and more true-to-type planting materials to the growers. So, more number of hi-tech nurseries under protected cultivation, with year-round propagation facilities are needed to generate the maximum number of planting material to cater for demand. Greenhouses technology can become an important tool for nursery business by achievement of better germination under low tunnels & better graft success rate under polyhouses / nethouses giving assured returns. Walk-in tunnels, due to their low initial cost are also suitable & effective to raise off-season nursery of horticultural crops.

Protected cultivation systems also present opportunities for other allied services at village level such as for repair and maintenance of infrastructure an equipment. However, there will be need for capacity building of extension functionaries so that they can assist and guide the horticulture farmers who wish to take up protected cultivation. Specific skills such as humidity control, fan control, managing of fan and pad systems, structural repairs and calibration of instruments are some of the areas that will need to be focused on. In this context, special training for extension functionaries is recommended.

2.5 Annotation

The higher income opportunity for farmers, through horticulture, is buttressed by the fact that by the dietary patterns, which indicate that by volume, the bulk of the food consumed is vegetarian with animal foods occupying a small share of the consumers' plate.

The hybrid technology has capacity to revolutionise the production of vegetable crops and demand for hybrid seeds is continuously increasing. The use of rootstock in grape cultivation

has gained popularity, and almost all newer vineyards are planted on stress tolerant rootstocks only. Use of good quality seed and planting material is a prerequisite for the production of high yields. High quality seeds and planting material help to increase horticultural productivity; improve food security; lower money spent on food purchases and imports and raise domestic economic activity.

Technologies for high density planting, canopy management and rejuvenation of old and senile orchards have been developed and successfully demonstrated at farmers' field. Precision farming application of fertilizers has proved to be profitable along with recommendations based on a package of practices. Protected cultivation is a good option for producing quality produce and efficient use of land and other resources in some horticultural crops.

Key Extracts

- The hybrid technology has capacity to revolutionise the production system especially in vegetable crops.
- Protected cultivation is a good option for producing quality produce and allows for efficient use of land.
- Precision farming calls for efficient resource use and requires greater initial hand-holding.
- High density planting has become a success story in several crops including but not limited to apple, banana, pineapple, guava, papaya, mango and cashew.
- Demand for Horticultural food items is expected to surpass others, and productivity enhancement will be essential to meet future demand.
- Increasing the share of farmer's land parcel under horticulture will contribute to enhanced income.

Chapter 3
Resource use efficiency or saving in cost of production

Horticulture is resource intensive in terms of inputs, effort, technology and care, during both cultivation and post-harvest phases of the venture. Resource use optimisation at every level takes on greater importance in case of horticultural crops and contribute to minimise costs as well as mitigate risks.

Logically, all enterprising farmers would try to maximise their returns from the farm by allocating resources in an efficient manner. This means allocating land, labour, water and other resources in an optimal manner, so as to minimise on cost, on a sustainable basis. But as resources (both qualitatively and quantitatively) and managerial efficiency of farmers vary widely, the net returns per unit of inputs used, also vary significantly from farm to farm. A farmer's access to technology, credit, market and other infrastructure and policy support, coupled with risk perception and risk management capacity under erratic weather and price situations would determine his resource use efficiency.

Moreover, a farmer knowingly or unknowingly may over-exploit land and water resources for maximising farm output in the short run, thereby resulting in soil and water degradation and rapid depletion of ground water, that in the long run poses a problem of sustainability of agriculture. Soil degradation, groundwater depletion and water pollution due to farmers' managerial inefficiency or otherwise, have a social cost, and the farmers who forego certain sustainable agricultural practices may also face a higher opportunity cost, consequentially.

In addition, from the point of view of the exchequer, the resource use inefficiency means that public investment, subsidies and credit for agriculture are not used effectively. Therefore, it is important to promote high resource use efficiency in the system, as reflected through changes in factor productivity/profitability over time, along with sustainable use of land and water resources and required policy interventions.

3.1 Water and nutrient use technology for high efficiency

Good water management using well designed systems is critical for sustaining production and quality of produce, especially in the case of horticultural crops. If water deficit is experienced at the active growth phase or fruit development stages it causes severe loss to production and quality. Therefore, a scheduling based on plant water balance in consonance with soil and climate is appropriate. Water has to be applied to the root zone to save the losses. Among various methods tried drip irrigation has proved successful in exhibiting high water productivity by saving irrigation water from 25 to 60 per cent in various orchard crops and vegetables with a 10 to 60 per cent increase in yield as compared to the conventional method of irrigation. It is one of the latest methods of irrigation which is becoming popular in areas with water scarcity and salt problems.

The impact of micro-irrigation on resource conservation (saving in input costs to the farmer) is estimated in the range of 20 to 40 per cent in case of horticultural crops and enhancement in

the productivity of fruits and vegetables in select states may be seen in Table 4.4 of Volume-II of the DFI Report.

Table 3.1 Water and fertilizer use efficiency in horticulture

SN	Plasticulture Applications	Water Saving (%)	Water Use Efficiency (%)	Fertilizer Use Efficiency
1	Drip Irrigation System	40-70	30-70	20-40
2	Sprinkle Irrigation System	30-50	35-60	30-40
3	Plastic Mulching	40-60	15-20	20-25
4	Greenhouse	60-85	20-25	30-35
5	Shade nets	30-40	30-50	Under Trial
6	Plastic Tunnel	40-50	20-30	-do-
7	Farm Pond Lined with Plastic Film	100	40-60	Not Applicable

Source: NCPAH, 2017

Table 3.2 Performance of fruits and vegetable crops under drip irrigation

SN	Crop	Yield. T/ha	Water applied, mm	Fixed cost, Rs.	WUE, Kg/ha Mm	B.C. Ratio
Fruit Crops						
1	Banana (2m x 2m)	3.9	1059	45000	37.32	4.49
2	Guava (5m x 5m)	37.70	206.0	30200	183.0	4.40
3	Pine apple	70.00	1085.0	84000	64.5	6.85
4	Mango (5m x 5m)	20.9	512.0	28210	54.42	7.01
5	Sapota (5m x 5m)	15.6	232.5	10929	6.71	3.55
Vegetable Crops						
6	Turmeric (Intercrop to Sapota) 0.5m x 0.25m	14.10	483.5	86674	29.16	2.25
7	Potato 0.3m x 0.5m	250.86	220.0	118320	114.02	1.75
8	Okra 0.6m x 0.3m	13.06	665.0	65666	19.64	1.77
9	Tomato (0.6m x 0.6m)	70.28	560.0	65000	125.5	6.79
10	Cabbage	106.68	400.0	95279	266.7	6.99

Fertigation has become the state of art technique in orchard crops and vegetables because nutrients can be applied to plants in the correct dosages and at the time appropriate for the specific stage of plant growth.

Fertigation requirement in fruits (mango, banana, grapes, papaya, and pomegranate, citrus and strawberry), vegetables (tomato, chillies, brinjal, okra, potato, muskmelon, cucumber), in case of ornamental crops (rose, carnation, gerbera) and for plantation crops (coconut, arecanut and coffee) have been standardised, to improve both the nutrient and water use efficiency from 120 to 290 per cent.

Table 3.3 Resource use efficiency with & without use of foliar nutrition in Banana

Particulars	With foliar nutrition		Without foliar nutrition	
	Main Crop	Ratoon Crop	Main Crop	Ratoon Crop
Total Cost	102572	88752	99250	85652
Yield (No. of bunches)	2437	1536	2437	1536
Total Yield	67017	42240	60925	38400
Gross Return	451367	264000	380781.25	230400
Net return (Rs.)	348795	175248	281531.25	144748
BCR	4.40	2.97	3.84	2.69

Table 3.4 Fertilizer Use Efficiency under Conventional Method and with Drip Irrigation

Crops	Practices	Yield (kg/ha)	Quantity of Nutrient Applied (kg/ha)			FUE (%)
			N	P	K	
Capsicum	Conventional	18,200	250	150	150	33.09
	Drip Irrigation	45,600				82.91
Tomato	Conventional	20,000	250	150	250	30.76
	Drip Irrigation	48,000				103.08
Potato	Conventional	18,600	120	240	120	38.75
	Drip Irrigation	28,950				60.31
Okra	Conventional	12,860	200	100	100	32.15
	Drip Irrigation	23,910				59.78
Cucumber	Conventional	37,100	150	75	75	123.67
	Drip Irrigation	44,700				149.00
Chilli	Conventional	1,990	120	80	80	6.78
	Drip Irrigation	2,740				9.78
Pea	Conventional	58,700	60	80	70	279.52
	Drip Irrigation	77,400				368.57

Low use of organic matter and non-replacement of depleted micro and secondary nutrients in the soil has consequences that lead to decreasing the soil fertility and makes farming unproductive. The proper use of knowledge on kinetics and co-kinetics of different nutrients being partitioned across different growth stages of a crop so that the growth stage wise nutrient demand is precisely determined, and accordingly type and source of nutrients is provided can go a long way in increasing the input use efficiency. This will also help maintain soil fertility. New dimension in providing the nutrient supply as per canopy size in time domain manner is possible by sensor based technology which will be soil and crop specific.

3.2 Mechanisation in horticulture

Efficient machinery helps in increasing production and productivity, besides enabling the farmers to raise a second crop or multi crop making the agriculture attractive and a way of life by becoming commercial instead of subsistence and makes Agriculture more profitable and attractive profession for rural youth. Most of the horticultural operations in India are done manually or with animal power. It is evident from, that more the availability of farm power, better the productivity. Several machines and tools have been developed to enhance the efficiency of farm operation. In fruit crops, tractor operated pit-hole digger and bucket excavators have been developed but farm level use has yet to occur. In the fruit nurseries mechanisation using media siever, media mixer and plastic bag filler has been achieved.

The cultivation of horticultural crops is labour intensive and it needs timely operations for maximising the production. The availability of the labours is reducing in the villages. The end to end mechanisation of the horticultural crops is required to be adopted. Vegetables and seed spices are short duration crops and need maximum labour. These are to be cultivated on ridges or raised beds for ease mechanisation. The crops cultivated in paired rows on raised beds can be irrigated efficiently by drip irrigation system.

For fruit crops high density planting and pruning are becoming popular for increase of production. It is possible to mechanise the high density fruit crops. Machineries are required for end to end mechanisation i.e. seed bed preparation, pit digging, nursery raising and transplanting, seed sowing, weeding, inter-culture, spraying and harvesting. Indian Institute of Horticultural Research has taken initiative in this direction and machineries for nursery raising, seed sowing, seedling transplanting, weeding, harvesting of fruit crops, pickle making, mushroom spawn production have been developed to address the problems of the farmers.

3.3 Bio-fertilizers

Among various inputs, fertilizers alone account for a significant amount of the total cost of production. The nutritional requirement of various horticultural crops in different agro-climatic zones has been worked out and successfully adopted by farmers. However, streamlining is required in the use of bio-fertilizers, VAM fungi, biological N fixers and other beneficial microbial agents for effective nutrient use efficiency.

Bio-fertilizers are microbial preparations containing living cells of different microorganisms which have the ability to mobilize plant nutrients in soil from unusable to usable form through biological process. They are environmental friendly and play significant role in crop production - previously, mainly used for field crops, but now-a-days also used for fruit crops. Bio-fertilizers are able to fix 20-200 kg N/ha/year, solubilize P in the range of 30-50 kg P2O5/ha/year and mobilises P, Zn, Fe, Mo to varying extent. Bio-fertilizers are used in live formulation of beneficial microorganism which on application to seed, root or soil, mobilise the availability of nutrients particularly by their biological activity and help to rebuild the lost microflora and in turn improve the general soil health.

Use of bio-fertilizer is increasing day by day, due to increase in the price of chemical fertilizers, its beneficial effect on soil health and crop production. There are several reports that the commercial yield in fruits and vegetables increased by 25-30 per cent and saved 50 per cent of inorganic fertilizers.

3.4 Nanotechnology

Nanotechnology is an interdisciplinary research field. In recent past efforts have been made to improve agricultural yield through exhaustive research in nanotechnology. The green revolution resulted in blind usage of pesticides and chemical fertilizers which caused loss of soil biodiversity and developed resistance against pathogens and pests as well.

Nanoparticle-mediated material delivery to plants and advanced biosensors for precision farming are possible only by nanoparticles or nanochips. Nano encapsulated conventional fertilizers, pesticides and herbicides helps in slow and sustained release of nutrients and agrochemicals resulting in precise dosage to the plants.

Nanotechnology based plant viral disease detection kits are also becoming popular and are useful in speedy and early detection of viral diseases. Modern nanotechnology based tools and techniques have the potential to address the various problems of conventional agriculture and can modernise this sector.

3.5 Plant health management system

There are several pests and diseases such as fruit fly, stem and fruit borer, bark, eating, leaf gall midge, aphids, mites and moths and diseases like scab, powdery mildew, leaf spot, brown spot, gummosis, canker causing serious damage to various horticultural crops. Among different pests, termites, rodents also cause considerable damage particularly in low rainfall areas. The chemical control measures for various pests and diseases have been worked out at various centres. But there if need for eco-friendly practices.

During the last two decades IPM has moved from a peripheral position to the central stage of horticultural production programmes. A variety of techniques have been developed and refined for controlling different insect pests.

Plant health management in horticultural crops involves not only pre-harvest but also posts harvest-health management strategies such as production of pest and disease-free planting materials, use of bio-inoculants and other growth enhancing soil amendments, indexing for major pathogens and certification of planting materials, seed plot technique and mother garden technique and other such measures. Disease forecasting models that are developed proved to be useful in determining the role of climate factors in disease appearance and progression and in devising a suitable management strategy.

Table 3.5 Existing technologies to boost production & productivity

Crop	Existing Technology with the institute	Expected Increase in yield with use of technology
Banana, Papaya Pomegranate,	IPM and Integrated Nematode Management package with biopesticides	+22%
Tomato	IPM of fruit borers and nematodes with biopesticides	+ 22%
Brinjal	IPM of fruit and shoot borers and nematodes with biopesticides	+ 25
Cabbage	IPM of DBM and nematodes with biopesticides	+ 20%
Mango	Mango micronutrient foliar formulation	+40%
	AM Fungi culture, Arka Microbial Consortium	+25%
	IPM for major pests (lure traps, crop sanitation, need based insecticide application)	+ 20%
	Arka Saka Nivarak (to control spongy tissue in Alphonso mango)	+60%
	Regular & synchronised flower inducer formulation	+60%
Gerbera & Carnations	IPM and INM under protected conditions	+ 24

3.6 Horticulture-based cropping systems

Normally cropping system refers to temporal and spatial arrangement of crops and management resources like soil, water and vegetation in order to optimise the biomass production per unit area, per unit time and per unit input. It is looked in as the management of systematic arrangement of crops as influenced by local factors of crop production.

Cropping system approach for sustainable use of farm resources and reduced risks has been successfully demonstrated in perennial horticulture. Various farming system models have been developed. Shade loving medicinal and aromatic crops like patchouli, rose, geranium, long pepper, *sarpandha*, *kacholam*, etc., are successfully grown under coconut and areca nut.

The elephant foot yam is widely grown as intercrops in litchi, coconut, banana orchards. Spices like black pepper, ginger, turmeric, vanilla, nutmeg, clove and some medicinal plants are ideal intercrops for coconut.

Horticulture based cropping system optimises use of the space and time and improves upon productivity from same piece of land. This has an income doubling impact for farmers. Since, the extent of suitable agricultural land is static or decreasing and demographic pressure has forced to consider the role of multiple cropping as a means to enhance agricultural production.

Horticulture based cropping systems may not only limited to the programmed rotational mono-culture but also the poly-culture cropping system conventionally practiced so that it involves integrating crops using space and labour more efficiently. In addition such a system helps in better utilization of environmental factors, greater yield stability in diverse environmental condition, conservation soil and other resources.

Agri-horticulture systems (i.e. integration of horticulture crops mostly fruit trees with the agricultural crops) or Horti-silviculture (i.e. integration of horticultural crops with forest crops) are recognised as an important agroforestry system for improving the productivity, reducing the risk in production with additional employment generation.

Intensive horticultural systems are often based on optimizing the productivity of single crop on the other hand; multispecies cropping systems may often be considered as a practical application of ecological principles based on biodiversity, plant interactions and other natural regulatory mechanisms. With this farmers can maximise water use efficiency, maintain soil fertility, and minimise soil erosion, which are the serious drawbacks of mono-cropping In this direction, research has yielded design patterns in time and space that would maximise crop production.

The essence of this concept is in the application of space and time utilisation techniques, by merging the concepts of intercropping, multi-layer cropping, relay cropping, off-season cultivation and crop regulation to increase productivity of the same piece of land with more crops throughout the year rather than the single crop.

Fruits and plantation crops are perennial in nature and long pre-bearing period and majority of the crops have wider spacing and are tall growing. Canopy cover in these crops is very slow, and take longer time more over 60-70 per cent inter space is not effectively utilised. Crop geometry and rooting pattern among perennials, semi perennials and annual crops could be compatible without any adverse effects.

Some of the crops are shade loving and tolerance to high humidity (Banana, Cocoa, Turmeric, Ginger, Pineapple and Pepper) allowing them to be intercropped with fruit trees and plantation crops, additionally some crops encompass different harvesting time and period which facilitates for sustainable income.

There are several Tools to evaluate the performance of the multi-cropping system. This includes, Multiple Cropping Index or Multiple Cropping Intensity (MCI), Cultivated Land Utilization Index (CLUI), Crop Intensity Index (CII), Land Equivalent Ratio (LER), Relative Yields Total (RYT) and Area Harvest Equivalency Ratio (AHER). The horticulture based multi-cropping systems not only give additional return to the farm families but also generate additional working days for rural youths in a sustainable manner.

Table 3.6 Successful models of multi-cropping in horticulture based cropping systems

Cropping system/sequence	Place of report	Remarkable outcome of the system	Reference
Coconut + Cocoa + Banana + Moringa + Pineapple	AICRP, Aliyarnagar	This cropping system with 75 % NPK + organic recycling with vermicompost recorded highest nut yield of 182 per palm and highest net income (Rs. 3.80 lakhs per ha) and B:C ratio (2.71).	Nimbolkar et al. (2016)
Coconut + cocoa + lime + banana + drumstick	AICRP, Arasikere	With all physical and chemical quality of coconut, this system recorded net income of Rs. 2, 94,810 per hectare compared to mono crop (Rs. 68,200/ha).	Roy et al. (2001)
In an area of 1 ha 150 coconut (7.5 X 7.5 m) + black pepper (1.25 m away from coconut base –150 vines) + cocoa (2.5 m between 2 rows of coconut – 525 plants) + pineapple (1-2 m in the rows, two rows of pineapple-4900 plants)	Coastal region of southern state of India	This model recorded higher yield of coconut (20%) and net returns compared to mono cropping of coconut, besides enhancing soil fertility due to recycling of byproducts. Khan and	Krishnakumar (2002)
Mango+ cowpea+ Indian mustard	IARI, New Delhi	This system recorded significantly highest values of system productivity, gross returns, net returns and benefit: cost ratio during both the crop seasons.	Mirjha and Rana (2016)
Mango + Phaseolus acutifolius cv, "Frijol Escumite" + Cajanus cajan (Pigeon Pea)	Mango orchards in the Soconusco, Chiapas, Mexico	The biomass of Cajanus cajan and Phaseolus acutifolius (Frijol Escumite) and their incorporation to the ecosystem produced positive effects on the quality and yield of mango. Likewise the intercropping of mango with Cajanus cajan or Phaseolus vulgaris influences the insect diversity in these systems.	Agreda et al. (2006)

Cropping system/sequence	Place of report	Remarkable outcome of the system	Reference
Mango+ mandarin / Egyptian clover + date palm . -	Madhya Pradesh	Could be used for the higher net return per unit area and also to combat desertification in sandy soil in arid lands regions.	Abouziena et al. (2010)
Mango+ cowpea (Kharif) + bengal gram (Rabi)/ Mango+ pigeon pea + tomato	Madhya Pradesh	Maximum monetary returns.	Baghel et al. (2003)
Coconut + Black pepper + Banana + Elephant Foot Yam	East Coast Region of Tamil Nadu	This system considered as the most suitable intercropping system in coconut based on the feasibility, marketability, soil health and economic viability.	Thivruvarssan et al. (2014)
(Aonla+ ber + cluster bean+ fennel), (Aonla + bael + cluster bean + Coriander), (Aonla + khejri + cluster bean + ajowain)	Arid regions of Rajasthan	These systems were reported as sustainable and remunerative under the arid ecosystem	Hare Krishan et al. (2013
(Aonla + ber + karonda + cluster bean + brinjal), (Aonla + ber + karonda + mothbean [Vigna acontifolia Jacq. Marechal] + indian mustard (Brassica juncea (L) Czernj & Cosso)	Arid regions of Rajasthan	Plant height, number of branches/plant, fruits/plant and yield was found to be superior in these multispecies cropping systems as compared to sole cropping.	Arya et al. (2010)

3.7 Productivity and economic evaluation of horticulture based systems

ICAR-IAFSR, Modipuram evaluated three modules, viz. fruit based (0.3 ha), vegetable crops based (0.22 ha) and field crop based (0.4 ha) were for improving profitability, enhancing productivity and nutritional security of small and marginal farmers particularly of western plain zone of Uttar Pradesh. Under fruit crop based model, mango, guava and banana were grown as the main crops whereas cucumber, radish, carrot and onion as the intercrop in mango; brinjal, veg pea and okra as intercrops in guava and turmeric as intercrop in banana respectively.

In vegetable based model turmeric, bottlegourd cauliflower-tomato and brinjal-potato were grown while under crop based system, rice-wheat and sugarcane ratoon were evaluated. It was raveled that field crop based models recorded the highest net returns worth Rs. 263,912 ha-1

followed by fruit based with net returns of Rs. 224,928 ha-1. Among the vegetables, the maximum net returns of Rs. 202,657 ha-1 was recorded for cucumber- radish-carrot-onion system followed by turmeric alone (Rs. 147,780 ha-1) and brinjal-potato-beans system (Rs. 68,035 ha-1). The highest net return was recorded for radish (Rs. 107,781 ha-1) followed by turmeric (Rs. 87,014 ha-1), carrot (Rs. 53,375 ha-1) and okra (Rs. 42,557 ha-1).
The highest economic efficiency of Rs. 617.93 ha-1 day-1 was recorded for fruit based model followed by vegetable based (Rs. 565.51 ha-1 day-1). Economic efficiency was more for fruit based model than field crop based but the production efficiency was more for crop based than the fruit based and vegetable based, respectively.

Table 3.7 Integrated farming models and economics per hectare

Component	Employment Generation (man days)	Total Expenditure (Rs.)	Net Returns (Rs.)	Returns/Rs. Invested (Rs.)
Field crops	98.2	3,315	5,638	2.70
Multi-storeyed cropping	87.0	3,831	9,089	3.37
Pomology	18.4	900	1,466	2.63
Olericulture	96.4	3,812	8,302	3.18
Floriculture	4.0	125	100	1.80
Pisciculture	31.0	3,722	16,603	5.46
Poultry	23.0	9,240	981	1.11
Duckery	23.0	5,387	713	1.13
Mushroom	180.0	18,181	12,856	1.70
Apiary	1.0	170	1,180	7.94
Biogas	11.0	600	1,431	3.38
Total	573.0	49,286	58,360	2.18

3.8 Integrated Farming System:

(i) **Promotion of Integrated farming system approach** involving synergic blending of crops, horticulture, dairy, fisheries, poultry, etc. seems viable option to provide regular income and at site employment to small land holder, decreasing cultivation cost through multiple use of resources and providing much needed resilience for predicted climate change scenario.

(ii) **Dairy husbandry is a boon for small farmers**, as a family with three cows or buffaloes can earn an annual income of Rs. 50,000 to 60,000, while conserving our precious native breeds. With stall-fed, high yielding animals, the dung availability will increase by 3 to 4 times, giving a boost to biogas and agricultural production. With introduction of good goat husbandry practices by appointing local youth to facilitate the activities as Field Guides, 35 million goat keepers in the country who are living below the poverty

line, can enhance their income by four folds from Rs. 8000 to 35,000 per annum (BAIF's experience in Jharkhand, Odisha and Rajasthan).

(iii) **Promotion of intensive vegetable production** using improved varieties, organic manure and drip irrigation, can provide five times higher annual income, to the tune of Rs. 2 lakhs per acre (BAIF's experience in Andhra Pradesh, Karnataka and Maharashtra). Farmers in semi-arid areas with 2-3 cows or 8-10 goats and cultivating dual purpose foodgrain crops on 0.4 ha land, have been earning Rs. 60,000 – 75,000 per annum. With efficient watershed development, land use planning and selecting of suitable crops, the income of the farmers can go up by 80-100 per cent to generate an annual income of Rs. 40,000 to Rs. 60,000.

3.9 Increase in cropping intensity

The net sown area of the country has not increased much since independence, and at 140±1 million hectares has reached a point of stagnation. Thus, raising the cropping intensity is the only viable option left. Cropping intensity refers to the number of crops raised from the same field during one agricultural year. This ratio of the cumulative or gross sown area to the net physical area is also a measure of productive use of land.

At present the cropping intensity in agriculture as a whole is 138.9 per cent, and segregated statistic is not available for horticultural crops. Any increase in the intensity would add to the production from farms accordingly.

Higher cropping intensity is made possible with various measures, primarily irrigation that enables raising of crops during the dry season; use of fertilizers, to regain the lost nutrients; crop rotation, in which is the suitable selection of successive crops is made in such a way that the different crops draw nutrients in different proportions or from different strata; mixed cropping; relay cropping, simultaneous sowing of different crops with different development periods in the same field and harvesting them in a staggered manner, etc.

Table 3.8 Recommended intercrops for different horticultural crops

Crop	Age	Intercrop
Mango	Upto 7 years	Leguminous vegetables, Papaya (filler)
Grapes	Upto 8 months	Snake gourd or bitter gourd in pandal
Apple, pears	Upto 5 years	Potato, Cabbage
Banana	Upto 4 months	Sunhemp, onion
Tapioca	Upto 3 months	Onion, beans, lab-lab, black gram
Turmeric	Upto 3 months	Small onion, coriander
Arecanut	Upto 10 years	Pineapple
Coconut	Upto 3 years	Banana, tapioca, vegetables

In perennial horticultural crops, the brown space available in the pre-bearing age of the orchard can be effectively utilised to grow short duration crops to gain higher income. Many horticultural crops are amenable for intercropping or for interspaced planting and cultivation. Mechanical tools, tiller tractors, sowing gadgets, etc. can save critical time between crops thus enabling use of short duration crops or fast maturing varieties.

Table 3.9 Costs and returns from intercrops of mango per hectare

SN	Particulars	2nd year (in Rs)	3rd year (in Rs)	4th year (in Rs)
1	Total costs	25,599	25,367	24,075
2	Gross income	36,400	31,200	28,600
3	Net income	10,801	5,832	4,525

Table 3.10 Yield and economics of gardens (Rs/Ha, average of two years)

Crop	Yield (t/ha of Areca garden)	Cost of production	Gross return	Net Return	B:C ratio
Radish	9.2	6,850	27,675	20,825	4.05
Knolkhol	4.2	7,350	14,735	7,385	2.00
Cabbage	21.4	9,150	42,750	33,600	4.68
Cauliflower	9.5	8,950	38,000	29,050	4.24
Tomato	6.6	12,713	32,750	20,037	2.57
Potato	5.9	12,765	28,925	16,160	2.26
Brinjal	10.2	8,045	40,600	32,555	5.05
Gladiolus	17938* 34638**	68,850	123,089	54,239	1.78
Chrysanthemum	6	12,300	29,850	17,550	2.43
Marigold	4.5	10,950	22,425	11,475	2.05

Note; * number of spikes, ** number of corms *(Ray et al, 2007a)*

3.10 Interventions for high cropping intensity

Irrigation: Irrigation has played an important role in raising the cropping intensity in northern states where it has risen considerably. Irrigation helps raise the cropping intensity by enabling raising, of crops during the dry season also.

Fertilizers: The need to leave the land fallow for some period to regain the lost nutrients can be dispensed with by using fertilisers and following some other suitable cropping practices.

Crop Rotation: It is the suitable arrangement of successive crops in such a way that the different crops draw nutrients in different proportions or from different strata. For instance, if

legumes (pulses, gram, etc.) or certain oilseeds are sown just before the cereals, they fix the atmospheric nitrogen in soil, which can be absorbed by the cereals.

Mixed Cropping: It refers to the practice of growing certain perennial crops in the alley spaces of the main perennial crops. The main advantage is the effective utilisation of available area and increase in the net income of the farm per unit area. Extensive research conducted by CPCRI, Kassargode on mixed cropping in coconut and arecanut plantations showed that cocoa, pepper, cinnamon, clove and nutmeg can be grown as mixed crops in coconuts while nutmeg and clove as mixed crops in between four arecanut palms on alternate rows. In all the above cases, increase in yield (upto 10 per cent) is obtained in the main crop due to the synergistic effect of the crop combinations arising out of beneficial microorganisms in the rhizosphere and the more availability of major nutrients in the active root zone of the crop mix as compared to the pure stand.

Relay Cropping: This means simultaneous sowing of different crops with different nurturing periods in the same field and harvesting them one after the other. For instance, highly fertilizer-intensive crops like sugarcane and tobacco can be followed by cereals, in order to utilise the residual nutrients.

Selective Mechanisation: Use of tractors, tillers, threshers, etc. can save critical time between raising two crops, thus enabling the sowing of more than one crop.

Use of Fast Maturing Varieties: These varieties can enable growing of more than one -crop within one growing season.

Appropriate Plant Protection: These measures include the use of pesticides and insecticides, seed treatment, weed control, rodent control measures, etc. These measures are effective when all the farmers in an area take these up collectively.

Multi-tier system of cropping: Multi-tier system of cropping involves raising companion of crops compatible with the morphological frames and rooting habits, grown together in such a manner that their canopies intercept solar energy at varying heights and their roots forage the soil at different zones. The main principle here is that the land, water and sunlight should be effectively used.

Certain horticultural plants like coconut and arecanut are grown for about 50 years in a particular land. It takes nearly 4 to 7 years for the above trees to reach the bearing stage. Adequate alley spaces (nearly 75 per cent) are available in between these trees and being the palm trees, their root system will not also spread beyond one metre in diameter. These vacant spaces can be profitably used for raising other crops, thereby increasing the employment opportunities and profit. An ideal combination of crops for multitier cropping in coconut and areca nut plantations is as follows.

Table 3.11 Multi-tier cropping in coconut and arecanut

Tier	Crop
First (Top)	Coconut or arecanut
Second	Pepper trained over the trunk of coconut or arecanut trees
Third	Cocoa or cloves planted at the centre of four arecanut or coconut
Fourth (ground)	Pineapple, ginger and dwarf coffee

Therefore, these measures should be promoted on an institutional basis. Also, substantial improvement in yield can be attained through soil improvement measures, such as land levelling, sloping, contour bunding, terracing, removal of salinity and alkalinity, etc.

Table 3.12 Average Rice Equivalent Yields (REY) and income generated by various components from their area (during 2007-08 to 2013-14)

Component	Area (Ha)	Rice equivalent Yield (t/ha)	Gross Income Rs.	Expenditure Rs.	Net Income Rs.	B:C Ratio
Rice-Wheat	0.2	11.1	49075	18850	30225	2.6
Rice-Wheat-Moong	0.2	12.2	54145	19630	34515	2.8
Maize-Wheat-Moong	0.2	7.0	31135	11700	19435	2.7
Winter Maize – Soyabean	0.2	3.7	16250	6435	9815	2.5
Pigeon Pea – Mustard - Maize	0.2	4.3	19175	8710	10465	2.2
Fodder	0.2	4.4	19305	6695	12610	2.9
Vegetables	0.2	6.4	28210	14625	13585	1.9
Fruit trees	0.2	6.6	29315	7020	22295	4.2
Livestocks	0.2	67.7	299130	134550	164580	2.2
Fisheries	0.2	9.3	41015	9945	31070	4.1
Enterprise Mix Diversification	2	13.3	586755	238160	348595	2.5
Rice- Wheat System on 2 ha basis	2	-	490750	188500	302250	

Source: CSSRI, Karnal

3.11 Post-harvest technology and processing

There remains a considerable gap between the gross production and net availability of fruits and vegetables due to heavy post-harvest losses in case of horticultural produce. Therefore, in order to achieve our target of feeding the population with high nutrition food, as well as meeting other requirements of the processing including and export, only increasing the production and productivity will not only be enough.

When we look at the causes for Post-Harvest Losses, the losses generally originate at the field itself. The pre-harvest factors include varietal or genotypic, abiotic factors (temperature, light, wind, salinity, hail damage, physiological disorders), biotic factors (insect infestation, diseases, etc.), inappropriate and/or negligence in intercultural operations, maturity stages (if not harvested at correct stage of maturity as per requirement of target market and consumer), method (mechanical/manual) and time of harvest (morning/evening, immediately after rainfall or heavy irrigation).

Mechanical damage during harvesting and post-harvest handling are added cause for loss. As the produce in question is highly perishable due to the presence of excess moisture and plant metabolites, if care is not taken in their harvesting, handling and pack house operations, i.e. sorting, grading, post-harvest treatments where needed (like wax coating, application of antimicrobial agents) packaging pre-cooling, transport and storage, they readily start to show unmarketable symptoms like desiccation, shrinkage, discoloration, spoilage and become unfit for consumption. The pre-cooling phase, after initial sorting and packaging is critical as this removes initial field heat and reduces subsequent respiratory heat load. Once, packaged and precooled, the produce is then not directly handled and the package is moved to next level market connections.

It is estimated that India incurs post-harvest fruits and vegetable losses worth over two lakh cores each year largely owing to the absence of modern cold storage facilities and lack of proper food processing units. As per available latest estimates, India has created around 6,700 cold storage facilities, with a capacity of about 34 million tonnes. The existing cold storage capacity is confined mostly for certain crop types and not integrated with other requirements. The majority of fruit and vegetables are therefore sold at local or regional markets as they do not have cold chain facility. There is a large requirement of pack houses (70,080), reefer vehicles (61,826), ripening chambers (9,131) and onion storage units (280,241).

The Indian consumer has demonstrated a preference for fresh fruits and vegetables, and in this sector this is reflected in the low ratio of fresh to processed fruits and vegetables. This actually provides a long term growth opportunity to horticulture farmers, provide they are able to connect with the markets.

More emphasis needs to be given to post-harvest management of fruits and vegetables. In order to make horticulture a viable enterprise, the time at hand to capture value is critical. Harvest indices, grading, packaging, storage techniques have been developed and standardised for major horticultural crops. The use of integrated cold-chain, permits extra time to communicate the produce to multiple markets, as well to buffer the supply. Therefore, the cold-chain is seen as a value adding activity as it allows farmers to capture greater value.

Use of certain specialised packaging such as breathable polymers also allow to extend post-harvest life, of fruits and vegetables when used in tandem with cold-chain. However, post-

harvest market connectivity is the biggest income enabler in case of perishables. Volume 3 of the DFI Reports enumerate on the logistics systems needed for perishable produce.

On the other hand, consumption patterns have also drifted towards more convenient foods, such as potato chips, ketchup, frozen peas, etc. In such cases, a specific segment of horticultural crops, where value addition is carried out on the produce itself, are cultivated for the processors. However, the value addition is in the hands of processing industry, where the farmer is the supplier of the raw materials. In these cases, many farmers have vertically integrated with the processing industrialists to cultivate crops of processing variety.
Some produce is also amenable to dehydration including freeze drying, sun drying, juices and fermented products are also developed. In such cases, farmers have option to divert the non-marketable produce types, which can be pulped, juiced, pickled, etc. to the processors.

Small and cottage industry in food processing are also part of this market option. In case of red chilies, turmeric, ginger, cardamom and similar, the farmers can themselves undertake sun drying or local grinding and packaging as par to value addition. However, all these are variations of preparing the produce for the consumer, and subsequently, effective marketing system remains key for post-harvest productivity.

3.12 Annotation

Good water management using well designed systems is critical for sustaining production and quality of produce, especially in the case of horticultural crops. If water deficit is experienced at the active growth phase or fruit development stages it causes severe loss to production and quality.

The cultivation of horticultural crops is labour intensive and it needs timely operations for maximising the production. The availability of the labours is reducing in the villages. The end to end mechanisation of the horticultural crops is required to be adopted.

Bio-fertilizers are microbial preparations containing living cells of different microorganisms which have the ability to mobilise plant nutrients in soil from unusable to usable form through biological process. Nano encapsulated conventional fertilizers, pesticides and herbicides helps in slow and sustained release of nutrients and agrochemicals resulting in precise dosage to the plants.

Plant health management in horticultural crops involves not only pre-harvest but also posts harvest-health management strategies such as production of pest and disease-free planting materials, use of bio-inoculants and other growth enhancing soil amendments, indexing for major pathogens and certification of planting materials, seed plot technique and mother garden technique and other such measures.

Horticulture based cropping system optimises use of the space and time and improves upon productivity from same piece of land. This has an income doubling impact for farmers.

Promotion of Integrated farming system approach involving synergic blending of crops, horticulture, dairy, fisheries, poultry, etc. seems viable option to provide regular income and at site employment to small land holder, decreasing cultivation cost through multiple use of resources and providing much needed resilience for predicted climate change scenario.

Key Extracts

- There remains a considerable gap between the gross production and net availability of fruits and vegetables due to heavy post-harvest losses.
- Technological interventions for high cropping intensity are available and proven in the field level.
- In perennial horticultural crops, the brown space available in the pre-bearing age of the orchard can be effectively utilised to grow short duration crops.
- Good water management using well designed systems is critical for sustaining production and quality of produce.
- Post-harvest handling systems need to be developed in pace with growth in production to avoid losses because of poor handling and lack of market connectivity.

Chapter 4
Horticulture Plus

Horticulture is considered as high value agriculture. However, within the horticultural sector, there are specific crops that can be considered as "Horticulture Plus". This category comprises crops that have higher demand and hence offer higher value to farmers. Therefore, there also exist options, within the horticultural ecosystem, to strategically diversify into the horticulture plus category of crops.

4.1 Diversification to higher value

At the juncture when focus is being directed more towards remunerative crops and export potential crops fruit and vegetable cultivation among horticultural activates are no doubt pays higher dividends per unit area to farmers compared to most of the field crops, the other sub-sectors of horticulture like floriculture, spice and medicinal plant cultivation are emerging as more profitable ventures. Growing demand both in domestic as well as international markets due to ecstatic affordability, change in life-styles, social values, increase in the number of IT Units, Hotels, Tourists, and Temples, more over the greater awareness among the people to improve the deteriorating environment of the people and much higher return per unit of land than any other agricultural activity has nudged farmers to take-up floriculture.

Horticulture is considered high value agriculture, and many farmers view horticultural farming as crop diversification. Diversification of cropping systems into high value commodities is important to make the transition from subsistence to market-oriented agriculture, with the concomitant improvement in income. Most high value agricultural crops are those known to have a higher net return per hectare of land than other widely grown crops.

Horticultural produce has higher demand and fetch better value in the domestic as well as in the global market. This trend is expected to continue due to rising affluence leading to greater affordability and consumers becoming more health conscious. The scope for diversification into horticultural crops is high within the country, due to the range of agro climatic conditions, land use and economic returns. Diversification into horticulture should also help to meet domestic nutritional requirements besides raising economic status of the people. Intercropping fruit trees with short duration crops like vegetables, spice crops, pulses can help in gaining some income in the initial non-productive years as well as in doubling the income of the farmers during later productive years apart from improving the nutrient content of the soil wherever leguminous crops are used for intercropping. Wherever shading effect is a hindrance, shade loving plants like ginger, turmeric, etc. can be grown. Exploitation of wild fruits for production of the value added products of apricot, seabuckthorn, wild pomegranate and mulberry fruits which are rich sources of vitamins, minerals and essential fatty acids is also required.

Within horticulture itself, there are crops that offer higher value - categorised as Horticulture-Plus, these include flowers, cashew, cocoa, mushrooms, aromatics, etc. In many cases of horticulture-plus crops, there is option to effect vertical coordination with the retailers, such that supply is in relative balance with demand.

4.2 Floriculture

Floriculture is an age old farming activity in India and has emerged as an important agribusiness with immense potential for generating self-employment and entrepreneurship among small and marginal farmers in both urban and rural areas. Floriculture is increasingly regarded as a viable diversification from the traditional field crops because of higher returns per unit area and the increasing habit of "saying it with flowers" during all the occasions. Floriculture is a multifaceted enterprise in India. Floriculture sub-sector which includes cut flowers, loose flowers, bedding plants, potted plants, hedges, value added products, etc. has made appreciable growth in the last two decades as a commercial venture.

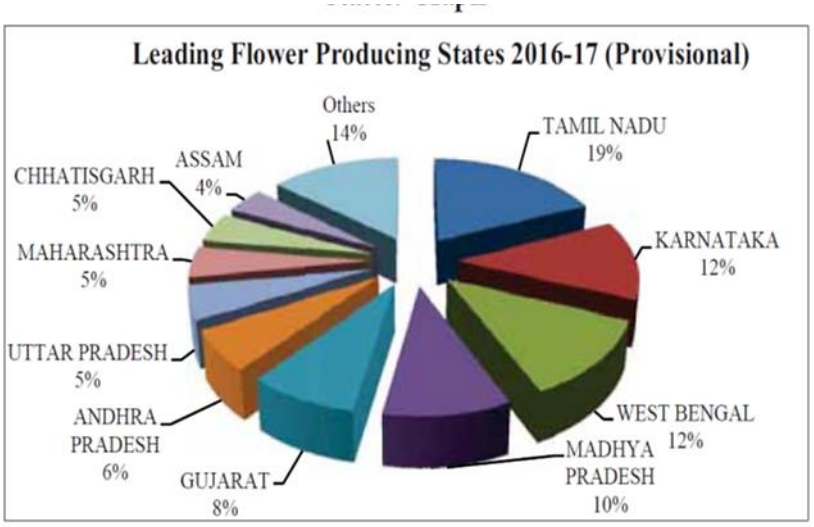
Globally more than 145 countries are involved in floriculture industry and the global floriculture trade is estimated to be at US$ 70 billion at present (ICAR Vision 2050).The area under floriculture is steadily increasing in the recent past. It was 2.49 lakh hectares in 2014-15 to 2.78 lakh hectares in 2015-16, to 3.09 lakh hectares during 2016-17. Similarly, the production of both loose and cut flowers saw a leap from mere 21.43 lakh tons in 2014-15 22.46 lakh tons in 2016-17, the percentage of cut flower to loose flowers ranged from 29 to 35 in different years. The available figures indicate that the share of floriculture is meagre 1.4 to 1.5 per cent of agriculture output valued at 18,000 crores, although the fruits and vegetables contribute to 23 per cent with 3,70,500 crores in the year 2013-14, indicating the ample scope for increasing the activities under floriculture.

Commercial floriculture has been steadily increasing with increased use of protected cultivation employing greenhouse, shade nets, polyhouse etc. Commercial flowers cultivation in India provides an opportunity for rural development owing to its higher returns per unit area and the new employment opportunities. Greenhouse technology started only during 1980 and total area covered under protected cultivation in our country is approximately 30,000 hectares as of 2014 for horticulture as a whole and that of floriculture is insignificant.

Government of India has identified floriculture as a sunrise industry and accorded it 100 per cent export oriented status. In addition the new seed policy had already made it feasible to import planting material of international varieties. It is well established that commercial floriculture has higher potential per unit area than most of the field crops and is therefore a lucrative business. Indian floriculture industry has been shifting from traditional flowers to cut flowers for export purposes. The country has exported 22,086.10 MT of floriculture products to the world for the worth of Rs. 548.74 crores in 2016-17.

Within floriculture, there are different modes of value addition which include, fresh flower products comprising of cut flower arrangements like bouquets, baskets, bunch, buttonaire, corsage etc. and loose flower products like garland, floral strings, pomanders, wreaths, floral jewellery etc. Since the fresh flower have limited shelf life dry flower products are becoming popular and are being exported for the last 40 years to USA and Asian countries. The dry flower export from India has a share of around 70 per cent of total export and therefore there is a great scope of drying the flowers to convert them into value added products like dry flower

arrangements, baskets, bouquets, table arrangements, pot pourri etc. Besides this there are press dried flower products including greeting cards, bookmarks, swaths, paper weights, wall hangings, table tops, table mats, etc., Preparation of such product will generate employment in rural areas. Essential oils, absolutes, concrete, petal jam (rose, rhododendron), jelly, ready to serve beverages, wine, floral tea, rose hip juice, poultry feed, insect repellent, floral dyes, petal embedded handmade paper, cosmetics like calendula cream, rose water, rose cream, pharmaceutical and neutraceutical compounds are the other range of products that can arise from value addition in floriculture industry which is yet to be exploited effusively although world floriculture trade is mostly depending on the trade of cut flowers and buds, cut foliage, potted plants and bedding plants.



Nearly eighty per cent of area under floricultural crops is concentrated in seven states comprising Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal, Maharashtra, Haryana, Uttar Pradesh and Delhi. A major part of the area under flower cultivation is devoted to the production of Marigold, Jasmine, Rose, Chrysanthemum, Tuberose, etc., with considerable increase in the area under cut flower cultivation in the recent years.

This horticultural sub-sector is growing at 10-15 per cent every year. The traditional flower cultivation, comprising of growing loose flowers mostly for worship, garland making and decorations, forms the backbone of India floriculture, which is mostly in the hands of small and marginal farmers. However, the use of floricultural produce is no longer confined to religious purposes alone and floriculture has become a part of modern lifestyle and is being used in floral decorations, floral craft, interior-scaping and commercial landscaping. Further, some of the produce is used as raw materials in the manufacture of essence, perfumes, and medicines.

The development of floriculture also provides very good business opportunities in other allied sectors like specialised transport services and production of supply of allied products, nursery bags, pots, potting media, tools, plant protection and other equipments, etc. This has happened due to the vision of policy planners who were involved with various stakeholders in floriculture sector and provided the required direction that resulted in appropriate growth in floriculture.

Though, India dominates in terms of area under cultivation compared with some leading countries which are relatively prosperous in floriculture like the Netherlands, Colombia, Ecuador and Belgium, yet India's yield per hectare is low. As a result, India's contribution to the global floricultural export market is very minimal. Since India is having a better scope in the future as there is a shift in trend towards tropical flowers and this can be gainfully exploited due to presence of high amount of diversity in indigenous flora.

Besides the domestic industry, export potential of floriculture products is also growing by day; there exists a big gap between the demand and supply of floricultural products globally. Notwithstanding, the floriculture industry is facing a number of challenges mainly associated to trade environment, infrastructure and marketing issues such as high import tariff, higher freight rates and inadequate refrigerated and transport facilities, India can capitalise on this by exporting the diverse and rich varieties of flowers that it grows. Globalisation, liberalisation, and implementation of trade reforms are necessary to bring in structural changes to this sector to give further boost by way of competitiveness of Indian floriculture produce for exports. Enormous genetic diversity, varied agro climatic conditions, versatile human resources offer India a unique scope for diversification in new avenues which were not explored to a greater extent. With the opening up of international market in the WTO regime there is a free movement of floriculture products worldwide.

In present times of increasing demand for cut flowers, protected cultivation in green houses is the best alternative for using land and other resources more efficiently because it provides favourable climatic conditions by controlling temperature, humidity and light intensity inside for plant growth which ultimately provides quality products. Flowers such as roses, orchids, lilium, carnations, and anthurium have global markets. India has an immense potential to bridge the gap between demand and supply as global demand of floricultural products is growing at a faster rate. In 2016-17, cut flower and loose flower production is estimated at 2.3 million tonnes from an area of 328,000 hectares. Flowers such as roses, orchids, lilium, carnations, and anthurium have global markets. During 2015-2016, a sum of Rs 306.95 crore from the floriculture sector has been achieved in terms of export earnings while annual trade of Indian flowers is worth Rs. 37,000 crores/annum.

Commercial Floriculture schemes have been initiated by the Government to improve the production and productivity of traditional as well as cut flowers through availability of quality planting material, production of off-season and quality flowers through protected cultivation, improvement in post-harvest handling of flowers and training persons for a scientific floriculture. The schemes of Ministry of Agriculture (National Horticulture Board, National Horticulture Mission, Horticulture Mission for North East & Himalayan States etc.) and Ministry of Commerce (APEDA). National Horticulture Board (NHB), National Horticulture Mission (NHM) and Rashtriya Krishi Vikas Yojana (RKVY). National Bank for Agricultural Rural Development (NABARD) is also providing financial assistance to the farmers to adopt the methods of protected cultivation and precision farming too. Under MIDH, the central

government incentivises infrastructure across the entire supply chain from modern pack-houses to transport and cooled retail shops.

An example of effective market linkage of floriculture produce is seen in IFAB of Karnataka. The International Flower Auction Bangalore (IFAB) Limited is a joint venture company of various aspirant shareholders, established during 2002 to strike the potential of both export and domestic flower market. It deployed 'Dutch Auction' system in which the Digital Auction Clock runs in the decreasing order and the price per stem reduces from maximum to minimum and only registered sellers and buyers are allowed to participate in the auction. The auction is done on all 365 days in a year, helping sellers and buyers in maintaining business continuity. Such auction centres can be replicated across the flower growing areas in the country.

4.3 Spices

Production of spice crops is also gaining momentum; India has been playing a very important role in the spice market of the world since time immemorial. In ancient times nearly all of the global requirement of the spices were produced in India and exported. This attracted people across the borders and forced them to come to India for Spice trade. India produces spices on 2.0 million ha with an annual production of about 2.3 million tonnes valued at about Rs. 4500 crores. Since the world demand for organic spices is growing rapidly in developed countries like Europe, USA, Japan and Australia, India has a greater potential to encash this trend. There is every opportunity to release land for the most expensive like Saffron, Cardamom, turmeric, chilies, ginger and Vanilla beans and are profitable to grow. One of the best ways to start growing these crops, is to pre-sell or to grow by using the support of farmer producer organizations. The organic farming practice of growing such crops in India is increasing rapidly, especially in northeaster parts of the country.

Spices sector is one of the most vibrant sectors of the Indian agricultural trade. The share of spices in the total agricultural export works out to about 6 per cent annually. With stiff competition arising from several existing players and new entrants at the International level, retaining the traditional competitive advantage in this sector has become an issue in the spices industry. With this in background, the government has been attaching very high priority for the development of the spices sector through the improvement of productivity, quality and value addition the results of which is seen from the increase in area, production and productivity as given below.

Table 4.1 Trend in area, production and productivity of spices since 2005-06

Year	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
2005-06	2345	3897	1662
2006-07	2471	4107	1662
2007-08	2631	4460	1696
2008-09	2829	5079	1795
2009-10	2855	5268	1845

Year	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
2010-11	2962	5784	1953
2011-12	3401	6629	1949
2012-13	3055	5963	1952
2013-14	3149	6240	1981
2014-15	3195	6651	2082
2015-16	3489	6907	1980
2016-17	3706	8203	2213
Average annual growth rate (%)	4.4	7.3	2.7

India is playing a very important role in the global spice market since time immemorial and is the largest producer, consumer and exporter of spices and spice products in the world. In ancient times nearly all of the global requirement of the spices were produced and exported from India. Demand for spices continues to spur production. In 2016-17, India produced 8.2 million tonnes of spices from 3.7 million ha.

Table 4.2 Spices area and production (2016-17 e)

Spice	Area ('000 Hectares)	Production ('000 tonnes)
Carom (*ajwain*)	29	26
Cardamom	85	28
Chillies (dried)	845	2,126
Cinnamon (*tejpata*)	3	5
Celery, Dill & Poppy	36	35
Clove	2	1
Coriander	704	900
Cumin	781	489
Fenugreek	210	256
Fennel	91	153
Garlic	322	1,697
Ginger	168	1,076
Nutmeg	23	15
Pepper	131	72
Vanilla	4	0
Tamarind	49	191
Turmeric	222	1,132

The overall productivity of spices has also gone up substantially from 1.66 tonnes/ha to 2.22 tonnes/ha. With global demand for organic spices growing, Indian farmers have opportunity to encash this trend. This requires educating the farmers to release land for the spices and diversify into high-value-plus crops like saffron, cardamom, turmeric, chillies, ginger and vanilla beans.

Crops like Chilli is the major spice crop occupying about 23 per cent of area under spices cultivation and contributing about 26 per cent of total spices production in the country. The productivity of chilli (4.85 tonnes/ha in Andhra Pradesh and 3.66 tonnes/ha in Telangana) is one among the best in the world. The production of spices has doubled in the last ten years and export of spices has also shown steady growth. Of the total spices produced, 90 per cent of it caters to the domestic industry and is consumed within the country. Only 10 per cent of the production is exported.

Table 4.3 Trend in export of spices

Year	Quantity ('000 tonnes)	Value (Rs in Crores)
2005-06	350.36	2628
2006-07	373.75	3576
2007-08	444.25	4436
2008-09	470.52	5300
2009-10	502.75	5561
2010-11	525.75	6841
2011-12	575.27	9783
2012-13	726.61	12113
2013-14	817.25	13735
2014-15	893.92	14900
2015-16	843.26	16238
2016-17	947.79	17664

It is imperative that the farmers cultivate spice crops in tune with nature, preserving the health of the soil, creating the environment for microflora to assist the crop so that we get sustained production, year after year with minimum inputs. Productivity increase and lower unit cost of production are essential to maintain and regain Indian prominence in the world trade for spices. Application of scientific production technologies could play an important role in improving productivity and returns from the crop bringing back its past glory. This involves the spreading of the high production technologies evolved at the research institutes among the growers at the grass root level.

4.4 Cashew nut and Cocoa

Cashew is being grown in small and marginal holdings of Kerala, Karnataka, Goa and Maharashtra in the West Coast and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal in the East Coast. It is also cultivated in Chattisgarh, Jharkhand, Gujarat and North Eastern States to a limited extend. It brings substantial foreign exchange to the country on an average of Rs. 5000 crore per annum. Cashew improves the farm income and sustains employment for 1.5 million people in the cashew farming and industrial sector, whereas in the industrial units 90 per cent of the labour force is women.

During 2004-05, area under cashew was 7.99 lakh ha with production of 5.44 lakh tonnes (average productivity of 681 kg/ha). In 2016-17, the area rose to 10.40 lakh ha with production of 7.79 lakh tonnes. The national average productivity is 753 Kg/ha.

Table 4.4 Production scenario of Cashew (2016-17)

State	Area (000 ha)	Production (000MT)	Pdty (Kg/ha)
Kerala	90.866	83.980	962
Karnataka	126.860	85.147	672
Goa	58.180	32.659	561
Maharashtra	186.200	256.610	1378
Tamil Nadu	141.580	67.650	478
Andhra Pradesh	185.570	111.390	600
Orissa	183.319	93.895	513
West Bengal	11.360	12.960	1140
Jharkhand	14.830	5.830	393
Chattisgarh	13.700	9.330	681
Gujarat	7.220	6.500	900
Pondicherry	5.000	2.160	432
Assam	1.050	1.080	1028
Tripura	4.250	3.450	812
Meghalaya	8.500	5.830	686
Manipur	0.900	0.324	360
Nagaland	0.500	0.540	1080
Total	**1040.89**	**779.335**	**753**

Cultivation of cocoa is gaining momentum in India and is presently cultivated in an area of 82,940 ha. Of these 29,209 ha is in Tamil Nadu followed by 24,156 ha in Andhra Pradesh. The country is importing about 60 per cent of the demand for cocoa and the demand in the domestic market is increasing in the country by 15 per cent annually.

The country produced 18,920 tonnes of cocoa, with an average productivity of 580 kg per ha. Cocoa is cultivated in four southern states namely Kerala, Andhra Pradesh, Tamil Nadu and Karnataka. It is mainly cultivated as an intercrop in coconut and arecanut gardens and now it is also extended to Oil palm and rubber. Cocoa is also an export oriented commodity and India exported cocoa bean and cocoa products valued Rs. 1,118 crore during 2015-16.

Table 4.5 Production scenario of Cocoa (2016-17)

State	Area (ha)	Production (MT)	Pdty (Kg/ha)
Kerala	16421	7150	750
Karnataka	13801	2420	450
Tamil Nadu	30305	1650	320
Andhra Pradesh	24156	7700	800
Total	**82940**	**18920**	**580**

4.5 Organic horticulture

The organic production system which avoids or largely excludes the use of synthetically compounded inorganic chemicals. This system entirely relies on crop rotation, crop residues, animal manures, legumes, green manures, off-farm organic wastes, bio-fertilizers, mechanical cultivation etc. and aspects of biological pest control to maintain soil productivity and tilth to supply nutrients and to control insects, weeds and other pests.

The demand for organic fruits and vegetables is increasing at a rapid pace. Such horticultural produce grown through organic means is nutritionally superior and free from the injurious pesticide residues that are otherwise found in inorganically grown produce. Growing awareness, therefore, about the organic fruits and vegetables would further enhance the supply of nutrients in a safer way.

India is best known as an exporter of organic tea and also has a niche market for spices, fruits and vegetables. The protocol for organic production in many horticultural crops has been worked out which includes a use of resistant varieties, management of soil vermin-compost and bio-fertilizer, and management of disease and pests using biological control as well as bio-pesticides.

Recognising the adverse impact of excessive use of chemicals on soil health and human health, there has been a realization for integrated management system. Since organic farming addresses soil health, human health and environmental health and is eco-friendly, appears to be one of the options for sustainability. Therefore, organic farming is receiving a focused attention of Government of India Organic farming is a system which avoids or largely excludes the use of synthetic inputs such as fertilizers, pesticides, hormones, feed additives etc. and to the maximum extent rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection. The growth of organic agriculture in India has three dimensions and is being adopted by farmers for different reasons.

First category of organic farmers are those which are situated in no-input or low-input use zones, for them organic is a way of life and they are doing it as a tradition (may be under

compulsion in the absence of resources needed for conventional high input intensive agriculture).

Second category of farmers are those which have recently adopted the organic in the wake of ill effects of conventional agriculture, may be in the form of reduced soil fertility, food toxicity or increasing cost and diminishing returns.

While majority of farmers in first category are traditional (or by default) organic they are not certified, second category farmers comprised of both certified and un-certified but majority of third category farmers are certified. The third category comprised of farmers and enterprises which have systematically adopted the commercial organic agriculture to capture emerging market opportunities and premium prices. The data available on organic agriculture today, relates to these commercial organic farmers.

Emerging from 42,000 ha under certified organic farming during 2003-04, the total area under organic certification at present is 5.71 million ha (2015-16). This includes 26 per cent cultivable area with 1.49 million ha and rest 74 per cent (4.22 million ha) forest and wild area for collection of minor forest produces. The data on area and production under organic horticulture is inaccessible. Get data from organic farming horticulture from JS organic farming

India produced around 1.35 million MT (2015-16) of certified organic products which includes all varieties of food products namely Sugarcane, Oil Seeds, Cereals & Millets, Cotton, Pulses, Medicinal Plants, Tea, Fruits, Spices, Dry Fruits, Vegetables, Coffee etc. . The production is not limited to the edible sector but also produces organic cotton fibre, functional food products etc. among all the states, Madhya Pradesh has covered largest area under organic certification followed by Himachal Pradesh and Rajasthan..

Recently Sikkim has been announced as one hundred per cent organic cultivation state. The total volume of export during 2015-16 was 263687 MT. The organic food export realization was around 298 million USD. Organic products are exported to European Union, US, Canada, Switzerland, Korea, Australia, New Zealand, South East Asian countries, Middle East, South Africa etc. and only spices and dry fruits figure among horticulture produce,

Conventional horticulture has certainly led to very high toxic levels in our food. If we look in to the menace carefully it is mainly due to the continued use of persistent pesticides, faulty application, ignorance and greed of farmers to get better prices of their product. However, the products grown in potential organic areas (where no pesticides are being used) have been found to be free of pesticide residues. Organic agriculture policy was announced in the year 2005, under this policy to get boost major horticultural crops included were fresh vegetables, grapes, banana, mango, papaya, pineapple, guava, passion fruit, orange, cashewnut, walnut, Chillies, garlic, turmeric, coriander, ginger, etc.

Regulatory mechanism does exist for organic certification of horticulture produce. For quality assurance internationally acclaimed certification process in place for export, import and domestic markets. National Programme on Organic Production (NPOP) defines the regulatory mechanism and is regulated under two different acts for export and domestic markets. NPOP (launched during 2001) notified under Foreign Trade Development and Regulation Act (FTDR) looks after the export requirement. Studies indicate that practically there are no detectable differences between organically and conventionally grown fruits and vegetables.

Important liquid manures formulations for soil enrichment are being used by farmers. Few important and widely used formulations are Sanjivak, Jivamrut, Amritpani and Panchgavya and most of them have cow dung, cow urine, cow milk, curd, cow ghee, jaggery and flour as ingredients.

Realizing the potential of organic farming in the North Eastern region of the country, a Central Sector Scheme entitled "Mission for Organic Value Chain Development for North Eastern Region" for implementation in the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura during the 12th plan. The scheme aims at development of certified organic production i.e. value chain system made to link growers with consumers and to support the development of entire value chain starting from inputs, seed, certification, to creation of facilities for collection, aggregation, processing, marketing and brand building initiation. So far, 2321 farmers cluster and 08 Farmers' Producers Organization have been formed.

4.6 Production for Export

India's diverse climate ensures availability of all varieties of fresh fruits & vegetables. India is the largest producer of Ginger and Okra amongst vegetables and ranks second in production of potatoes, onions, cauliflowers, brinjal, Cabbages, etc. Amongst fruits, the country ranks first in production of Bananas (22.94 per cent), Papayas (44.03 per cent) and Mangoes (including mangosteens, and guavas, 37.57 per cent).

The country has a vast production base which offers growth opportunities for export. During 2016-17, India exported fruits and vegetables worth Rs. 10811.84 crores which comprised of fruits worth Rs. 3,947.24 crores and vegetables worth Rs. 6864.60 crores. Mangoes, Walnuts, Grapes, Bananas, Pomegranates account for larger portion of fruits exported from the country while Onions, Okra, Bitter Gourd, Green Chillies, Mushrooms and Potatoes contribute largely to the vegetable export basket. The major destinations for Indian fruits and vegetables are UAE, Bangladesh, Malaysia, Netherland, Sri Lanka, Nepal, UK, Saudi Arabia, Pakistan and Qatar.

Floricultural exports from India comprise of fresh cut flowers (to Europe, Japan, Australia, Middle East and USA) loose flowers (for expatriate Indians in the Gulf) cut foliage (to Europe) Dry flowers (To USA, Europe, Japan, Australia, Far East and Russia) Potted Plants (limited to Middle East) besides seeds and planting material. Dry flowers contribute nearly Rs. 320 crores (70 per cent) of total exports valued at Rs.460 crores (2014). India's position as an exporting

country for cut flowers stands at 29 among the flower exporting countries with a value of USD 8227,000 which translates to a percentage share of 0.31 per cent.

Though India's share in the global market is still nearly 1 per cent only, there is increasing acceptance of horticultural produce from the country. This has occurred due to concurrent developments in the areas of state-of-the-art cold chain infrastructure and quality assurance measures. Apart from large investment pumped in by the private sector, public sector has also taken initiatives and with APEDA's assistance several Centres for Perishable Cargoes and integrated post-harvest handling facilities have been set up in the country.

Capacity building initiatives at the farmers, processors and exporters' levels has also contributed towards this efforts.

Table 4.6 Export of different commodities (2016-17)

Product	Qty in tonnes	Value in Rs. Lakhs
Other Processed Fruits & Vegetables	351834.58	311607.87
Fresh Onions	2415757.11	310650.09
Other Fresh Vegetables	1002396.86	281537.74
Miscellaneous Preparations	283265.21	257048.23
Fresh Grapes	232940.76	208834.98
Alcoholic Beverages	231332.48	200062.59
Other Fresh Fruits	409939.00	185890.63
Cocoa Products	25700.17	108998.74
Dried & Preserved Vegetables	87279.99	108854.99
Cucumber and Gherkins (Prepd. & Presvd)	180820.87	94271.78
Mango Pulp	135621.22	86497.48
Natural Honey	45537.99	56320.70
Floriculture	22086.10	54873.96
Fruits & Vegetables Seeds	11638.46	52741.88
Fresh Mangoes	53177.26	44554.54
Walnuts	2191.19	5527.26

As also discussed in DFI Volume-IV section 5.9, there is scope to enhance exports from the country. APEDA alongside the Department of Agriculture, Cooperation and Farmer's' Welfare has identified certain regions for developing production in clusters for exports purpose. This forms part of the strategy of APEDA and will help in doubling the income and some of identified pockets for growing different vegetables are given in table below.

Table 4.7 Some pockets identified for growing vegetables for export

Crop	Area of production
Okra	Nasik, Ozar, Saikheda, Dindhori, Kolhar, Naraingaon and Sholapur in Maharashtra, Valsad in Gujarat
Watermelon	Panvel near Mumbai
Bottle & bitter gourd	Nasik and Pune districts in Maharashtra
Gherkin	Nasik in Maharashtra and Bangalore in Karnataka
Capsicum	Nasik, Pune and Satara districts in Maharashtra
Baby corn	Bangalore in Karnataka, Nasik and Pune in Maharashtra
French bean	Dindhori in Nasik district, Wai in Satara district
Cluster bean	Naraingaon in Pune district, Dhule and Ahmednagar in Maharashtra
Tomato	Nasik and Pune in Maharashtra and Bangalore in Karnataka
Potato	Jallandhar and Ludhiana in Punjab, Kurukshetra and Karnal in Haryana, Ooty in TN and Indore in MP, Mathura, Agra, Farukhabad in UP and Hassan in Karnataka

4.7 Medicinal and Aromatic Plants

The medicinal plants based industry is growing at the rate of 7-15 per cent annually. According to a conservative estimate, the value of medicinal plants related trade in India is to the tune of about Rs 5,000 crores per annum while the world trade is about 62 billion US dollars and is expected to grow to the tune of 5 trillion US dollars by the year 2050.

The present international situation in the production and trade of essential oils and aroma chemicals is very complex and vibrant. The world production from the developing countries accounts for 55 per cent followed by developed countries (10 per cent).

4.7.1 Status of Aromatic Crop Production in India

Many species of aromatic plants (APs) are cultivated for industrial uses, but some are still wildly collected. The need for renewable sources of industrial products as well as the need to protect plant biodiversity creates an opportunity for farmers to produce such crops. The production of plants as raw material for fine chemicals is different than cultivation of ornamental or food crops.

Table 4.8 Status of Aromatic crops

Name of crop	Botanical Name	States cultivated	Uses
Damask Roses (Desi Gulab)	Rosa damascena	Rajasthan, U.P., Himachal Pradesh, J&K	Used in perfumery and to make rose water and "rose concrete".
Artemisia	Artemisia annua	J&K, Himachal Pradesh, Uttrakhand and NEH region	The essential oil is used in perfumery, cosmetics as davana oil dermatology and also having fungicidal properties.
Mentha (Pippermint)	Mentha piperita	Uttrakhand, U.P., Punjab	Peppermint essential oil is mainly used as flavouring in toothpaste, ice cream, confectionery, soft drinks, tobacco, chewing gum, and other varieties of foods. It can also be found in shampoos, soaps, balms and liniments. The oil has a cooling effect for fevers. Peppermint tea and tea blends are becoming more popular as a natural foodstuff. Peppermint tea is used for relief of palpitations of the heart and nausea
Citronella	Cymbopogon winterianus	Assam, Meghalaya, Karnataka, Tamil Nadu, Maharashtra, UP, Bihar and Madhya Pradesh.	Used extensively in soaps, detergents, house-hold cleaner, mosquito cream, Agarbatti, tea-blending etc.
Lemongrass	Cymbopogon citratus	Kerala, Andhra Pradesh, Telengana Assam, Karnataka, Tamil Nadu, Maharashtra and NEH region	Used extensively in soaps, detergents, house-hold cleaner, mosquito cream, Agarbatti, tea-blending etc.
Patchouli (Peholi in Hindi)	Pogostemon cablin	Assam, Andhra Pradesh, Telengana, Karnataka, U.P, Himachal-Pradesh, Uttrakhand, Maharashtra, Tamil Nadu.	The heavy and strong scent of patchouli has been used for centuries in perfumes and, more recently, in incense, insect repellents, and alternative medicines.
Vetiver(Khas Khas)	Chrysopogon zizanioides	U.P., Bihar, Haryana, M.P., Kerala, Tamil Nadu and Andhra Pradesh and Telengana	The oil is used in the flavor and fragrance for manufacture of soaps, cosmetics, perfumery, agarbatti, soft drinks etc. In blended perfumes.

Name of crop	Botanical Name	States cultivated	Uses
Vanilla Orchid	Vanilla Planifolia	Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and NEH region	It contains strong antioxidant and antibacterial properties, and even cancer or tumor fighting abilities.
Saffron(Jafaran or Kesar)	Crocus sativs	Jammu & Kashmir and Himachal Pradesh.	Saffron's aroma is often described by connoisseurs as reminiscent of metallic honey with grassy or hay-like notes. Used as. Confectioneries and liquors also often include saffron. Common saffron substitute
Palmarosa(Rusha ghas)	Cymbopogon martinii	UP, Andhra Pradesh, Rajasthan, Karnataka, Maharashtra, Madhya Pradesh, Gujarat and Tamil Nadu.	The constituents of palmarosa essential oil are geraniol and used in perfumery, food flavourings and medicinal pharmaceutical industry.
Lavender	Lavandula angustifolia	Jammu & Kashmir, Himachal Pradesh. U.P., Karnataka	The major users of essential oils are the soft drink company's and flavouring industry.
Basil (Tulsi)	Ocimum basilicum	Entire Indian continent	Leaves and Foliage should be harvested before the plants bloom. Essential oil 71 per cent eugenol and is comparable to that of clove oil. Eugenol is widely used in perfumery, cosmetics, pharmaceuticals and confectionary industries. The juice of the leaves possesses antiseptic, diaphoretic, antiperiodic, stimulating, expectorant, anti-pyretic and memory improving properties.
Sandalwood	Santalum album	Tamil Nadu, Karnataka,	The heartwood of Sandalwood yields fragrant oil, which is used mainly in the perfume industry but also has medicinal properties. The wood is used for carving and manufacturing incense.

4.8 Agroforestry, Agri-silvi and Horti-silvi pasture

As population has increased, increasing the need for agricultural production, the use of multiple cropping systems is more prevalent. Agroforestry has high potential to simultaneously satisfy objectives like protecting and stabilizing the ecosystem, producing a high level of output of economic goods, providing stable employment, improve income and basic material to rural population.

Agroforestry conserves natural resources through various systems under different agro climatic regions including the hot arid zone of India. The hot arid zone is spread 3.17 million hectare. The productivity of this area is very low due to low rainfall, high evaporation and high wind speeds, which causes a great loss of soil and vegetation resources. Several alternate land use systems viz., *Prosopis cineraria, Acacia tortilis, Acacia Senegal, Ailanthus excels*, Zizyphus spp. Based silvipastoral/agrisilvicultural systems developed in hot arid zones are much remunerative than the sole cropping.

Millions of farmers are dependent on agroforestry farming systems as a way of increasing and sustaining agricultural productivity, as a source of essential food, fuel wood, fodder and building materials and as a supplementary source of income that buffers instability in agricultural income. As forest resources have become increasing scarce, poor small farmers have become more dependent on agroforestry systems to sustain their livelihoods.

Table 4.9 Employment Generation Potential through improved Agroforestry

AF System	Area ('000 ha)	Employment/ha/yr (man days)	Total Employment year ('000 man days)
Agri- Silviculture (Irrigated)	2282.4	40	9129.6
Agri- Silviculture (Rainfed)	126.8	30	3804.0
Agri- Silviculture (Irrigated)	1521.6	50	76080.0
Agri- Silviculture (Rainfed)	507.2	40	202880.0
Silvi-pasture	5579.2	30	167376.0
TBOs	12426.4	40	497056.0
Total	**25360.0**		**943392.0**

Source: NRCAF Perspective Plan Vision 2025

4.9 Annotation

Growing demand both in domestic as well as international markets due to ecstatic affordability, change in life-styles, social values, increase in the number of IT Units, Hotels, Tourists, and Temples, more over the greater awareness among the people to improve the deteriorating

environment of the people and much higher return per unit of land than any other agricultural activity has nudged farmers to take-up floriculture.

Commercial floriculture has been steadily increasing with increased use of protected cultivation employing greenhouse, shade nets, polyhouse, etc. Commercial flowers cultivation in India provides an opportunity for rural development owing to its higher returns per unit area and the new employment opportunities. Spices sector is one of the most vibrant sectors of the Indian agricultural trade.

The share of spices in the total agricultural export works out to about 6 per cent annually. The demand for organic fruits and vegetables is increasing at a rapid pace. Such horticultural produce grown through organic means is nutritionally superior and free from the injurious pesticide residues that are otherwise found in inorganically grown produce. The country has a vast production base which offers growth opportunities for export.

Growing domestic demand for fruits and vegetables and inefficiencies in the production and post-production system have not left surplus of appropriate quality for export purpose. However, there is sufficient scope to produce suitable quality and cater to external markets. Many species of aromatic plants (APs) are cultivated for industrial uses, but some are still wildly collected. The need for renewable sources of industrial products as well as the need to protect plant biodiversity creates an opportunity for farmers to produce such crops.

Key Extracts

- Horticulture is considered high value agriculture, and many farmers view horticultural farming as crop diversification
- Floriculture is an age old farming activity in India but has emerged as an important agribusiness with immense potential for generating self-employment and entrepreneurship among small and marginal farmers in both urban and rural areas
- The medicinal plants based industry is growing at the rate of 7-15 per cent annually.
- India exported fruits and vegetables worth Rs. 10811.84 crores which comprised of fruits worth Rs. 3,947.24 crores and vegetables worth Rs. 6864.60 crores.
- System wide interventions are needed to minimise food loss and to generate surplus for international markets.

Chapter 5
Horticulture - Focused Initiatives for Additional Income

There are a few specific initiatives that can be taken across the horticultural sector, to enhance and add to farmers' income. These can include building optimal synergy with other activities like beekeeping, mushroom farming, linking of Swachh Bharat program with peri-urban horticulture.

5.1 Hybrid seed production

Quality seeds play significant role in the agriculture production. Farmers can enhance their income through participatory hybrid seed production program for different seed companies. It is a form of contract farming where farmers are supplied with inbred lines for further crossing and production of hybrid seeds of vegetable crops. The gross profit margin from production of F_1 seed comprises 350 times more. The economic analysis showed that the net profit per kilogram of tomato F1 seed is 92 per cent. F_1 seed production has been carried out even by rural women farmers after getting good skill through training.

Table 5.1 Employment Generation through Vegetable Hybrid Seed Production

Crop (Hybrid)	Hybrid Seeds Produced (tones)	Area Covered (Acres)	Man-Days Employed per acre	Crop Duration (days)	Total Man-days Employed (million)	Per cent Contribution
Tomato	38	1,583	460	120	0.75984	27.97
Hot pepper	30	375	1,800	150	0.67500	24.85
Okra	700	2,333	180	120	0.41994	15.46
Watermelon	65	1,083	165	110	0.17870	6.58
Cucumber	15	180	450	100	0.08100	2.98
Ridge gourd	20	166	472	110	0.07835	2.88
Melons	10	200	350	100	0.07000	2.58
Eggplant	15	115	600	150	0.06900	2.54
Bitter gourd	20	200	150	150	0.03000	1.10
Bottle gourd	20	166	150	120	0.02490	0.92
Sweet pepper	1	56	534	150	0.02990	1.10
Squash	60	1,500	200	120	0.3000	11.04
TOTAL	**994**	**7,957**	**5,531**		**2,71663**	**100**

Source: Singh and Dutta, 2005.

5.2 Nursery Establishment

To supply quality planting material to the farmers, it is necessary to have accredited nurseries under public & private sectors. Mission for Integrated Development of Horticulture (MIDH) supports the establishment of high tech nurseries and up gradation of nurseries by public and private sector both.

The productivity of horticultural crops like fruits, vegetables, flowers, plantation crops and spice crops can be increased by supply of disease free quality planting material to farmers. Therefore, it is one of the important drivers to increase the productivity of crops which ultimately affect the farmer's income.

5.3 Bee keeping

Beekeeping is an agro-based activity which is being undertaken by farmers/landless labours in rural area as an integrated farming practice. Beekeeping supplements income generation and nutritional intake of rural population. It is being increasingly realised that bees could be less expensive input for promoting sustainable and eco-friendly Agriculture and enhancing crop productivity. Crop wise yield increase has been reported to be increased from 2 to 300 times depending upon crop, season and location. Value of additional yield obtained due to bee pollination alone is 15-20 times more than the value of honey & bees wax / hive products put together.

In various agricultural and horticultural crops, honey bees' pollination also improves the quality of produce. Honeybees, in addition to enhancing the yield of various crops also convert nectar and pollen into honey and other beehive products, viz. bees was, royal jelly, propolis, etc. which provides additional income to the farmers/beekeepers. This way, beekeeping/honey bees helps in diversification of crops and increasing income through enhancement in yield of crops and also income from various beehive products. Further, beekeeping also generates employment opportunities to the rural masses. In normal course, a beekeeper with 100 bee colonies of *Apis mellifera* can earn an income/ profit of Rs. 4 to 5 lakhs per annum by practicing scientific beekeeping. However, the Economics of beekeeping is directly linked with the market prices of honey & other beehive products and prices of bee colonies/ beehives, supers, etc., which fluctuate time to time.

5.4 Mushroom

India's per capita consumption (20-25 g) is comparatively low as compared to Europe and USA (2 to 3 kg). The domestic demand is growing at a rate of 25 per cent. India produces only 0.12 million tonnes mushroom out of which, button mushroom contributes about 85 percent of the total mushroom production of country, the other types are shiitake, oyster, wood ear and paddy straw mushrooms. In India, the full potential of mushroom cultivation is yet to be unleashed. Mushrooms are of excellent food value as they provide a full protein food containing all the twenty one amino acids besides containing useful amount of fats, vitamins and minerals. Mushroom protein being easily digestible (70-90 per cent) is considered superior to vegetable proteins. Two essential amino acids lysine and tryptophan are enormously present in mushrooms which are not found in cereals. Mushroom cultivation will help in eliminating protein malnutrition among people, primarily dependent on cereals, and offer remunerative employment opportunities.

Demand and production of mushrooms in country is increasing consistently. In recent years mushroom cultivation in India has witnessed a tremendous growth with respect to the type of

mushrooms and their productivity. Indian growers as well as consumers further need to be well-informed of the qualities of mushrooms, particularly the nutritional and medicinal values. The importance of mushroom is also seen as an eco-friendly alternative for agro-waste recycling, capability to provide better nutrition for the vast vegetarian population, employment generation and a good income source. Mushrooms play a very important role in eco-friendly recycling of agricultural wastes. This process leads to the production of highly nutritious and medicinal mushrooms which can be easily grown by anyone at home or scale up to industrial production. India produces about 98 million tons of surplus agro wastes per annum.

The following table shows the estimated benefit of utilizing just 10 per cent of agricultural wastes produced in the country for mushroom cultivation. Mushroom technology is a composite technology with numerous activities and each activity has the potential to become a stand-alone enterprise to earn income.

Table 5.2 Mushroom- benefits of using surplus crop residues burnt annually in India

Surplus crop residues burnt in the country per annum	**98.4 million tons million tons per annum**
10% of this crop residue	9.84 million tons per annum
Fresh oyster mushrooms produced through 9.84 million tons @50 % biological efficiency	4.92 million tons per annum
Employment generated @150 mandays per ton production	738 million mandays or 2.02 million people can be employed every year
Protein produced @ 2% of the fresh mushroom produced	98400 tons per annum
SMS available as organic manure @ 60% (minimum) of residue used	5.9 million tons per annum

Mushroom cultivation can also represent a valuable small-scale enterprise option. Further, the various activities can be undertaken completely or partially and developed into a profit making enterprise through mushroom production as well as through mushroom spawn production. Partial mushroom cultivation activities for entrepreneurship, Enterprise for sale of ready, compressed raw material (straw) for cultivation; Enterprise for production of sterilised substrate; Enterprise for production of Ready to fruit (RTF) bags; Enterprise for dehydration of mushrooms; Production of value added mushroom products; Enterprise for packaging and marketing of fresh, dehydrated mushrooms and mushroom products; Production of vermicompost from spent mushroom substrate; Ancillary enterprise for single window supply of cultivation related requirements.

The economics of a small scale mushroom production unit indicates that the annual gross return would come to Rs. 48 lakhs at the yield rate estimated at 200 tonnes per annum, valued at Rs. 24,000 per tonne. After accounting for all costs including depreciation, interest, taxes and

retained profit etc., there are net cash accruals every year from year 1 to year 10. The BCR works out to 1.3 and IRR (Internal Rate of Return) to 26.4.

Government of India supports mushroom production through several affable schemes, there is a central scheme on mushroom farming by Ministry of Rural Development. The main focus of this scheme to train, information dissemination, technical and financial assistance for preparation of cultures/spawn cultivation, harvesting, storage, processing, packaging, marketing linkages with farmers to employment opportunities and generating income with special emphasis on women. Financial assistance and soft loans are also available from National Co-operative Development Corporation (NCDC), National Horticulture Board (N.H.B.), A.P.E.D.A., State Govt. Agencies responsible for development of Agriculture and Agro-based ventures.

5.5 Cluster based production

In Volume 4 of the DFI Report, it is recommended that 7,000 producer organisation be created. These would organise farmers or entire villages into cluster based production. The recommendation is also that each such organisation to cover 1000 farmers and/or 1000 hectares under cultivation. As such, the cluster approach will promote common production from farms to be aggregated and linked in a viable manner to the country's markets. Another way to effect a cluster approach, is to enable the bulking of output from individual farms into viable lots that can be linked to markets efficiently. This is evident in case of foodgrains, where the dry warehouses or local aggregators consolidate the production for subsequent delivery to consumers. In case of horticulture, such level of aggregation is not widespread except for potatoes, dried chillies, nuts which have simpler post-harvest handling. This is because most other horticultural crops have a lower holding life and require to be pre-conditioned before being transported to markets.

Considering the number of villages in the country in the form of clusters, at least 50,000 preconditioning or primary processing centres can be proposed to be created, with capacities designed to suit local assessment on the production potential of the area. Modern pack-houses to precondition the produce is discussed in Volume 3. The linkage to terminal markets can be facilitated by modernising rural periodic markets into aggregation hubs in the form of PRAMs (Primary Rural Agri-Markets) as discussed under new market architecture in Volume 4. It is expected that establishing of aggregation units at village level, will in turn further motivate the farmers to collaborate on the production side. Some such facilities could also serve as flower markets to and to prepare the flowers to travel to market, reducing the losses in handling and transportation. The PRAMs would also serve for direct marketing to local buyers. At least one modern state-of-art terminal flower market is required to be developed near each major metropolitan cities.

Cluster based production needs to be met with associated post-production management to minimise post-harvest losses and to optimise the output supply chain. As cluster production will output large volume of similar crops, the viability of the supply chain also gets enhanced.

Table 5.3 Interventions in Post-production that can increase farmers' income

SN	Interventions Required	Support System Required
1.	Establishing market linkage for supporting farmers	• Exploring the possibility of tying up with IRCTC, Airlines for supporting value added products or fresh fruits and vegetables in the menu • For doing this every taluk headquarter should have a aggregation (collecting and grading) centre • There is a need for identifying clusters growing the crops, the information is available with respective state departments
2.	Setting up of processing units at village clusters/ focal point	• Technical hand holding by ICAR Institutes/ KVKs • Linking of the growers with existing licensees and entrepreneurs • Setting up of incubation centres by governments

It would be desirable to promote organised retail chains for fruits and vegetables in urban centres through promotion of entrepreneurship amongst the educated unemployed youth in urban areas to cater to the daily need necessities in better organised hygienic and efficient manner. Such organised retail chains should be equipped with cool chambers and other facilities to maintain the freshness of the products as well as to minimise deterioration. A good example of consolidating and organising the demand from consumers is the SAFAL network in Delhi, which handles and supplies 315 tonnes of horticulture on a daily basis.

HOPCOMS: To benefit both the farming community and the consumers, the Horticultural Producers' Co-operative Marketing and Processing Society Ltd. (HOPCOMS) was established with the principal objective of establishing a proper system for the marketing of fruits and vegetables. It is a farmers' society for the direct marketing of farm produces and HOPCOMS handles around 100 metric tons of fruits and vegetables every day. The activities of HOPCOMS are threefold; procurement, storage and distribution. The member farmers bring their produce to the Society, where the produce is graded, weighed and the payment is made to the farmers immediately. To help the growers for transporting the produce, the Society has procurement centres in major supply areas and the procured fruits and vegetables are supplied to consumers through the Society's retail outlets. It has central godowns, procurement centres, retail outlets, processing units and transport vehicles. Such efforts may be replicated across the country.

SAFAL: On seeing the success in milk supply chain, Mother Dairy Fruit & Vegetable Pvt Ltd (SAFAL) was especially conceived to adapt and replicate same in the marketing of vegetables and fruits. The SAFAL model is primarily consists of procurement on receipt of supply from farmers, distribution operations from the hub retail to consumers from owned outlets and backward linkage through extension work on quality requirement and handling. The main

operations (procurement and marketing) are adjusted for non-homogeneous produce type. SAFAL deals with approximately 180 farmer associations (with membership of nearly 8000 farmers). The farmer's association manages local procurement from its members and the transportation. The entire life cycle from farm-to-consumer is majorly handled in the open ambient, without any pre-cooling at farm/village level. This is possible as the farm to consumption handling is fast-tracked in less than a 48 hour timeline. SAFAL has agriculture extension workers on call to support farmers for providing extension services on good agricultural practises. However, there is no formal contracted arrangement with SAFAL and farmers. The main strength of SAFAL is its established outlets which assures a predictable throughput or sales volume and against this fixed sales volume, SAFAL is able to undertake assured procurement and build relations with farmers associations. This system has allowed SAFAL to become a market linked model for the limited number of farmers it procures from.

It is noted that the SAFAL model does not extend to ownership of the back-end infrastructure, restricting itself to the front-end distribution hub and retail outlets. However, the HOPCOMS model extends itself into the back-end by taking ownership of collection centres, transport vehicles and on occasion, mobile vending units. The HOPCOMS model differs from the SAFAL model as it is able to pay higher than the reference mandi prices to farmers. HOPCOMS also provides opportunity for farmers to hold and directly sell to consumers at certain collection centre locations. Besides retailing of fresh whole produce, both SAFAL and HOPCOMS also process and sell products such as juice, frozen peas, etc.

5.6 Urban & Peri-urban Horticulture

In cities, environmental benefits and synergies can be achieved when horticulture is planned as a part of the urban landscape including safe recycling of solid waste and waste water. Further, trees and other ornamental plants are crucial for sequestration of carbon from atmosphere and play an important role in reducing carbon footprint. Moreover, flowering /foliage plants in the garden not only add beauty but also help to improve the ecosystem. India has responded well to the needs for effective urban and peri-urban horticulture (UPH) with emphasis on green space, green building, development of parks and gardens, and promotion of peri-urban vegetables production, but the integration appears to be poor. UPH is now a necessity rather than a luxury. The government's initiative of peri-urban vegetables production alone is not enough for the huge challenge to be met. This necessitates holistic approach having vertical and horizontal integration of the efforts of all the stakeholders, which should concurrently link all components of UPH.

Among the various gardening options, terrace gardening, a raised ground space around a dwelling house or on the sides of a hill, forms a link between the house and the rest of the outdoor living space and must, therefore, be designed in harmony with the plan of the house. Roof garden is one of popular alternatives in urban and peri-urban areas, because of the lack of available space on the grounds of a house. Particularly, in the big cities and towns, the only space left for garden enthusiasts is the roof of the house and the balcony. To ensure the success of roof gardening, technical and developmental support is inevitable. Airports have vast tracts

of open land which can be used for flowers and other greening initiatives. This has been successfully implemented in some other countries.

There is no defined scientific standard followed for green space in Indian cities. Therefore, the standard for green space and tree cover in the cities needs to be formulated for meeting the challenges of climate change which is expected to put increasing stress on urban and peri-urban areas. Green cities have become an option to mitigate the impact and adapt to climate change.

Although, there has been significant improvement in vegetable production, availability of vegetables, particularly fresh vegetables round the year in the large metro cities, like, Delhi, Mumbai, etc., remains a problem. This is on account of non-availability of land in the vicinity of these cities to take up large scale cultivation of vegetables. Moreover, vegetables coming to these cities have to be transported long distances thus leading to post-harvest losses and degradation in quality. This, to some extent could be overcome by taking up vegetable cultivation under protective cover in and around the metro/big cities.

Accordingly, matter has been initiated with the State Governments to promote vegetable cultivation under protected cultivation. The vegetables identified for this purpose are high value crops like capsicum, tomato, cucurbits, leafy vegetables etc.

Swachh Bharat and peri-urban horticulture:

We have been reading about several facets of keeping our city clean and urban and peri-urban horticulture is one of the facets as it has huge potential to utilise recycled water and the product of solid waste management (compost) for gainful purposes. Both the processes are simple and cost effective but requires willpower to implement. The water that has been reclaimed by wastewater is recycled water. Composting is simply the process of breaking down the organic matter (food or urban waste) in the presence of air and water, using micro-organisms present in nature. The end product is called compost which is rich in readily usable plant nutrients forming a part of healthy soil.

Recycled water

Recycled water is a valuable resource it is the water that has been used, captured, and used again; but there is considerable treatment before it is used again and the type of treatment depends on the intended use. The use of recycled water emancipates water for the environment and for drinking, and reduces the amount of waste water discharged into our waterways. By nature, the primary sources of recycled water (human or animal waste, rainwater, storm water or industrial) have different contaminants like pathogens and varying levels of salts and nutrients and their quantities may depend on the in the level of treatment. Normally the most commonly encountered materials are salts in recycled waters, they are sodium, magnesium, calcium and potassium salts and their proportion will largely depend on the source of recycled water and the nature of treatment. In addition, nitrogen and phosphorus are also present in significant quantities along with the micronutrients required by crop plants (e.g. iron, manganese, zinc, copper, molybdenum, boron, chlorine, nickel and cobalt) in varying

quantities. While salts are generally harmful to plants, nutrients can be beneficial and can reduce the amount of fertilisers or manures required for a crop. However, their presence in excessive amounts could adversely affect crop growth and hence their amounts be managed to ensure that harmful effects do not occur. In addition heavy metals (e.g. cadmium, chromium, copper, lead and mercury) contamination is a concern and it is required to be ensure through treatment, testing and monitoring, that the levels of these contaminants do not exceed.

The use of recycled water be made mandatory be used to meet peri-urban horticultural needs. This move will prevent extraction of ground water in a big way and millions litres of groundwater will be saved daily. Recycled water can fulfil most of water demands as long as it is adequately treated and is appropriate for the use. The use of recycled water in horticulture may require the farmers to make certain changes to current cultivation practices, depending upon the crop and quality of water. This will include frequent and stringent quality checks to avoid any use of contaminated water both in terms of microbes and heavy metals. As per the estimate of Central Pollution Control Baord, the total waste water generated from Class I cities (498) and Class II cities (410) in the country is around 35,558 and 2,696 MLD respectively. This water is sufficient to grow 3,18,558 tonnes of lettuce from an estimated area of 31,855 ha (120 litres of water is required to grow a kg of lettuce and 10000 kg per ha yield). This move will prevent extraction of ground water in a big way and millions litres of groundwater will be saved daily. The ground water usage should also be checked for contaminants as there is increasing evidence of the contribution of irrigation water in the contamination of produce leading to subsequent outbreaks of foodborne illnesses.

There may be consumer apprehension to accept produce grown with recycled water. The use of recycled water in horticultural production is accepted provided the water meets certain minimum quality criteria and certification requirements. However, there may be some limitations of the use of recycled water like the usage for post-harvest produce washing and processing or on-farm washing. Consumer awareness on such aspects may be required.

Solid waste Management:

In 2001, itself the Planning Commission had estimated a shortfall of 6 million tons a year of organic manure. This can be produced today by composting the municipal waste of just 35 largest Indian cities. The city compost, nutrient content (normally contain 1 to 1.5 per cent of Nitrogen ; 0.2 to 0.5 of Phosphorus and 0.5 to 1.5 per cent of Potash apart from other micronutrients) alone is not important, its real value is its rich microbial content which convert inert N P K in soil and air to soluble forms which are useful for plant growth. Further, city compost like farmyard manure and composted agro-wastes, contains tremendously useful soil microbes and humus, acts like a sponge holding the run-off nutrients till plants can absorb all of it and which helps to aerate the soil, improves water retention and resistance to both drought and water-logging, and reduces irrigation requirements and conflicts over water.

Solid waste management is a challenge in many towns and cities, if properly handled it could enormously benefit the peri-urban horticulture initiative. This will require residents to separate

biodegradable waste and non-biodegradable waste. Kitchen waste will go into compost plants while the non-biodegradable waste will go to recycling plants. People should be aware of the difference between biodegradable and non-biodegradable waste.

An example is that, according to the latest report of the Bruhat Bengaluru Mahanagara Palike's (BBMP) solid waste management wing released in April, 2017 over 4,000 tonnes of waste was generated from which over 2500 tonnes of wet waste and 263 tonnes of dry waste was segregated at source. From 2500 tons of organic waste, after maturation period the total amount of compost obtained will be equal to 875 tons/day @ of 35 per cent compost recovery. Similarly, 9,400 tonnes of municipal solid waste is being generated in Mumbai each day. Making it mandatory for all housing societies, residents' associations, industries and hotels to separate wet (biodegradable) and dry (recyclable) waste before handing it over to the municipal staff will give a big boost to the initiative. The Central Pollution Control Board has warned that municipal solid waste generated from our cities has crossed 1,42,870 (1.43 lakh) tonnes per day from which a substantial 12,858 tonnes is not even collected. Of the 91 per cent (1.3 lakh tonnes) collected, around 65,000 tonnes is being dumped or disposed off in the most unscientific and unhygienic manner. Only 23 per cent is being treated while 27 per cent is dumped into landfills.

The average waste generated per day by a household is 0.568 Kg (Wet waste = 0.366 kg & Dry waste = 0.202 kg) and the total waste generation per capita per day was found to be 0.205 kg. The wet fraction of the waste was 64.44 per cent. The urban Indian citizen generates nearly 700 grams of solid waste per person per day which is nearly 250 kg in a year. A family of four therefore, produces over a tonne of waste each year. Studies have shown that over 50 per cent of waste produced in a house is compostable organic waste. By composting, we reduce half of the garbage that leaves our homes while creating the black gold that is compost. Among the known processing technologies for organic waste, "composting" is quite common and it results in production of a stable product that is, compost, that can be used as a manure and soil conditioner on farms and orchards especially in urban and peri-urban areas.

According to parliamentary Panel, only about 1.6 per cent of the total waste generated by cities is being composted (although it is mandatory to co-market compost and inorganic fertilizers, the fertiliser companies are also reluctant to market it, saying it affects their fertiliser sales. Composting will not only reduce the volume of waste to landfill/ dumpsite by converting the waste into useful by-products but also provide nutrients to grow plants. A project worth Rs 7,000 crore have been approved for the solid waste management and by October 2019 one compost plant is expected to be established in each city. At present, 93 compost plants are functional in different parts of the country and 283 plants are under construction or in the revival stage.

More than half of what we carelessly throw into the trash is organic matter, which if composted, can produce rich top soil for our plants. Unfortunately most of us do not segregate our dry waste from wet waste, which makes composting impossible. The precious wet waste what can

potentially become black gold remains unusable junk inside our landfills. The key to a clean, garbage free city lies in citizens doing their civic duty of source segregation and composting.

5.7 Annotation

Quality seeds play significant role in the horticulture production. Farmers can enhance their income through participatory hybrid seed production program for different seed companies. The productivity of horticultural crops like fruits, vegetables, flowers, plantation crops and spice crops can be increased by supply of disease free quality planting material to farmers.

In various agricultural and horticultural crops, honey bees' pollination also improves the quality of produce. Honeybees, in addition to enhancing the yield of various crops also convert nectar and pollen into honey and other beehive products, viz. bees was, royal jelly, propolis, etc. which provides additional income to the farmers/beekeepers. Mushroom cultivation can also represent a valuable small-scale enterprise option.

The PRAMs (primary rural agricultural markets) would also serve for direct marketing to local buyers, while facilitating aggregation and traffic to markets farther afield. At least one modern state-of-art terminal flower market is required to be developed near each major metropolitan cities.

Urban and peri-urban horticulture needs to be promoted as one of the facets that will keep cities clean, as it has highest potential to reutilise recycled water and solid waste (compost) for gainful purposes. Horticulture can set off a symbiotic cycle, between cities and agriculture.

Key Extracts

- Use of good quality seed and planting material is a prerequisite for the production of high yields.
- Crop wise yield increase has been reported to be increased from 2 to 300 times depending upon crop, season and location as a result of on farm bee keeping practice.
- India's per capita mushroom consumption (20-25 g) is comparatively low as compared to Europe and USA (2 to 3 kg).
- The cluster approach will promote common production from farms to be aggregated and linked in a viable manner to the country's markets.
- Horticulture, especially per-urban horticulture, is favourable system that supports the Swachh Bharat agenda.

Chapter 6
Sensitive Trio: tomato, potato and onion

Onion, tomato and potato are staple food items from horticultural sector. Common on the consumers' plate, each is otherwise exclusive to one another in their production and post production management.

6.1 Crops trio

Tomato, potato and onion are the most sensitive crops to price fluctuations and are to be dealt distinctly. Information on seed sales, cropped area, weather, plant health and arrival forecast is critical and can help in furcating market trend and give a tool for policy makers.

The produce being perishable in nature, vegetable and fruits farmers are the most vulnerable to the involvement of intermediaries in the marketing system. Without facilitation to directly connect with large markets, which requires a changed market architecture, the aggregation and connectivity with urban demand is managed by 'middlemen'. Even if prices soar to one of the highest levels, farmers may only get a third or fourth of the prices in retail markets.

Onion, tomato and potato form almost 50 per cent of the total fruit and vegetable sales, being high volume items, these food items show lower bottoms and higher tops when subject to price instability. Onion, tomato and potato form almost 50 per cent of the total fruit and vegetable sales, being high volume items, these food items show lower bottoms and higher tops when subject to price instability. While the consumer wants to buy a commodity at the lowest price, the farmer (especially small, who depend on intermediaries to fulfil supply) desires to sell the produce at the maximum price. The middleman, also would wish to maximise profits as they provide a facilitation service while taking on some of the risks involved. Striking a balance among these stakeholders is necessary. There is clear need for suitable logistics and marketing infrastructure to address the issue of price fluctuations in horticultural crops which have no or minimum storability due to perishable nature of the crops.

The disparity between demand and supply, and resulting price fluctuations, also to on account of unfavourable weather. This can result in a drop in production, a rise in transportation cost, and other supply constraints. Historical price trends show a clear pattern in price spikes, where the high prices rule only for a few critical months. Further, onion area and production has seen increased concentration in a few states which also affects intra-year supply behaviour. This implies that excessive volatility in prices can be managed through appropriate mechanisms by breaking the seasonality and geographic barriers as well as encouraging storage by creating proper storage facilities as demand is relatively inelastic. To alleviate instability in market supply, production and prices, the key strategy would be to extensively develop a large number of supply chains so as to increase sourcing range into each market, promote competitiveness with efficiency of the supply chain system.

It is to note that potato and onion inventories are held over a comparatively longer term, and there is advance information in the market on remaining inventory (from potato cold stores or

onion farm-gate storage). However, this advance market-intel is not validated or updated with regulators for monitoring purposes. Such information in the hands of a few can be easily manipulated for transactional gains. To maintain a regular supply of onions and check speculative behaviour of market functionaries it may be necessary to bolster farmer producer organizations for onion production and processing in different agro-ecological zones than in the traditional pockets.

Excess demand, supply shocks, poor market infrastructure, speculative storage or hoarding, weak supply chains and trade controls are the major factors and dynamics responsible for price fluctuations. Although there are tools to safeguard domestic interests during high price situations by imposing a minimum export price (MEP) restricting the exports coupled with greater imports, swift actions are required to be followed. Efforts are needed to build a system for production forecasts and market intelligence that would facilitate timely policy decisions. To reduce the supply and price fluctuations, a complementary storage option can be developed to locate buffers of onion and potato close to the markets. These need not be high technology systems but designed to cater to a two week inventory cycle from the buffer into market.

However, in case of tomato, the situation is more dynamic as tomato selling cycle is shorter. Short term life cycle of tomato deters any large scope for manipulated pricing and hence it is more closely linked to the real-time physical supply constraints. The above assessment is with the assumptions that farm-gate production is not the core reason for the frequency of fluctuations but that the fluctuations are a reflection of market linkage, market competition, market level organisation and failures therein. For tomato, the back-end source and reefer transport needs developing to ensure tomato production in other states reaches the city markets safely and in quality. This development could be targeted through FPOs or rural enterprise.

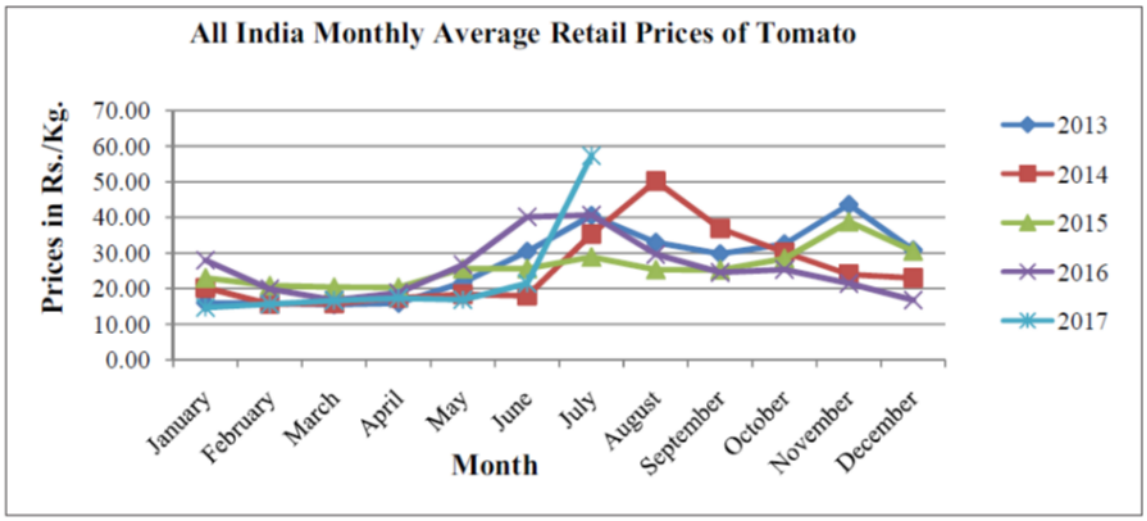
Table 6.1 Total Annual Production & Demand of Onion, Potato & Tomato - 2012-13 to 2016-17 in ('000 tonnes)

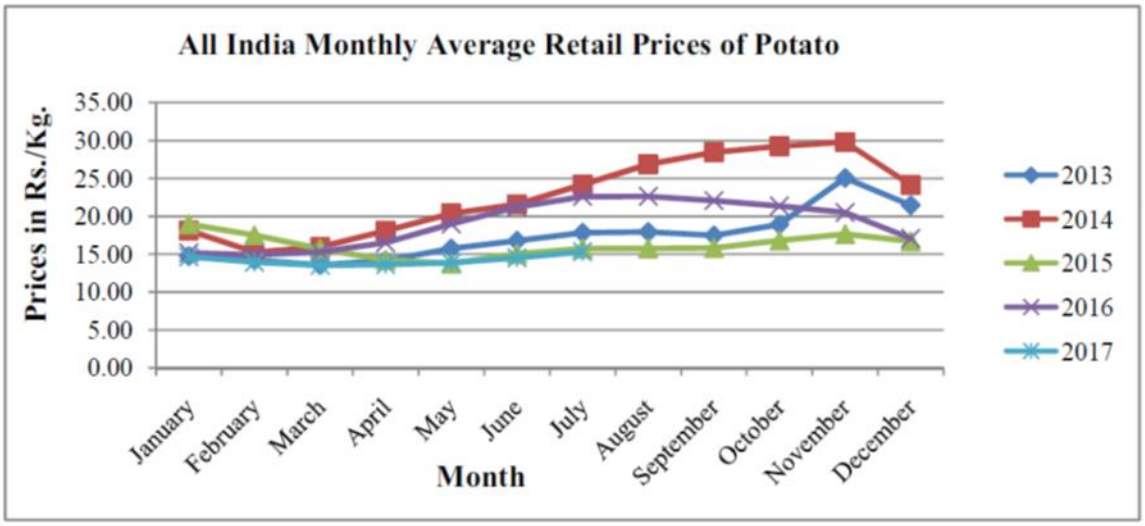
Years	Onion		Potato		Tomato	
	Production	Annual Demand	Production	Annual Demand	Production	Annual Demand
2012-13	16813	18252	45344	42203	18227	16766
2013-14	19402	18503	41555	41502	18736	17182
2014-15	18927	18488	42174	42151	18305	16961
2015-16	20333	19002	43417	43169	18732	17259
2016-17	21718	20770	48237	45739	19542	17871

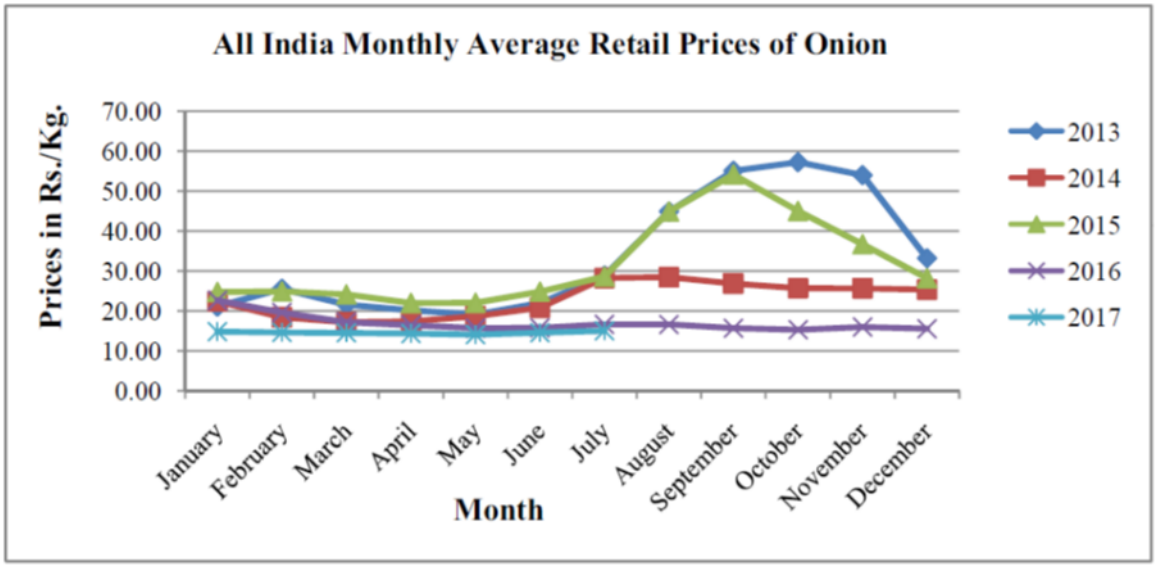
Source: NSS Report No. 558: Household Consumption of Various Goods and Services in India, 2011-12

Note: Annual Demand includes personal consumption, bulk consumption in hotels, marriages, etc., exports, seeds, losses, processing etc.

Figure 6.1 Monthly average prices (all India)







6.2 Tomato

This botanical fruit originated in the Andes where it is called "xitomatl", meaning "plump thing with a navel". When it was introduced into Europe in 1500s, the Germans referred to it as "the apple of paradise" and the French likened it to "the love apple". The Church of Rome banned it for nearly 150 years, as the "devils fruit".

Tomato is a good source of vitamin A and B and excellent source of ascorbic acid. Containing 0 grams of cholesterol, tomatoes are considered heart healthy – as a good source of potassium, they help lower high blood pressure. Tomatoes are an outstanding source of the antioxidant lycopene, high intake of which reduces the risk or severity of atherosclerosis, diabetic complications, asthma, and colon cancer. Lycopene intake also reduces absorption of UV rays, making tomatoes a natural sunscreen. A good source of riboflavin, chromium, calcium and magnesium, consuming tomatoes help reduce migraines, control sugar and avoid acidosis. On the other hand, the leaves are toxic.

More than 2700 genetic varieties of tomatoes are reported. These are typically categorised by those suitable for fresh table consumption and those compatible for processing into ketchup or other products. The latter are distinct from the fresh market variety: fresh-market varieties are juicier and harvested prior to being ripe, while processing varieties contain higher percentages of soluble solids, are vine ripened and typically have a thicker skin than fresh-market tomatoes. Globally, the processing varieties have a lower market value by weight, giving fresh market tomatoes a larger share in crop value. Processed tomato products are most often classified as one of four major subcategories: paste, sauces, ketchup and other products, which mainly consist of puree; whole canned tomatoes; and juices.

6.2.1 Status of Tomato in India

Tomato is the most widely grown vegetable crop in India and is grown throughout the country for fresh consumption as well as for processing purposes. However, the interstate trade is limited because of its perishable nature, susceptibility to weather anomalies and other supply disruptions. Supply disruptions tend to temporarily impact on the price at consumer end when shortfalls are faced. At the same time, the farmers frequently face a local glut due to inability to connect safely with the demand centres.

Table 6.2 Tomato production trends

State	2010-11		2011-12		2012-13		2013-14		2014-15		2015-16	
	A	P	A	P	A	P	A	P	A	P	A	P
Andhra Pradesh	-	-	301	6015	261	5218	168	3354	54	1474	59	2237
Arunachal Pradesh	-	-	-	-	1	15	1	14	1	14	0	3
Assam	-	-	17	398	17	402	17	408	18	418	18	445
Bihar	-	-	47	1105	48	1126	48	1062	48	1046	46	1001
Chhattisgarh	43	628	45	719	48	762	50	814	53	869	55	909
Goa	-	-	-	-	-	-	-	-	-	-	-	-
Gujarat	39	978	42	1092	44	1157	45	1259	45	1259	46	1319
Haryana	27	392	27	417	28	401	29	627	27	667	29	675
Himachal Pradesh	10	388	10	400	10	414	10	431	10	414	11	486

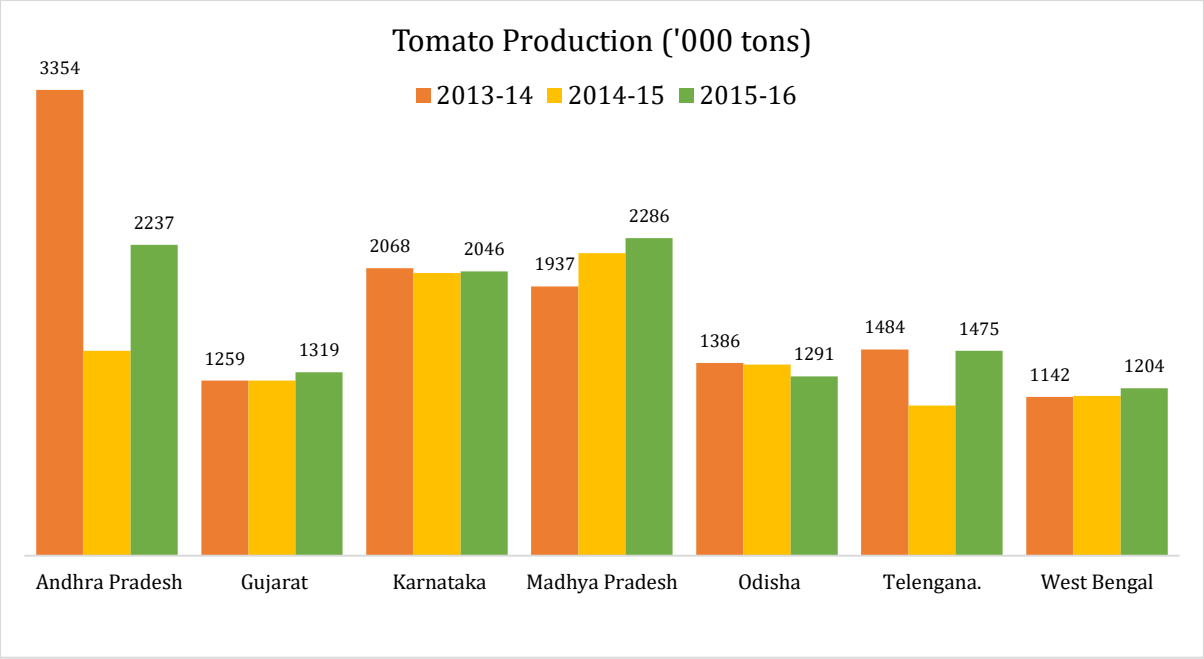
State	2010-11		2011-12		2012-13		2013-14		2014-15		2015-16	
	A	P	A	P	A	P	A	P	A	P	A	P
Jammu & Kashmir	8	137	4	88	4	88	4	88	4	88	4	88
Jharkhand	22	402	24	248	26	250	26	251	27	254	18	230
Karnataka	51	1757	57	1987	58	1917	61	2068	64	2034	61	2046
Kerala	-	-	-	-	-	-	-	-	23	8	3	59
Madhya Pradesh	28	347	55	1350	63	1845	66	1937	70	2177	74	2286
Maharashtra	52	738	48	1007	50	1050	50	1200	35	762	44	977
Manipur	2	29	2	23	-	-	3	29	3	26	3	32
Meghalaya	-	-	2	30	2	30	2	51	2	52	2	34
Mizoram	1	6	1	6	1	7	1	8	1	10	1	10
Nagaland	1	4	1	9	2	6	3	20	3	20	3	20
Odisha	97	1367	97	1378	97	1383	97	1386	97	1375	91	1291
Punjab	6	155	7	161	7	171	7	181	8	186	8	191
Rajasthan	17	68	18	68	16	74	17	82	17	75	21	83
Sikkim	1	8	1	8	1	9	1	9	1	9	1	4
Tamil Nadu	27	581	28	605	24	302	25	333	25	328	30	646
Telengana							74	1484	53	1081	58	1475
Tripura	1	30	2	39	2	38	2	39	2	44	2	54
Uttarakhand	9	97	9	102	9	102	9	114	9	115	9	93
Uttar Pradesh	7	249	7	265	7	311	8	328	10	414	21	819
West Bengal	54	1064	55	1105	56	1126	57	1142	57	1150	57	1204
Total	**503**	**9,423**	**905**	**18,623**	**878**	**18,204**	**881**	**18,719**	**766**	**16,368**	**773**	**18,718**

A is sown area in '000 hectares; **P** is production in '000 metric tonnes

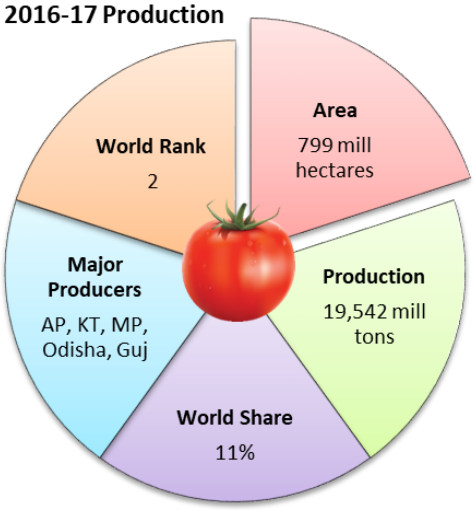
Source: Horticulture Division (DAC&FW)

Tomato is a warm season crop, and the fruits ripen best for yield, colour and quality during warm & sunny weather. High rainfall and humid conditions can proliferate foliar diseases.

Figure 6.2 Major tomato producing states



2016-17 Production

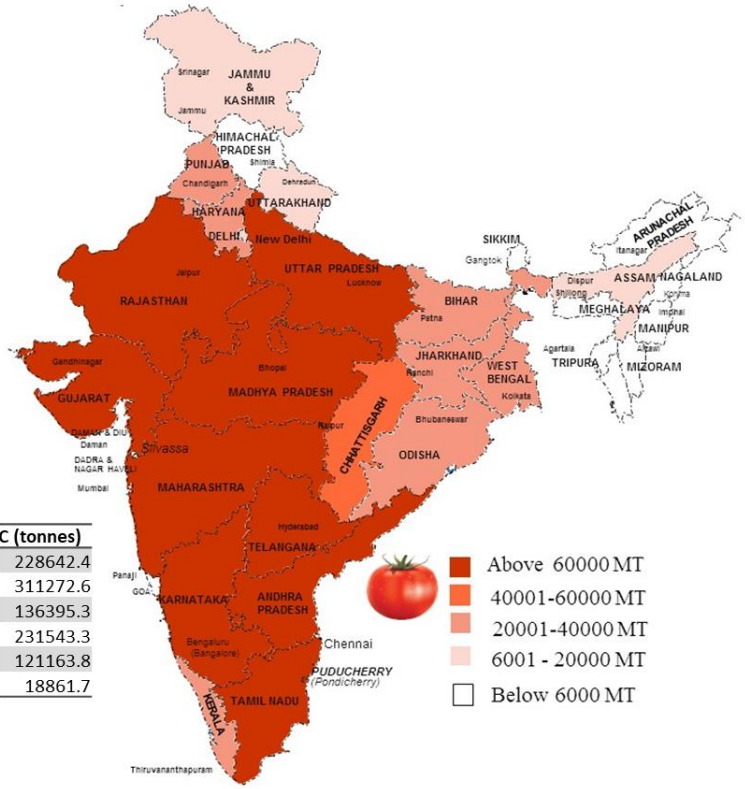


TOMATO - Peak and Lean Season

Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
AP												
KT												
MP												
Odisha												
Guj												

Lean Season Peak Season Throughout Year

Total Monthly Consumption Profile of Tomato



Zones	TMC (tonnes)
North	228642.4
South	311272.6
East	136395.3
West	231543.3
Central	121163.8
North-East	18861.7

Total Monthly Consumption (TMC) of Tomato in MT

State	TMC
Andhra Pradesh	123912
Arunachal Pradesh	799
Assam	12166
Bihar	38617
Chhattisgarh	45428
Delhi	18628
Goa	1325

State	TMC
Gujarat	61225
Haryana	31786
Himachal Pradesh	5940
J & K	11414
Jharkhand	28615
Karnataka	70895
Kerala	23864
Madhya Pradesh	75736

State	TMC
Maharashtra	101577
Manipur	613
Meghalaya	1674
Mizoram	394
Nagaland	1205
Odisha	37477
Punjab	23278
Rajasthan	67416

State	TMC
Sikkim	441
Tamil Nadu	92602
Tripura	1569
Uttar Pradesh	128776
Uttarakhand	8820
West Bengal	31687
All India	1061454

Source: NSSO data, extracts from NCCD.2015 AICIC Study

Tomato is mainly grown as Rabi crop in the plains of India. However in the hilly region it is grown as a summer and rainy season crop. Tomatoes through produced in large quantities, face contrary repercussions in its value system due to inefficiencies in logistics network. The facilitation through an efficient post-production management and marketing is required, similar to the one developed for the milk chain. Aggregation of the produce when it is still young and turgid enough to withstand travel to markets, preconditioning the produce through packaging and precooling, and dispatch to terminal markets requires organisation. Tomato consumption per capita reached 10.4 kg in 2013 in India, according to Faostat. This is 5.05 per cent more than in the previous year.

6.2.2 Gainful Productivity

Productivity enhancement in case of tomato is similar to those mentioned in Chapters 2 and 3. High yield planting material, drip irrigation, appropriate INM/IPM and pollination systems are key to improving yield, including protected cultivation. However, the priority action item is to improve the distribution system, post-production, to enable tomatoes to connect with any part of the country.

An organised supply chain for tomatoes would necessitate pre-conditioning centres at village level. These are envisaged at PRAM centres (recommended in Chapter 5 of DFI Volume IV), which would function both as direct marketing centres and aggregation facilitation centres. The PRAM at tomato growing regions would enable farmer groups or village level producing organisations to direct the tomato to markets of choice, provided the marketing cycle is managed within a week or so of harvest.

Such a system would also mitigate the risks from growing tomato, which in port harvest phase is largely from a local glut impacting negatively on the price offering to the farmer. Whereas, the same produce, as a unit of value, is assigned a higher price once connected with areas of higher demand. Lack of appropriate market connectivity results in a lack of marketing range and farmers have no recourse but to recover value at locally determined prices. The current post-production practices can be summed up as:

(i) **On the farm** – Farmers harvest the produce with transport arranged in advance hence immediately after harvesting, sorting, grading and packaging is done. The produce is transported out of the field. The produce which has to be sent to market is harvested in the evening and takes overnight to reach the designated wholesale market

(ii) **Rural collecting point** – As soon as the produce is collected, it is transported to the neraby *mandi*. Preconditioning facility with precooling is not available at aggregation point.

(iii) **Wholesale market** – at the *mandi* retailers pick up the produce as soon as it is readied by wholesaler. Some of the retailer/buyer use their own way of protecting the tomatoes.

(iv) **Retail market** – retail cycle is about 1 to 2 days.

This current post-production set of affairs, has put constraints on the marketing range of the tomato. Therefore, while there may be surplus supply at one state, in another location or city in the country, the tomato wholesale price can be in multiples to that in the growing region, due to a lack of supply.

The setting up of aggregation hubs to prepare the sensitive crop for long distance travel, will help to offset such demand-supply gaps and stabilise prices, while allowing farmers to cater to the larger one-India market.

The demand for tomatoes has not plateaued and is increasing at a rate that is higher than organic growth of consuming population, as it is equally influenced by upsurge in spending power of consumers. The growth demand is frequently met with differential price dispersions within the country, in the face of tomato production going to waste in the growing region. This is a clear indicator that the tomato supply chain frequently fails to balance demand with supply and that this crop requires an organised collection and distribution system. Lack of such a marketing backbone is a wasted opportunity for the famers, and gainful productivity can occur with the provision of effective agri-logistics in the case of tomatoes.

6.2.2.1 Envisaged marketing supply chain model

Tomatoes are not amenable to long term storage at farm gate and the production is primarily of table variety. Further, being soft skinned and less tolerant of dynamic forces during travel, it require to be suitably packed for moving long distance. Lack of such facility, means poor market connectivity and wasteful discards. Hence, the output supply chain must focus on using a modern pack-house, co-located at the farming cluster. Produce from farms would undergo pre-conditioning for rapid evacuation to city based terminal markets. Any supply surplus would be optimally buffered as inventory held in proximity to terminal markets, as the partially aged tomato could still withstand the last mile movement for subsequent sales.

Handling damage and discards at pack-house level can be valorised as natural additives or ingredients in nearby processing units, or recycled as compost. The village level pack-house should function such that, any delay in evacuation should trigger a signal to attached farmers to defer the harvesting for a short time. Each pack-house should have at least two or more reefer trucks attached (depending on distance to target market). The packing should utilise CFB boxes to avoid returning cost of plastic crates. The project can be designed as a service to the catchment farmers, ensuring a share of wholesale price to individual farmers. Tomato has a very fast selling cycle, which supports models based on large volumes and fast cash flow.

The capacity use of pack-house can be determined on the basis of packing line and period it comes in use. Such projects can also be undertaken by state agencies and should optimally focus on spatial extension to distant markets. Women can be actively employed in sorting grading and packing activities and rural youth can be promoted to take up driver-entrepreneurship on the associated transportation units.

6.3 Potato

Potato is a major food crop, grown more than 100 countries in world. The native South Americans brought Potato under cultivation possibly 8000 years ago. In the 17th century, potato was introduced by the Portuguese, they called it '*batata*', in the western coast of India. Today, potato ranks fourth in the world and third in India with respect to food production. Potato is the most used food crop in the world after wheat, rice and maize.

Potato is the most important vegetable crop which has always been the poor man's friend as it provides a source of low cost energy to the human diet, rich source of starch, vitamins especially C and B and minerals. Sunshine along with cooler nights is essential for reducing the spread of diseases.

A short duration crop, it produces more quantity of dry matter, edible energy and edible protein in lesser duration of time than cereals like rice and wheat. This property makes potato a nutritionally superior vegetable as well as staple food not only in our country but also throughout the world. Now, it has become as an essential part of breakfast, lunch and dinner worldwide. Potato is a tuber and has a long holding life in optimal conditions. Unlike tomatoes, potatoes can be stored for a full year, until the next harvest. However, similar to tomato, the crop is also categorised into fresh table use variety and processing variety. The fresh variety is not preferred for processing and vice versa. Therefore, a surplus situation in the table variety production cannot be diverted into processing factories as both varieties have specific uses.

6.3.1 Status of Potato in India

India is the second largest producer of Potato in the world next to China. India has a single annual harvest of potato, mostly grown in winter time, and in 2016-17, estimates indicate that production was up by 5 million tons, from 43 million tonnes in the previous year. In 2014, the potato production ranking was China (25 per cent), India (12 per cent), Russian Fed. (8.2 per cent), Ukraine (6.2 per cent) and USA (5.2 per cent) respectively.

Table 6.3 Potato production trends

State	2010-11		2011-12		2012-13		2013-14		2014-15		2015-16	
	A	P	A	P	A	P	A	P	A	P	A	P
Andhra Pradesh	-	-	5	98	9	190	3	51	3	44	3	39
Arunachal Pradesh	-	-	5	40	-	-					1	6
Assam	-	-	89	783	100	975	98	700	99	1706	105	1037
Bihar	-	-	315	6102	322	6641	318	6536	319	6346	319	6346
Chhattisgarh	36	526	41	579	43	649	38	556	39	601	42	645
Goa	-	-			-	-						
Gujarat	65	1882	81	2396	81	2500	74	2267	98	2964	112	3549
Haryana	27	598	28	619	29	676	30	697	30	723	34	854
Himachal Pradesh	15	206	16	206	14	181	19	243	19	243	18	183
Jammu & Kashmir	8	151	7	127	7	127	7	127	7	127	7	127
Jharkhand	43	656	46	653	47	660	49	653	50	660	45	627

State	2010-11		2011-12		2012-13		2013-14		2014-15		2015-16	
	A	P	A	P	A	P	A	P	A	P	A	P
Karnataka	40	401	45	483	44	698	41	540	44	589	33	455
Kerala	1	0	0	5	0	5	0	8	0	2	1	18
Madhya Pradesh	62	743	88	1817	109	2299	110	2322	136	3048	141	3161
Maharashtra	18	318	18	360	14	321	20	370	11	201	13	251
Manipur	2	15			-	-						
Meghalaya	18	162	18	165	18	173	18	182	19	192	19	184
Mizoram	0	2	0	3	0	3	0	3	0	1	0	1
Nagaland	2	10	3	20	4	32	5	65	5	65	5	61
Odisha	14	191	14	201	14	201	15	250	16	269	25	279
Punjab	84	2088	84	2104	85	2132	87	2189	90	2262	92	2385
Rajasthan	11	76	12	178	9	107	10	113	13	150	14	230
Sikkim	9	46	10	47	10	49	10	50	10	50	11	54
Tamil Nadu	5	97	5	105	5	105	5	116	6	131	4	72
Telengana							5	99	5	106	4	72
Tripura	6	110	7	123	8	149	9	154	9	159	8	129
Uttarakhand	24	424	25	434	25	434	25	410	28	452	26	358
Uttar Pradesh	557	13577	568	14125	604	14430	564	13809	607	14879	607	13852
West Bengal	406	13391	377	9693	387	11591	412	9030	412	12027	427	8427
Total	**1,453**	**35,670**	**1,906**	**41,466**	**1,992**	**45,329**	**1,973**	**41,540**	**2,075**	**47,997**	**2,116**	**43,402**

A is sown area in '000 hectares; **P** is production in '000 metric tonnes

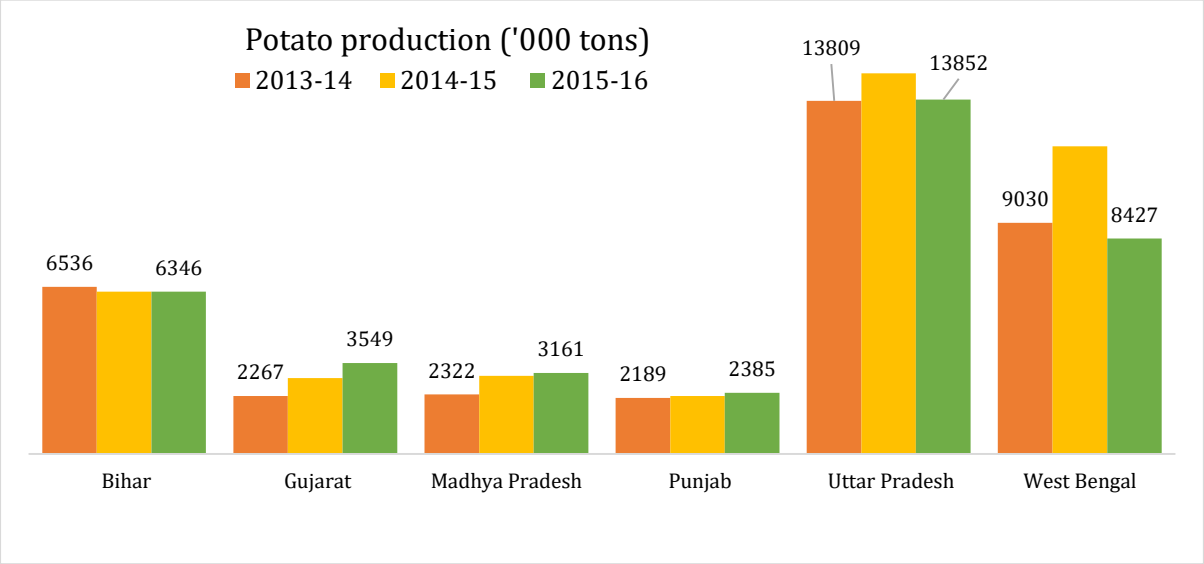
Source: Horticulture Division (DAC&FW)

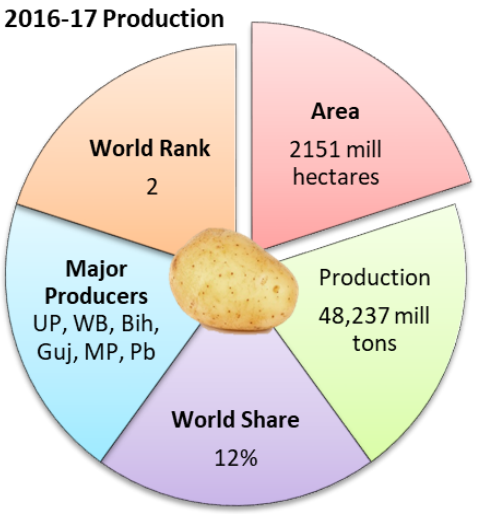
According to 3rd Advance Estimate, the area under potato during 2016-17 was 21.51 lakh hectare as against 21.17 lakh hectares in 2015-16 i.e. increase of 0.34 lakh hectares. The potato production during 2016-17 was 482.22 lakh tones as against 434.17 lakh tonnes in 2015-16 i.e. increase of 48.05 lakh tones. The major producing states are Uttar Pradesh (31.26 per cent), West Bengal (23.29 per cent), Bihar (13.22 per cent), Gujarat (7.43 per cent), Madhya Pradesh (6.20 per cent), Punjab (5.22 per cent), Assam (2.21 per cent).

The major area of production is covered under Rabi season (85-90 per cent) in U.P., West Bengal, Bihar, M. P. and Punjab. To a limited extent kharif season production is also taken in Karnataka, Maharashtra, Himachal Pradesh and Uttrakhand. State-wise Peak harvesting season of potato in the country: Jan-Feb (U.P.), Feb-March (W.B.), Feb- March. (Bihar), Feb-March (Gujarat), Feb. to March (M.P.).

In the last five years including 2016-17, at the national level a classic cobweb pattern is visible in potato production. The production increased 9 per cent in 2012-13, dropped the 8 per cent next year, increased 16 per cent in 2014-15, dropped again in 2015-16 by 10 per cent and has shown an increase of 11 per cent in 2016-17 at 48.23 million tonnes. The Marketable Surplus Ratios in Table 7.4 in DFI Volume IV, indicate similar annual swings for potato.

Figure 6.3 Major potato producing states





POTATO - Peak and Lean Season

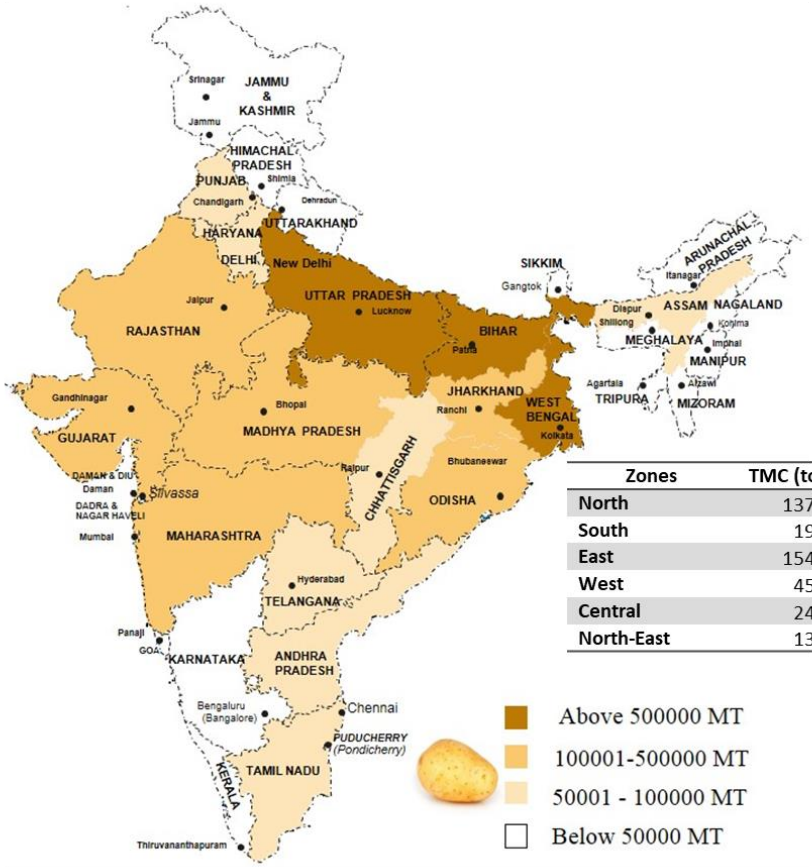
Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
UP	Lean	Lean	Peak	Peak								
WB		Lean	Peak	Lean								
BIHAR	Peak	Peak								Lean	Lean	Lean
MP		Peak	Peak	Lean								
Guj	Peak	Lean										
Punjab	Peak	Lean										Peak

Lean Season Peak Season

Potato, does not have as much spread in production as tomato, and has a single season harvest. In 2016-17, due to large production on potato, the government had to undertake procurement to mitigate distress selling by the farmers. Unless production is planned, to match existing demand from consumers, the seesaw of surplus production viz low price and low production resulting in price rises may continue unabated.

Another alternate is to promote regular trade of potato, such that markets outside the country are developed for long term opportunity for farmers that grow potato. However, the random opening and closing of export window, dissuades exporters from building any long term trading relationships with Indian traders.

Total Monthly Consumption Profile of Potato



Zones	TMC (tonnes)
North	1370917.0
South	199033.2
East	1548233.3
West	452474.9
Central	242481.0
North-East	132606.3

Total Monthly Consumption (TMC) of Potato in MT

State	TMC	State	TMC	State	TMC	State	TMC
Andhra Pradesh	74061	Gujarat	149874	Maharashtra	164957	Sikkim	1736
Arunachal Pradesh	3623	Haryana	84428	Manipur	5111	Tamil Nadu	58331
Assam	95836	Himachal Pradesh	17436	Meghalaya	7634	Tripura	10903
Bihar	621223	J & K	26052	Mizoram	2848	Uttar Pradesh	1062987
Chhattisgarh	63706	Jharkhand	179435	Nagaland	4914	Uttarakhand	33872
Delhi	53998	Karnataka	42287	Odisha	159966	West Bengal	587609
Goa	1556	Kerala	24353	Punjab	92143	All India	3881674
		Madhya Pradesh	178775	Rajasthan	136088		

Source: NSSO data, extracts from NCCD.2015 AICIC Study

6.3.2 Gainful Productivity

Potato witnesses a steady state of demand, with a very large section of the population already as consumers. There is little change in demand growth, which is mostly organically linked to population growth. Unlike tomato, demand for potato is less influenced by growing consumer affluence. This comparatively steady trend in demand, does not support even a 10 per cent growth in production - a minor spurt in production, creates a situation to immediately and disproportionately lower the price, detrimental to final value captured by farmers. The price difference is normally highest during harvesting season, when the crop is expected to be stored for deferred sales all through the year. A large inventory in cold stores can also depress prices all through the year as stocks are cleared on a monthly basis. On removing the stored potato, it

remains fresh and is consumable for another 2 to 3 weeks, if kept in dark and dry conditions at consumers' homes.

It is noted that a hefty majority of the cold stores developed in the country are for storing and trading in potato. It is the success of such longstanding capacity for managing potatoes in the cold-chain, that a seasonal produce like potato, is a national staple in the average person's diet. However, this capability to store potato for the long duration, can be optimally utilised by catering to export markets. Instead of surplus resulting in depressed pricing, higher production can be encouraged, linked to exports.

The processed potato crop system, is well developed and closely linked with the processing industry. The industry has vertically integrated the farmers into their own value chain and any growth in farmers' income is predictably coupled with growth in processed potato products. However, the bulk of farmers grow fresh table variety potato as that market opportunity is the bulk of the consumers demand. It is felt that transformational growth for potato farmers will come from tapping into external markets, while incremental growth will be from improving resource use efficiency and disease prevention.

For more gainful returns and productivity, this crop will benefit from demand forecasting and associated crop planning at district level. Agricultural extension services and policy implementation agencies will need to intervene and not push production at any cost, but to promote market linked production. Strategically, an excess of 10 to 20 per cent of domestic consumption can be produced to offset any production vagaries. All efforts to increase production must be balanced with developing external demand and hence export trade needs to be promoted if pursuing future growth in production. A favourable trade policy for potato will favour higher production and productivity and also promote growth in cold-chain.

6.3.2.1 Envisaged marketing supply chain model

Potato is amenable to very long term holding, in bulk sized cold storage. Nearly five per cent of production is of processing variety and this is directly linked to demand from potato processing industry. Having tapped domestic demand, the output from these factories is also exported to neighbouring countries. However, the bulk of production is of the table variety which is not amenable to processing. In the Indo-Gangetic plains and harvested in winter months, but it is in demand as a staple food on tables across the country, all through the year. The output supply chain utilises very slow initial cooling in a refrigerated warehouse, and it is slowly released to market, until next harvest is readied. On evacuating the cold store, further use of refrigeration it not mandatory.

Overall, potato production is seen to oscillate between years, in the range of four to five million tons. In case of potato, projects that promote farmers to shift from table to process variety for export can be envisaged. In case of table variety crops, export of surplus can also be promoted. The table produce remains consumable for a few weeks after exiting the cold warehouse, and does not require specialised transport to connect from source to terminal markets. Being able

to use ordinary, on-convenience, transportation to markets, the crop is useful for cold storages to plan a timed release, on the basis of market opportunity. The price to farmer is very dependent on whether they need immediate monetisation or have the capacity to hold stock until a more favourable demand supply situation arises.

Export is also assumed by cold storage owners in the producing areas. A steady state of domestic price is disrupted when exports are curtailed on short notice or stocks are running out. However, if stock is already assigned and stored nearby target consumption centres or cities, it will help to balance such variations. Cross regional trade of potato can be done on the eNAM platform. A project can transport potatoes at first instance, to cold storage at cities, distant from the producing areas, and in the process allow farmers to avail post-harvest loan. Any external supply chain disruption at target cities can be mitigated by releasing this co-located inventory, to the advantage of farmers, while simultaneously dampening any high price fluctuations. To facilitate the early movement to market destination, a freight subsidy can be provisioned, so that farmers are encouraged to take up off-location storage (see case study in Vol III, 6.6.4). This will also help bring any underutilised storage capacity in other parts of the country into use, and avoid capacity overruns in the potato producing regions.

6.4 Onion

Onion features almost daily in the consumers' diet and commonly used as an important ingredient in most dishes. Onion can also be harvested before or soon after bulb formation, while immature, used as spring onions or leeks when even the green leaves are edible. However, the mature onion bulb is most commonly used, after a simple curing procedure. Once the bulb is cured with a layered dry exterior, the onion is a hardy and durable food item, easy to store and transport. For this reason, it was a common companion of travellers from ancient times. Onion was probably domesticated almost simultaneously some 7000 years ago, as there are different species found all over the world.

Onion once properly cured after harvest, stays fresh for 3 to 4 months if kept free of moisture, even without the cold-chain. Spoilage can be prevented with fresh air ventilation and by avoiding exposure to high humidity conditions. Water deposits on onion can cause fungal growth and rot.

The domestic per capita onion consumption has shown a significant growth in recent years. Based on NSSO data, per capita consumption at household level, during period 2004-05 to 2009-10, has increased by 32 per cent in rural areas and 18.6 per cent in urban areas, implying an average annual growth rate of 6.4 percent and 3.7 percent respectively. Being an essential ingredient in most non-vegetarian cooking, the increasing trend in consumption of meat and poultry meat should also translate into increased onion demand. Besides, about 1 million tonnes of onion goes for further processing such as dehydration, pickling, etc. Seed use of onion bulbs is estimated to be around 50,000 tonnes per year. Thus total annual consumption requirement of onion is 2012-13 is estimated at 12.5 million tonnes, growing at around 6 percent annually.

6.4.1 Status of Onion in India

Onion is one of the oldest vegetables known to humankind and being consumed worldwide. Today, onion ranks sixth among the world's leading vegetable crops in terms of overall production. Like other condiments it is widely used in culinary preparations and as a flavouring agent. Among different factors water will exert a profound effect on growth. Onion being a shallow rooted bulb crop is highly responsive to better irrigation. Major onion growing States are Maharashtra (30.41 per cent), Karnataka (15.51 per cent), Madhya Pradesh (13.66 per cent), Rajasthan (6.49 per cent), Gujarat (6.31 per cent), Bihar(5.7 per cent),Andhra Pradesh (4.21 per cent).

Table 6.4 Onion production trends

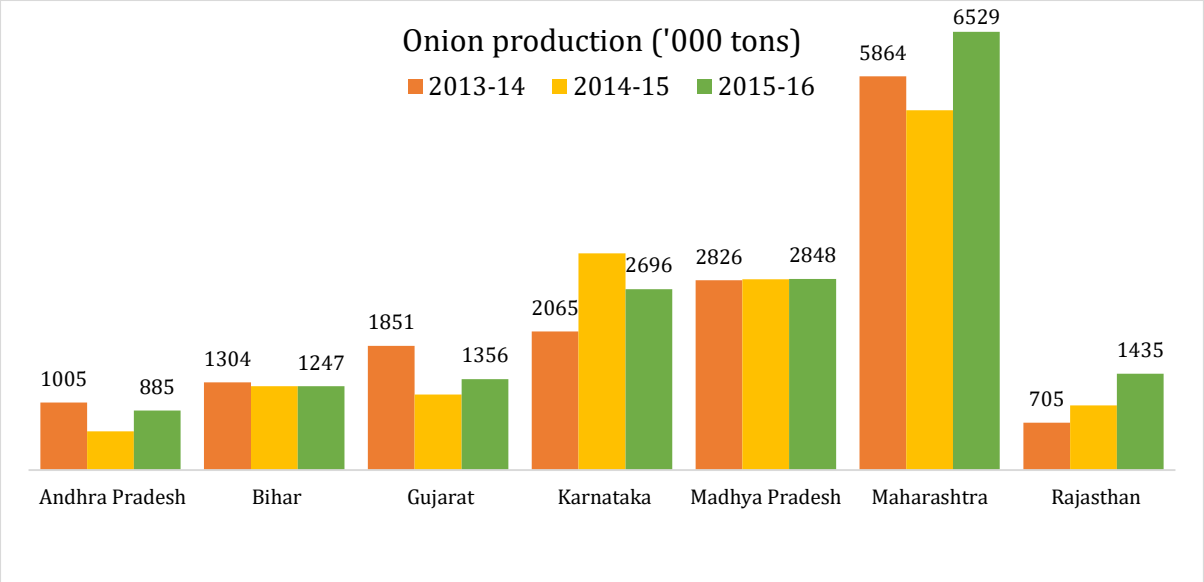
State	2010-11		2011-12		2012-13		2013-14		2014-15		2015-16	
	A	P	A	P	A	P	A	P	A	P	A	P
Andhra Pradesh			49	825	87	1560	56	1005	38	576	45	885
Arunachal Pradesh												
Assam			8	24	9	31	7	29	8	32	8	80
Bihar			54	1237	53	1108	54	1304	54	1247	54	1247
Chhattisgarh	11	174	14	222	18	269	20	310	20	308	23	376
Goa												
Gujarat	62	1514	61	1562	29	704	73	1851	44	1127	53	1356
Haryana	22	454	27	590	28	604	30	672	29	640	31	706
Himachal Pradesh	2	36	2	36	2	39	2	44	2	39	3	48
Jammu & Kashmir	3	64	3	65	3	65	3	65	3	65	3	65
Jharkhand	15	305	16	318	17	322	16	321	16	323	15	255
Karnataka	191	2592	177	2451	160	2396	137	2065	187	3227	190	2696
Kerala									0	0	0	0
Madhya Pradesh	58	1022	88	1957	112	2691	117	2826	118	2842	118	2848
Maharashtra	415	4905	382	5638	260	4660	468	5864	442	5361	522	6529
Manipur							0	4	0	5	0	5
Meghalaya			0	4	0	4	0	4	1	4	1	5
Mizoram	0	1	0	4	0	4	0	4	1	10	2	8
Nagaland			0	3	1	6	1	8	1	8	1	7
Odisha	35	386	35	419	35	419	36	432	33	396	33	379
Punjab	8	182	8	183	8	184	8	185	8	188	9	194
Rajasthan	49	494	73	664	139	476	57	705	61	961	86	1435
Sikkim	0	2	0	2	0	2	0	2	0	2	0	2
Tamil Nadu	34	339	37	556	38	430	40	473	26	260	37	381
Telengana							24	424	24	451	21	396
Tripura									0	3	0	1
Uttarakhand	4	38	4	39	4	39	4	36	4	41	4	42
Uttar Pradesh	23	369	24	383	27	474	24	410	24	414	25	423
West Bengal	21	298	22	305	22	309	24	343	25	380	34	545
Total	**953**	**13,174**	**1,086**	**17,488**	**1,051**	**16,797**	**1,203**	**19,385**	**1,173**	**18,909**	**1,319**	**20,914**

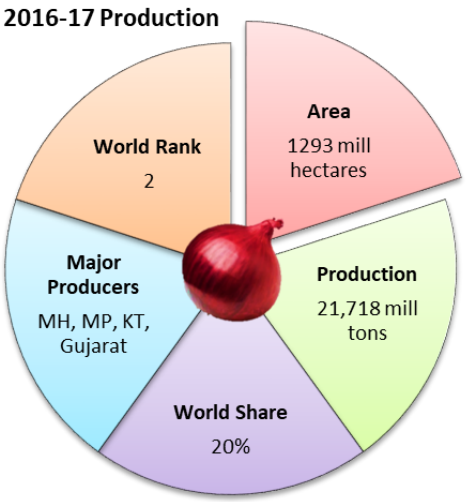
A is sown area in '000 hectares; **P** is production in '000 metric tonnes

Source: Horticulture Division (DAC&FW)

Onion is grown in kharif and rabi cropping seasons. The kharif harvest is usually with higher water content and more susceptible to bruising and associated spoilage. The rabi harvest has a lower water content, and easier to store. is In Gujarat, Bhavnagar region, white onion bulb is produced, almost exclusively for export purposes, while the Indian consumer prefers the more pungent red or brown onion, along with some seasonal consumption of the immature green in winters.

Figure 6.4 Major onion producing states





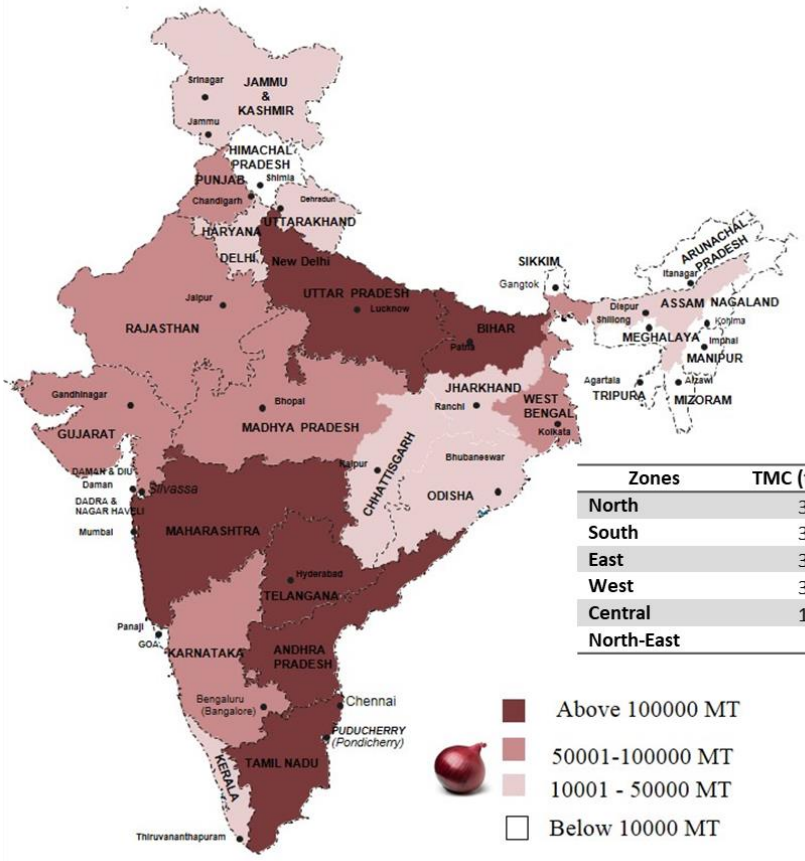
ONION - Peak and Lean Season

Major States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
MH	Lean		Peak	Peak	Lean						Lean	Lean
MP	Lean		Peak	Peak	Lean							Lean
KT				Peak	Peak	Lean		Lean	Peak	Peak	Lean	
Guj	Lean	Peak	Peak									Lean

Lean Season Peak Season

Developing varieties, cultivation practices and technologies suited to varied environments so as to dilute regional concentration in production and marketing have its own significance in price stabilization in a long term mode. Since, the production of crops like onion is highly seasonal in many growing areas (restricted to rabi season), it is necessary to popularise onion production in the kharif as well with suitable technology support.

Total Monthly Consumption Profile of Onion



Zones	TMC (tonnes)
North	398121.8
South	367121.4
East	362027.9
West	329078.9
Central	119218.5
North-East	31615.7

Total Monthly Consumption (TMC) of Onion in MT

State	TMC
Andhra Pradesh	135901
Arunachal Pradesh	850
Assam	23190
Bihar	171740
Chhattisgarh	30096
Delhi	23512
Goa	2752

State	TMC
Gujarat	71511
Haryana	43058
Himachal Pradesh	9362
J & K	17662
Jharkhand	45958
Karnataka	85113
Kerala	43990
Madhya Pradesh	89122

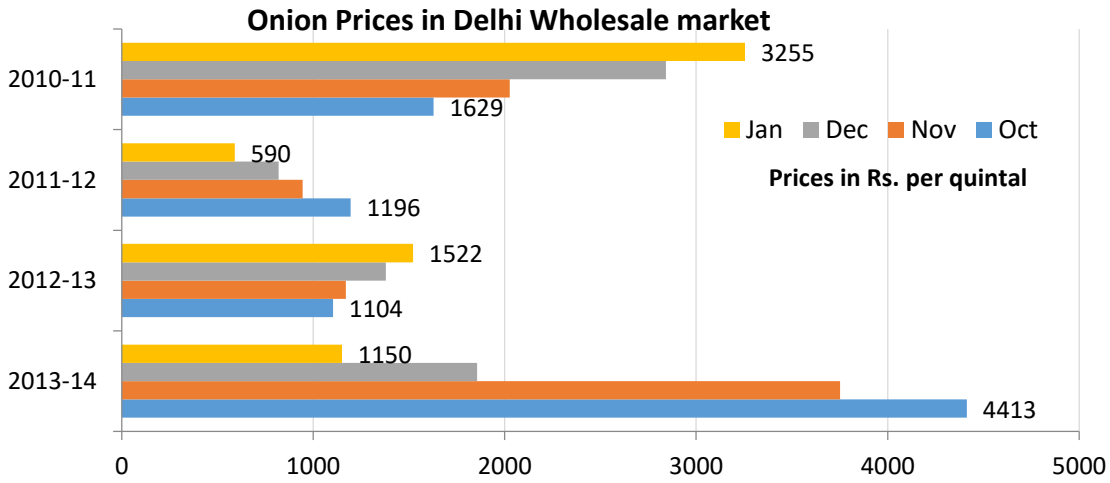
State	TMC
Maharashtra	158736
Manipur	1194
Meghalaya	1999
Mizoram	545
Nagaland	898
Odisha	45733
Punjab	61697
Rajasthan	96079

State	TMC
Sikkim	426
Tamil Nadu	102118
Tripura	2514
Uttar Pradesh	229735
Uttarakhand	13096
West Bengal	98596
All India	1612406

Source: NSSO data, extracts from NCCD.2015 AICIC Study

The wholesale prices in Delhi market indicate how onion prices increased month-on-month from October to January in 2010-11, the trend reversing for the same period the next years and the pattern repeating in following years. That the range of change in price was not directly in ratio to the changed supply also indicates that other factors influenced the price situation.

Monsoons and post monsoons are generally lean periods for onion, especially if the previous rabi crop is depleted or damaged due to poor holding conditions. This is also the season when road traffic is impacted due to rains and transport is disrupted due to weather conditions. If conditions are known to have delayed or effected the post monsoon rabi sowing, the expectation of a supply gap also tends to increase the price of onion in wholesale centres.



6.4.2 Gainful Productivity

India is the second largest producer of onions, just a million or so tonnes short of China. India can become the largest producer in the world, provided the onion output does not depress market prices and instead find market abroad.

Out of the trio, onion and tomato are most sensitive to supply variations, which is reflected immediately in large price swings in the market price of these two items. However, unlike tomatoes, in case of onions the reason is not the basic lack of suitable market linkage. Onions can safely travel long distances to market in ordinary ambient conditions and the price is affected by transport delays (due to various reasons), on forecasts of next sowing or harvest statistics, and spoilage that may occur at holding locations. The areas that grow onions, are also regions that receive monsoon rains in advance of the rest of the country, and harvested onions inclement moist conditions. In fact, the onset of monsoons also serving as an indicator to next seasons sowing cycle, the combination can cause a wild swing in prices by the time monsoons is over. This pattern can be mitigated by moving the onion into the northern regions before start of rainfalls. On the other hand, usually agencies like NAFED and SFAC are asked to procure onions for northern markets like Delhi, only after the price swing has occurred.

Onions have two forms of storage for extended periods. In countries where ambient temperatures are cooler and hence cost of keeping a space cool is low, onions can be kept at about 2°C (at 65 per cent humidity) in cold stores for 4 to 6 months. However, this is suited for Himalayan cool climates in India. In the warmer regions of the country, the onions can also be stored between 27 to 35°C provide they are regularly aired and kept dry. Between 20 to 27°C the temperature is most suitable for germs and infestation and not preferred for storing onions.

The covered *jaali* type storage structures, improved upon and recommended by NHRDF (National Horticultural Research and Development Foundation, the premier agency that has focused on onion cultivation and post-harvest handling), normally created at village level in hand of farmers, is a cost effective method for storing onions, with minimal spoilage for 3 to 4 months. Care should be taken that the roof overhang is not shortened and is sufficiently long and angled, so as to ward off any wind driven rain from wetting the dry onions.

Onions can also be flash dried (whole, flaked or powdered) and vacuum packed, pickled or undergo other food processing techniques. This can also be adopted for long term storage and supply of onions to markets, to mitigate price fluctuations from supply fluctuations. However, this will required wide scale acceptance from consumers, to make any ready impact to the periodic inflationary situations that are witnessed.

6.4.2.1 Envisaged marketing supply chain model

Onion is amenable to long term holding, in a well aerated storage structure, at production location. However, it quickly deteriorates when exposed to humid conditions and rain. The market supply can avail a delayed, but planned movement into terminal markets. The crop does not mandate specialised packaging or refrigeration in storage or transit from farm-gate to consumer. An operation can look at optimising the design of farm-gate *jaali* storage system, and subsequently evacuate to terminal markets, using ordinary transport.

Evacuation of the *rabi* crop from farm-gate storage should be scheduled well before the start of monsoon rains, and it can then be stored in the name of farmers at peri-urban located storage. The disruption in supply usually seen after the rains, which causes annual price fluctuation, can be eased by releasing the stock from the peri-urban storage. The farmers can remain owners of the produce till terminal wholesale, and can be accordingly assured a share of price realised. Post-harvest loans can also be facilitated. In case of late *kharif* onion, the evacuation from farm-gate can be conveniently timed to counter winter fog and other expected supply disruptions, bringing the peri-urban storage into use once again. The peri-urban locations can also use net-packing systems for the onion for brand appeal. Skin and other waste at these bulk storage locations, can be utilised to extract phenolic compounds and flavonoids. As and when the consumer shifts preference to flaked or frozen red onion, the established supply chain can divert required volume to any associated onion processing unit. The project will therefore need to maintain suitable ventilated storage at peri-urban locations, lease ordinary trucks, and strengthen the smaller onion storage with the farmers at the back-end.

6.5 Annotation

The fluctuation in vegetable prices, which is very well established as 'seasonal,' is associated with the economics of demand and supply fuelled by the clash of interests between the consumer, the producer and the middlemen. The prices of tomato, onion and potato fluctuates owing to disparity between demand and supply on account of a drop in production because of unfavourable weather, a rise in transport costs, seasonality and supply chain constraints.

Historical price trends show a clear pattern in price spikes and high prices rule only for a few months. To reduce the supply and price fluctuations, a complementary storage option to be developed to locate buffers of onion and potato close to the markets. These need not be high technology systems but designed to cater to a two week inventory cycle from the buffer into market.

Potato seed production at present is being taken up only in a few states like Punjab, Haryana

and Uttar Pradesh. The seeds produced in these states are supplied to other producing states of the country. Seed production in states like Karnataka, Madhya Pradesh, Gujarat and Odisha can be promoted, so that the farmers of these states may get quality seed at reasonable prices.

Protected cultivation of tomato under different Central Sector Scheme needs to be promoted in different peri-urban areas, to meet the demand during lean period, i.e., from July to October.

Area expansion programme for Kharif and Late Kharif Onion can to be taken up in non-traditional states like Madhya Pradesh, Rajasthan, Haryana, Bihar, Odisha and Gujarat to avoid the pressure on Maharashtra, Karnataka, Andhra Pradesh etc. during lean period i.e., July to March. Onion seed production is presently being undertaken by traders in the states of Maharashtra, Gujarat and some part of Madhya Pradesh, to supply the seed all over the country. Suitable seed producing pockets in other state like Rajasthan, Punjab, Bihar and Odisha can be developed so that there is more availability of seed at reasonable price, across the country.

Special focus for developing alternative marketing system, outside the existing that is largely centred around Lasalgaon can be promoted. Onion storage capacity is required to be enhanced in the states of Madhya Pradesh, Rajasthan, Gujarat, Uttar Pradesh, Bihar, Odisha, etc. to cater the needs of north and north eastern regions of the country.

Key Extracts

- Potato, tomato and onion are the vegetable crops trio are most sensitive to supply variations and markets prices are seen to swing for short duration seasonally.
- Monsoons and post monsoons are generally lean periods for onion, resulting in drops in supply and price fluctuation. Onion cultivation can be expanded into other regions, which will allow a spread in the supply period.
- Tomato is the most widely grown vegetable crop in India and is grown throughout the country, mainly the variety suitable for fresh table consumption. Expanding the range of market connectivity is necessary to balance demand with supply.
- Unlike tomatoes, potatoes can be stored for a full year, until the next harvest. Production planning to suit market demand will mitigate surpluses that depress prices for farmers.
- It is noted that hefty majority of the cold stores developed in the country are for storing and trading in potato. However, in a scenario of oversupply, this does not result in gains as demand is saturated. Expanding into exports markets is needed.
- For gainful returns from production, efficient marketing and agri-logistics is necessary. This will promote access to markets and ability to select markets that return higher value to farmers.

Chapter 7
Horticulture - Observations & Recommendations

Horticulture deals with food, non-food, medicinal and aesthetic produce. The observations and recommendations for horticulture sectors are all encompassing. The recommendations below are listed by thematic activity with an approach to enhancing farmers' income.

7.1 Production through Productivity

(i) Field level productivity: Growth enhancing technologies, pest management systems and farming practices like precision farming are important aspects that need to be promoted. This will also require focused extension services. Most importantly, the crop planning and intercropping with horticultural commodities needs to be actively supported including bund planting of selected horticultural crops.

(ii) Planting material: A good quality planting material is pre-requisite for increasing productivity. Moreover, the juvenile period is also longer in horticultural corps during which sizable investment will be made. In this scenario, unless the truthful/genuine planting material is ensured, the farmers will be exposed to great loss. To this extent the present system of accreditation of nurseries to be made mandatory.

(iii) Since horticulture is evidently a future growth driver in the agricultural sector, the committee recommends a higher allocation of resources in the R&D system to develop disease and climate resilient varieties for the farmers' welfare. Further, there is need to fast track the selection and sourcing of such varieties which are available globally.

(iv) Rejuvenation: Special incentives that focus on replacing senile orchards and covering a larger area and crops, is needed. A limited rejuvenation promotion system is active and this needs to be strengthened. The support needs to buttress the farmers, at least until start of the fruit bearing cycle.

(v) Reducing post-harvest losses: To fetch optimal value, the horticultural produce must reach the consumer in marketable condition. The horticultural sector is marked by a very high degree of physical loss due to perishable nature of the crops involved, which results in value loss. The pre and post-harvest systems are inadequate, and by & large all crops are harvested simultaneously without considering the demand and the time to reach end-consumer. The cool chain for perishables, which includes post-harvest preconditioning, transport and efficient marketing, is an essential value added activity for farmers. The need to efficiently link the produce to market, while minimising loss, or by reutilising the waste as material for processing is important. This loss that prevails is effectively wasted productivity and requires urgent attention. The horticultural market supply system, in particular the cold-chain needs to be strengthened by creating PRAMs (aggregation hubs at village level as has been recommended in DFI Vol-4).

Due to perishable nature and the existing level of losses, any further increase in area or productivity in horticulture, should be integrated with associated development in the post-harvest management requirements. As such, higher production may be supported only with

equal support to the PHM system in the target areas. Food loss and wastage is a moral issue negatively affecting the global economy mainly caused by the poor functioning of the production and distribution of the supply chain. Both the public and private sector have a role to play. Furthermore, food loss reduction is normally less costly than equivalent increase in food production. FPOs that specialise in horticulture can play an important role, provided they are given suitable training.

7.2 Input management and Resource-use efficiency

(i) Fertilizer Subsidy and Rationalizing the NPK pricing: The gap in retail price of Urea and other fertilizers has seen to be widening. Indian farmers tend to overuse urea as it is cheaper and highly subsidised, compared with other macronutrients such as phosphorous and potassium fertilizers, prices of which are not regulated. Therefore, unless corrections are made in the fertilizer price policies, the benefit of soil health card (SHC) will not be realised. The SHC is intended to assess and maintain appropriate NPK ratio in the soil to improve efficiency and reduce unnecessary fertilizer use. The use of soil health card can play an important role in horticultural crops which have high nutrient demands. The Soil Health Cards should be made mandatory for where horticulture based crop clusters are being developed. In the coming years along with soil testing, leaf or tissue analysis be practiced to correct the imbalance of nutrients in the plant system which is vital for increased productivity as well as quality of produce. Most perennial crops are amenable for this intervention as critical stages have been identified in majority of crops and standard protocols are already available. The judicious use of micronutrients in vegetables and fruit crops after soil analysis will help farmers to increase the productivity and the quality of these high value crops. The fertilizer policy should promote crop and area specific, specialty fertilizers and fertigation, besides setting of standards and regulating bio-fertilizers under Soil Health Mission.

(ii) Integrated water use policy. There is need to critically examine several ongoing initiatives and develop its country-wide system for judicious and integrated use and management of water. This will especially help resource-poor farmers in the rainfed ecosystems, who practice less-intensive agriculture. Farmers however need to be educated on water usage systems to drift them away from flood irrigation systems, which affects productivity and wastes water. The most important part is the crops planning, which needs to be done keeping water resources of a region and the water intake by various crops. For example high water consuming crops like paddy and sugarcane should be grown in high rainfall areas.

Promotion of micro /drip and sprinkler irrigation should be on high focus apart from promoting other water use efficiency / water saving technologies like mulching, crop location strategies, conversion to crops with higher economic value or productivity per unit of water consumed, and adoption of alternate drought-tolerant crops, emerging computerised GPS-based precision irrigation technologies, scientific irrigation scheduling, site-specific irrigation, anti-transparents, etc.

(iii) Crop losses estimates to thousands of crores of rupees annually and share of these losses is due to pest infestation and disease. Pesticides play an important role not only in crop

productivity and quality improvement, but also in protecting crops from pests and diseases especially in horticulture crops. There is need to check spurious pesticides in market by better regulation of registrations, strengthening enforcement, especially to support horticulture. There is also the need to revaluate existing policies, such that well established molecules, effectively in use in similar ecological environments, be allowed for use in India. Global research will otherwise remain untapped for the benefit of Indian farmers. Hence, there is need for more simplified procedure for registration of molecules without sacrificing the interest of the environment / biosecurity of the nation.

(iv) Taxes: The inputs used in horticulture sector should be made available to the growers at affordable prices for better profits. The implementation of GST in the country has brought in public outcry in the farming sector. There is need for a relook in to the rates of taxes imposed on some of the inputs like items used in drip irrigation, protected cultivation, smaller hand held implements. Soil-corrective items like lime and gypsum, water soluble fertilizers, bio-fertilizers, bio-pesticides/bio-control agents (BCA), organic manures/vermin compost/farmyard manure (FYM) and others even though put up in unit containers and bearing a registered brand name. Higher GST on bio-fertilisers, organic manures may directly promote chemical usage & impact public health.

(v) Support to Urban and Peri-Urban Horticulture: Enhancing productivity through recovering urban waste (water and solid) boots not only production of horticultural corps but also ensures fresh and quality produce to the consumers without much ado of transportation and handling. The concept of smart cities should ensure dedicated space for horticulture based activities. It should be made mandatory to frequently test the recycled urban water and compost for both microbial activity and heavy metal toxicity to ensure food safety. These activities require establishing testing facilities and also promote entrepreneurship among the youth.

(vi) ICT systems in Horticulture: This sector, in its production and post post-production phase, demands greater management, monitoring and care for which modern technologies are most helpful. Drone based high-resolution imaging (for plant health and pest detection), sensor based fertigation (for resource use efficiency), protected cultivation systems (for partial environment control) can be effected in horticulture. Such new technologies may not be immediately viable on commercial terms, though their benefits are clearly evident and accepted. Additionally the use of geographical information system, global positioning system, hyper spectral remote sensing and site specific nutrient management strategy exploiting spatial variability in soil fertility have offered tools to combat the reduced fertilizer use efficiency. Therefore, it is recommended that a higher ratio of support be allocated to new technologies.

(vii) Smart Horticulture: The country has demonstrated pockets of excellence in using precision farming, high density plantation, protected cultivation and organic or residue free production. Such smart practices need to be actively promoted across regions so that more number of horticultural farmers can benefit equally. Therefore, it is recommended that a special mission may be commissioned for smart horticulture. This would also promote future ready technologies and practices such as aquaponics, aeroponics, led based in-house cultivation, vertical farming, and any other modern systems as they develop. Since, vegetables are a major component of the Indian diet and urbanisation is growing, having horticulture staying in

advance of future demand is going to be a critical strategy. Smart Horticulture would be synonymous with the concept of Smart Cities. Conversely, smart city designs should incorporate an area designated for smart horticulture.

(viii) Phyto-remediation through horticulture makes land reclamation more viable. Districts with identified land for reclaiming may prepare a roadmap to introduce horticultural crops, that are locally in demand, for this purpose. Many of the horticultural crops which are not in the food chain, like aromatic and floricultural crops, can be candidate crops in lands that are otherwise not utilised due to heavy metal contaminated soils. This will allow, bringing in more area while releasing areas of good soil for food crops. There is also large tracts of land that is not arable due to reasons, such as high salinity, but can be utilised for protected cultivation (soil-less cultivation) and/or other horticultural activities. The task, to oversee and guide land reclamation strategies and implementation, may be mandated to a suitable existing agency like NRAA, SLUSI or other similar organisations.

7.3 Market linkage & Trade

(i) Marketing Board: there are various commodity specific Boards in the country to support the target crop. The support invariably is keeping production system as its thrust area. It is felt that at the national level, two Marketing Boards that specialise in storable and non-storable crop types be developed. One may focus on "store and sell" operational model and the other would specialise in "connect and sell" model, especially with mandate to access the unified national market as well as to support export promotion (to support APEDA). These marketing boards may be set up under PPP mode with a special one-time grant by the government. The Boards will liaise with state level marketing organisations and be in alignment with the National Value System Platform as proposed in DFI Vol-4.

(ii) Agri-supply chain and storage infrastructure, including market yards need to be strengthened. More multi-purpose market yard complexes, comprised of aggregation hubs including pre-cooling of horticultural produce, farmer's service centres, reefer transport (road and rail), cold storage, etc. need established for direct use of farmers, as users or under FPO management. Already, under RKVY a higher allocation for creation of infrastructure has been provided. However, the infrastructure components may be properly planned for at District or State Level, so that it is in convergence and relevant to the produce, market connectivity and allied activities. The same approach may be adopted by other govt. agencies that support infrastructure creation.

(iii) Adoption of the Model APLM 2017 Act: Perishable produce suffers a bulk of its losses due to repeated handling at each transaction level. The existing APMC Act, requires intermediary marketing which causes repeat handling of produce. Therefore, there is need to have a facilitation approach rather than a regulatory approach in perishable marketing, and this is provided under the new APLM Act, 2017. This Act also facilitates licensing for existing cold storage and warehouses as markets, which will in turn minimise unnecessary handling losses. Horticulture Mission in States should actively promote the adoption of APLM Act 2017 for furthering horticultural growth.

(iv) Reforms to the marketing system to permit pan-India trades, electronic auctions and trading in warehousing receipts. Enactment of policies that enforces the standardisation of agricultural produce such that graded product would have a form of a logo or label mandatorily attached to it to signify that the product meets all the standardisation and grading requirement for packing, sealing etc., and only traders who are willing to follow the regulation are given "Certificate of Authorisation".

(v) Farmers' vertical integration with food and non-food processing. Like agriculture, horticulture offers processible variety raw material to feed processing industries. Certain key crops like potato, tomato, grape, etc., can be converted into processed food items in case variety produced is for non-table use. In some, juicing, pulping, pickling from culled produce is done and various additives are also generated. In all such cases the horticultural farmer is vertically linked to the industry and to promote this, specialised varieties which are more amenable to processing need to be encouraged. Others like coconut, banana, bamboo, etc. also provide raw material to fibre and composites manufacturing sectors. Further, medicinal and aromatic crops are also primarily produced for processing industry. Spices are a regular food processed item of horticulture. While processing industry can focus to vertically integrate farmers that produce processing variety of crops, it should equally pay attention on value addition to recover value from residual waste and non-marketable surplus of food crops. Wherever fresh whole food marketing is possible, this should be given priority, with processing stepping in to integrate with farmers to extract value from non-marketables. This, thereby, will help farmers capture maximum value from their output.

(vi) Tariff and non-tariff barriers: It is now time to exploit and further the potential in production, value addition and export of vegetables and fruits as India is already a grain-surplus and grain-exporting country. Due to shift from tariff to non-tariff barriers in international trade more regulation of the industry to comply with the new market requirements has been necessitate. Different government agencies involved in regulating the industry need to come together and avoid delays and reduce the cost of complying with non-tariff barriers.

(vii) Quality Control: For better realization of the price, especially for exports, it is necessary to comply by the stringent export quality standards failing which would lead to barriers in trade. Growers often lack awareness on export quality requirements and do not follow the recommended practices leading to low quality produce with high pesticide residue again leading to rejection of the produce. Hence, it is necessary to promote awareness among farmers in this direction and advocate good agricultural practices is the need of the hour.

(viii) Market Intervention Scheme: The marketing of horticultural crops is a complex process. The current Market Intervention Scheme, applicable to those commodities which are not covered under Minimum Support Price scheme, comes into picture whenever there is a drastic drop in the price of the commodity. This requires quick intervention in case of horticultural crops, but the current institutional mechanism causes delays in implementation. Under the current mechanism, the state governments approach the Centre when there is crisis in the market, when a committee is setup to examine the request and to estimate the cost of production to fix the MIS price.

This process delays subsequent market intervention by the state, and hence, the very purpose of the scheme is defeated. To overcome this lacunae, it is suggested to set up a body in the system for which the members be drawn from DAC&FW, ICAR, SAU and State Governments, etc. which prepares advance guidance value for major crops, particularly tomato, onion and potato every season so that the response will be quick and state governments starts procurement process.

7.4 Diversification into and in horticulture

(i) A shift of five million hectare in next five years is suggested from different agro-ecological zones that is suitable for suggested crops. This area may also cover crops in temperate region, foothills, dry-land, planting along the river banks etc. The states may develop the district plans to target this initiative as forward and backward linkages are essential to absorb this increased production of perishable commodity; otherwise there is huge danger form problems of plenty leading to distress sale. This must be matched with appropriate infrastructural and logistic support, a chunk of area be shifted from cereal/grain based agricultural crops to horticultural crops like fruits and vegetables & within high value horticultural crops for generating higher returns to farmers.

(ii) Convergence of central and state subsidies to boost integrated farming. Horticulture is integral to integrated farming system, where horticultural crops are part of the cycle of dairy, poultry, fisheries, piggery, bee keeping etc. The waste from livestock generates manure and trimming of vegetables etc. is feed for the livestock. Similarly, presence of bees and flora in the integrated system is invaluable. Beekeeping aids in self and cross pollination of the crops, increasing the production and productivity and the by-product of this system is honey& other value added products and it is an additional money for the farmers. It is recommended that integrated farming as a commercial model be supported through the incentives mechanism.

(iii) Crop area estimates should be published at frequent intervals like that in agricultural crops to prepare the market on the arrivals and to aid policy makers as the produces is highly perishable, convergence of the systems becomes critical. Modern technologies of satellite imaging systems requires a boost

7.5 Credit and access to Capital

(i) Foreign Direct Investment: Horticultural sector allows 100 per cent FDI in protected cultivation. This makes horticulture unique in agricultural sectors as corporates can invest in such farming. However, this fact has not been promulgated and the general impression is that agriculture does not allow private investment by corporates, Indian or foreign.

(ii) Research & Development: Given the fact that there is higher scope for R&D in this sector, credit to private sector that wishes to carry out such R&D may be eased or provided at favourable terms. Capital investment by private sector through CSR funds in R&D may also be especially considered and promoted.

(iii) Public sector investment in R&D also needs larger allocation. Not as strong as in case of agronomic crops. Public sector R&D needs to be more robust. Leaving R&D to private sector will make the technologies unaffordable for farmers.

(iv) Financial benefits small horticulturists: Horticulture is amenable to small land holders and landless farmers. However, the land holding status prevents them from accessing various government benefits. A database of horticultural farmers, landed and without land may be developed through the state horticulture missions. Thereafter, the financial benefits, mainly incentives and subsidies, can be provided and transferred directly to the small scale horticultural farmers accounts.

(v) Horticultural tools and implements: The government has tended to support large scale farm mechanisation that mostly related to cereal grain systems. Horticulture is now the primary production system, being the largest crop sector in the country. There is need to provide equal impetus to promoting small hand held tools that are important for small scale farming, especially horticulture.

(vi) Many of the mechanisation system and automation systems used in horticulture, are not commonly used in other sectors and tend to get ignored. Lack of such support mechanism detracts from achieving the growth potential in horticulture.

(vii) Credit should be made available for perennial crops as term loan so that more marginal land can be covered in rainfed area and farmers may be encouraged to adopt such plantations.

(viii) Corporate farming: Corporate farming refers to direct ownership or leasing of farmland by business organisations in order to produce for their captive processing requirements or for the open market. When it is done for captive purposes, it is referred to as captive farming as well, though most of the time, the two terms are interchangeably used.

(ix) Contract Farming: Symbiotic contracts which confer benefits to both producers and purchasers, will be ideal for ensuring assured and remunerative marketing opportunities. A Code of Conduct for Contract Farming will have to be developed for major groups of farm commodities such as vegetables, fruits, flowers, medicinal plants, tuber crops, pulses, oilseeds, sugarcane, cereals and cotton. A farmer should not be alienated from his/her land under any circumstance. Available evidence indicates that direct contract between the producer and purchaser with the government, as third party for intervention in the case of legal disputes is more advantageous to small farmers than indirect contract through intermediary agencies. At the State level, a Monitoring Committee comprising farmers and appropriate officials may be set up to ensure the spread of a non-exploitative pattern of contract cultivation.

7.6 Dealing with Crops trio

Tomato, potato and onion are most sensitive to price fluctuations, which arise from imbalance in supply and demand. Information on seed sales, cropped area, weather, plant health and arrival forecast is critical and can help in forecasting market trend and give a tool for policy makers. The effect of rainfall and other climatic factors on production, and consequent delays in market arrival (the primary factor for triggering abnormal hike in consumer prices), feeds future expectations and fuel speculative activity.

Further, a multi-pronged, targeted strategy to improve supply chain options will help stabilise the price of these crops, besides the many short-term measures to check price fluctuations. This will require promoting logistics operations, designed specifically to suit the unique characteristics of each of these three crops (see chapter 4, Volume III). Dynamic logistics operations, on similar lines of Operation Flood, will need to be developed, to make sure that these three crops, which are always in high demand, are well connected at the pan-India level.

A close monitoring of market behaviour by appropriate market intelligence and developing reliable price forecast models to come up with early warning systems help the government to take appropriate actions in advance like procurement, regulating export, arranging imports and putting check on hoardings.

7.7 Horticulture Extension

(i) Greater attention to ATMA is needed in districts where horticulture is primary, ATMA should be led by horticulture. Productivity Gaps-Extension is one of the indicators that highlight the role of extension in horticulture sector. It is related to the flow of new technical information and to the existing state of unadopted technology. Person-to-person communication has traditionally been the most important form of information transfer in horticulture sector. However, there is need to look at alternative ways as this approach is rather expensive and impracticable considering the number of farm holdings in the country. The lack of a close working relationship between national agricultural research and extension organizations, and with different categories of farmers and farm organizations, is one of the most difficult institutional problems. There is the need to move towards specialisation and new professionalism in horticulture advisory services.

(ii) Horticulture advisory services are to be strengthened by dedicated extension teams, with special train-the-trainer activities as a starting point. Horticultural technologies are rapidly changing and keeping the trainers updated on latest developments and applications is critical.

(iii) Today, it would be difficult to imagine horticulture extension without modern information and communication technologies. Intensifying efforts of imparting of training to the farmers, unemployed youth, and officers of Govt. departments of horticulture using modern ICT tools and empowering farmers to organize themselves. Supporting Kisan Melas, Agri-fest, farmer's fair and arrangement of the exhibitions of departmental activities. Frontline demonstrations of improved varieties and technologies of fruits and vegetable adaptive trials on farmer's fields, are to be conducted. Mobile advisory service/ ICT based e-extension activities are to be strengthened. Virtual linkages are to be established for bringing research and extension together. Programmes like "virtual gardens" and "virtual farms" on the World-Wide-Web needs more encouragement. Horticulture in class room program for rural youth and farmers at their convenience should be a national program to pave way for integrated learning and discovery across disciplines, through active and engaging real-world experiences.

(iv) As the expectations with regard to extension personnel role are increasing, more robust, non-traditional strategies be evolved. These include, but are not limited, the establishment of

plant and pest diagnostic clinics in line with veterinary clinics where staff can diagnose plant health problems caused by diseases, insects or the environment and offer the best course of action. Commodity Based Extension is another approach which can be implemented on cluster basis for strengthening the production of a particular commodity with commercial or export potential.

(v) Extension as a Commercial Service is a rather recent phenomenon and is being offered by many private institutions which is picking up and needs to be promoted since, the idea of extension as a free public service is no longer being generally accepted. In the case of commercial input suppliers, the costs of extension are included in the product price, as are the costs for advertisement. Private extension services does not aim at substituting private sector for public extension service but complement the efforts of public sector involving private corporate firms, credit institutions, farmer's associations, non-governmental organizations and media organizations. Client-Based and Client-Controlled Extension is another concept in which extension work is done through farmers' associations it is to utilise the potential of local extension knowledge of and the self-help potential of rural groups. It can not only be effective but also cost saving. Interaction with the groups can also help in understanding their problems and finding suitable solutions.

(vi) Strengthening agricultural extension brings incredible opportunities and has the potential of enabling the empowerment of farming communities. Information technology can support better crop, fertilizer and pesticide use planning as well as disease monitoring and prevention, both in crops and animal husbandry, besides improving farmers' operational and financial management and to effectively connect them with the markets for better price realisation.

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Volume VIII-C

Sericulture

Chapter 8
Sericulture Farming, an Agri-business Enterprise

Silk, the special yarn spun by the work minded silkworm, is associated with luxury and is known as the queen of textile fibres for centuries. Produced from cocoons of certain larvae, sericulture is the art of raising these larvae and harvesting their cocoons. The produce has ready markets in the specialised silk textile industry. India holds a special place at the global level, when it comes to silk.

8.1 Introduction

Silk is a natural animal fibre, and is the protein material produced by certain insect larvae to create their protective shell, the cocoons. Sericulture is the art of raising these larvae and harvesting their cocoons. Harvesting is carried out by unravelling the cocoons into silk threads, and the threads are then turned into silk fabric by the agro-industry. Silk fabric has a natural sheen, due to the triangular, prism-like, cross section of the fibre, which allows it to refract incoming light at different angles.

There are different types of silk, which is primarily linked to the food on which the silkworms feeds. India is host to majority of the silk types, though mulberry silk dominates.

Table 8.1 Commercially exploited sericigenous insects of the world and their food plants

Common Name	Scientific Name	Origin	Primary Food Plant (s)
Mulberry Silkworm	*Bombyx mori*	China	*Morus indica, M. alba, M.multicaulis, M.bombycis*
Tropical Tasar Silkworm	*Antheraea mylitta*	India	*Shorea robusta, Terminalia tomentosa T. Arjuna*
Oak Tasar Silkworm	*Antheraea proylei*	India	*Quercus incana, Q. serrata, Q. himalayana, Q.leuco tricophora, Q. semicarpifolia, Q. grifithi*
Oak Tasar Silkworm	*Antheraea frithi*	India	*Q. dealdata*
Oak Tasar Silkworm	*Antheraea compta*	India	*Q. dealdata*
Oak Tasar Silkworm	*Antheraea pernyi*	China	*Q. dendata*
Oak Tasar Silkworm	*Antheraea yamamai*	Japan	*Q. acutissima*
Muga Silkworm	*Antheraea assama*	India	*Litsea polyantha, L. citrate Machilus bombycine*
Eri Silkworm	*Philosamia ricini*	India	*Ricinus communis, Manihot utilisma, Evodia fragrance*

Source: Central Silk Board, GoI

Except for mulberry silkworm, other varieties of silks (which are non-mulberry) are generally termed as vanya silks, where Vanya refers to forest that host the tree species on which the silkworms grow up naturally.

Sericulture is a labour intensive sector and much suited to the countries like India wherein more than 85 per cent of the farmers are small and marginal. The very nature of this industry with its rural based on-farm and off-farm activities and enormous employment and income generation potential makes it among one of the most appropriate tools for socio-economic development of a largely agrarian economy like India. Sericulture involves four different yet inter-related activities, namely, food plant cultivation as feed source to silk worms; rearing of silkworms to produce cocoons; reeling of cocoons to produce raw silk; and weaving, printing/dyeing. India has the unique distinction of being the only country producing all kinds of commercially exploited natural silks namely, Mulberry, Eri, Muga, Oak Tasar and Tropical Tasar. However, mulberry silk is the dominant one and contributes to about 70 per cent of the country's raw silk production.

India is the second largest producer of silk in the world after China. China and India together account for about 98 per cent of the global raw silk production of about 2,02,073 metric tonnes (MT) during 2014. Uzbekistan, Thailand, Brazil, Vietnam, North Korea and Iran are other major silk producing countries. The silk production has drastically reduced in developed countries such as Japan, Italy, France, South Korea etc., due to uneconomical labour. China is also now facing problem of increased labour cost. In this context, there is tremendous scope for India to increase her silk production in the country to emerge as a leading supplier of raw silk and silk products in domestic as well as the international market because of the following:

1. Salubrious subtropical climate enabling sericulture activates round the year
2. Suitable soil for cultivation of related food plants
3. Traditional knowledge blended with cutting edge technologies
4. Abundant work force at reasonable cost
5. Good extension network supported by excellent R&D Institutions
6. Well-developed infrastructure and policy support

Table 8.2 World Raw Silk Production during 2008- 2015

Country	**Raw Silk Production (metric tonnes)**					**% share**
	2011	2012	2013	2014	2015	
China	1,04,000	1,26,000	1,30,000	1,46,000	1,70,000	84.13
India	23,060	23,679	26,480	28,708	28,523	14.12
Uzbekistan	940	940	980	1100	1200	0.59
Thailand	655	655	680	692	698	0.35
Brazil	558	614	550	560	600	0.30
Vietnam	500	450	475	420	450	0.22
North Korea	300	300	300	320	350	0.17
Iran	120	123	123	110	120	0.06
Others	153	149	149	148	132	0.07
Total	**1,30,286**	**1,52,910**	**1,59,737**	**1,78,058**	**2,02,073**	**100.00**

Source: International Sericulture Commission (ISC)

8.2 Current Scenario of Sericulture Industry in India

India has an annual silk output of 30,348 metric tonnes, of which mulberry raw silk aggregated to about 21,273 metric tonnes during the year 2016-17. Within the category of mulberry silk, production of bivoltine silk has achieved momentum, growing at 20.92 per cent per annum in the period 2011-12 to 2016-17. Bivoltine silk is superior to multivoltine or cross breed silk in respect of quality, though the latter surpasses in terms of output. The Vanya silks, which include tasar, eri and muga silks, are also growing rapidly in the recent years. Vanya silk recorded a compound growth of 11.25 per cent per annum during the period between 2011-12 and 2016-17.

Silk has over centuries has entertained itself with the life and culture of the Indians, besides commerce. India has a rich and complex history in silk production and its silk trade dates back to 15th century. Sericulture is practised by about 1.2 million families and the associated industry provides employment to approximately 8.51 million persons in rural and semi-urban areas in India. Of these, a sizeable number of workers belong to the economically weaker sections of society, including women (women participation in sericulture is around 55 per cent).

Table 8.3 Raw silk production in India during 2011-12 to 2016-17

Particulars		2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	CAGR (%)
A	Mulberry Plantation (ha)	181089	186015	203023	219819	208947	216810	3.05
B	**Mulberry Raw Silk (metric tonnes)**							
	Bivoltine	1685	1984	2559	3870	4613	5266	20.92
	Cross Breed	16587	16731	16917	17520	15865	16007	-0.59
	Sub-Total (B)	**18272**	**18715**	**19476**	**21390**	**20478**	**21273**	**2.57**
C	**Vanya Silk (metric tonnes)**							
	Tasar	1590	1729	2619	2434	2819	3268	12.76
	Eri spun silk	3072	3116	4237	4726	5060	5637	10.65
	Muga	126	119	148	158	166	170	5.12
	Sub-Total (C)	**4788**	**4964**	**7004**	**7318**	**8045**	**9075**	**11.25**
Total (B+C)		**23060**	**23679**	**26480**	**28708**	**28523**	**30348**	**4.68**

DFI Committee

During 2016-17, the total raw silk production in the country saw an increase of 6.41 per cent over the previous year. The mulberry silk production increased 3.91 per cent during 2016-17 over the previous year. Similarly, vanya silk, which includes tasar, eri and muga raw silks, achieved 12.8 per cent growth during 2016-17 over 2015-16. The area under mulberry cultivation went up 3.8 per cent in 2016-17 compared to the previous year.

India's traditional and culture bound domestic market, and an amazing diversity of silk garments that reflect geographic specificity have helped the country to achieve a leading

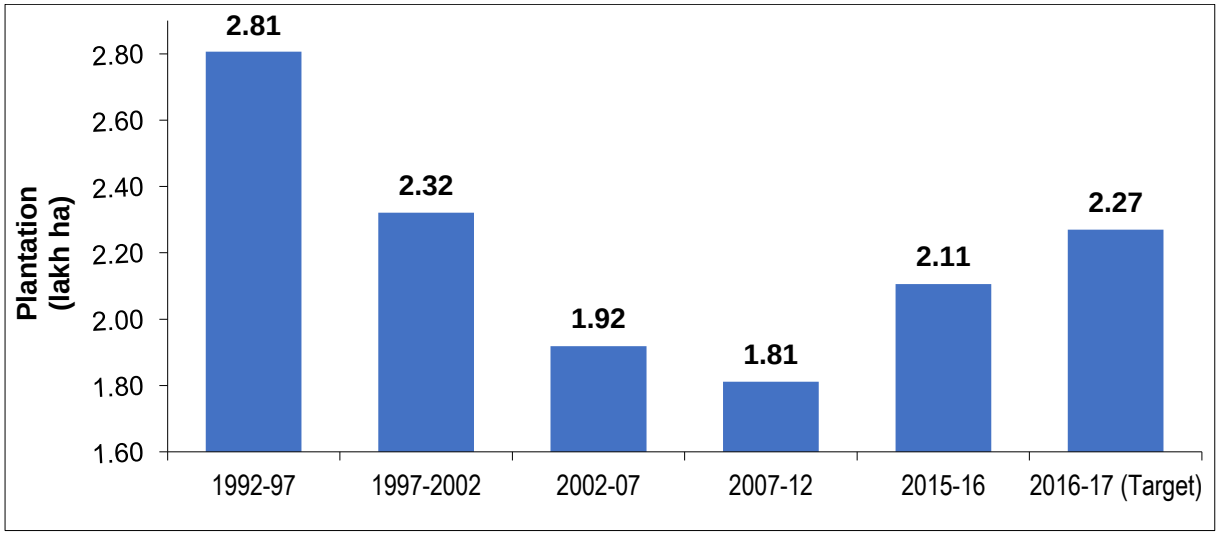
position in silk industry. India apart from being the only country producing all the five known commercial silks, it also holds the distinction as the only country producing muga known for its golden yellow glitter.

Indian Silk industry has evidenced a resurgence with various interventions having been made, and is on the threshold of renewed global identity in mulberry as well as vanya silk. This sector and allied industry is well positioned to capture a higher market share, but will continue to require new product development and expanding the range of products. End use diversification of silk fabrics to broad base its demand is important, which would be helped by generic promotion, networking and by creating Brand India.

Product diversification and development has been a pressing need of the Indian Silk Industry. Till now, silk sarees are the major product category that the industry thrived upon. The present generation is changing its dressing pattern from saree to western wear and other types of dress material. Hence, there is a need to develop newer patterns and products which can appeal to the younger generation. In the emerging silk scenario, where India is consolidating its position as the second largest producer in terms of quality as well as quantity, such diversification of products is vital. India silk Industry has certain inherent strengths that need to be projected in the right perspective and at the same time harnessed effectively.

Mulberry silk is primarily produced in the states of Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu & Kashmir of the country. These five states collectively account for 95 per cent of the raw silk production in country. However, mulberry sericulture is emerging in a big way in states such as Madhya Pradesh, Maharashtra, Uttarakhand, Tripura, etc.which were traditionally not silk producing regions.

Figure 8.1 Progress of Mulberry Plantation in India

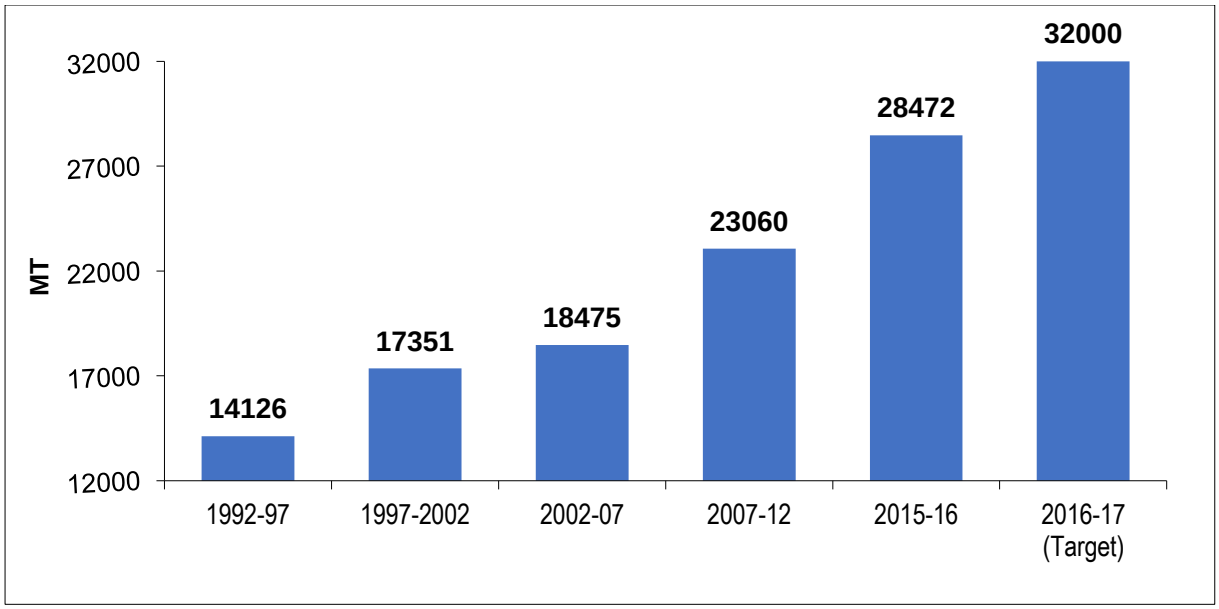


Source: CSB

With respect to tasar sericulture, Jharkhand and Chhattisgarh are the leading producers in the country followed by Odisha and Madhya Pradesh. Assam has, however, been occupying the

top position in muga as well as eri silk production. Meghalaya is the second largest producer of eri silk followed by Nagaland and Manipur. Meghalaya and Arunachal Pradesh also produce muga silk in appreciable quantities.

Figure 8.2 Progress of Raw Silk Production in India



Source: Central Silk Board

8.3 Salient features of Sericulture

Sericulture being an age-old industry practised for more than 400 years has many distinct features, which makes it more suitable and preferable relative to many agricultural crops for many farmers. Sericulture is not restricted to the agricultural activities of mulberry cultivation, silkworm rearing and seed production, but opens up into the post-cocoon sectors of silk reeling, twisting, weaving, dyeing, printing and garment manufacture. These activities in turn support the ancillary enterprises and bye product utilisation including spun silk yarn manufacture and pupae oil extraction, thus providing employment for the skilled and unskilled labour force and nurtures entrepreneurship right across the country. The progressive movement along the chain of activities is not just limited to conversion of form, but value addition as well. While, the farmers in the rural areas practice sericulture for producing cocoons, silk reeling/ spinning and weaving activities are concentrated in semi-urban area, towns and cities.

Reeling forms a vital link in converting the agricultural produce viz., Cocoon into an industrial product – the yarn. Reeling involves a series of intricate process converting the cocoons into raw silk. The reeling sector in India is highly decentralised, employing a variety of reeling devices viz., Charka, Cottage basin, domestic basin, multi-end reeling machinery and Automatic reeling machine. Unless the reeling sector is strengthened, the sericulture activity cannot be sustained. Raw silk quality improvement is therefore identified as one of the thrust areas.

8.3.1 Versatile enterprise

Sericulture is suitable to many kinds of farm situations. Mulberry, the food crop for silkworm, is a hardy and perennial crop. It can be cultivated in a wide range of soil and agro-climatic conditions both in rainfed and irrigated areas. It can be also cultivated as an inter-crop in/with some plantation crops. Sericulture can also be integrated with certain other agricultural crops, livestock, vegetables and plantation in the integrated farming system for optimum use of the available resources to maximise the productivity and thereby net farm income on a sustainable basis (Jayaram *et al.,* 2011).

Similarly, the cocoon production can also be taken up under a variety of situations. Silkworm rearing can be conducted on a range of scales - very small, medium and / or very large. Silkworms can be reared in wider range of climatic and seasonal conditions throughout the year. Thus, sericulture can be considered as a versatile enterprise suitable for different kinds of farming situations.

8.3.2 Eco-friendliness

Sericulture is an environment-friendly farm occupation. Since mulberry is a perennial crop, it does not require frequent opening of land, which exposes soil to natural vagaries such as wind and water erosions. Eco-friendly technologies such as bio-fertilizers, recycling of sericulture wastes into nutrient rich organic manure, bio-control measures for pests and diseases of mulberry and silkworm, and use of safe chemicals for disinfection of rearing houses and appliances are encouraged in sericulture for preserving and promoting the natural eco-system.

8.3.3 Suitable for weaker section of the society

The average holding size of agricultural land has declined from 1.01 ha in 1992 to 0.592 ha in 2013. The marginal ownership category (0.002 ha -1.000 ha) has registered an increasing trend from 52.98 per cent households in 1971-72 to 75.41 per cent households in 2013 (National Sample Survey Organization, 2013).

As sericulture is highly suitable to small and marginal farmers, because of its higher income generating nature with comparatively less investment, sericulture is one of the solutions for tackling the concerns of shrinking land holding sizes of farmers. Many of tasks are also easily taken up by the elderly as home employment offering them gainful occupation.

8.3.4 Women friendliness

An important feature of sericulture industry is the involvement of women in the production cycle of silk to the extent of 54 per cent in different activities like mulberry plantation, silkworm rearing and silk reeling. The participation of women in Sericultural activities is significant compared to other agricultural or agro-based enterprises. The nature of work involved in the sector, namely, rearing of silkworm, spinning or reeling of yarn and weaving are such that can be done by women of all ages providing gainful home employment.

Table 8.4 Involvement of women in different Sericultural activities

Sl.No	Activity	Involvement of women (%)
1.	Mulberry cultivation	49.55
2.	Silkworm rearing	49.67
3.	Silkworm seed production	20.46
4.	Silk reeling	48.81
5.	Silk t wisting	56.34
6.	Silk weaving	49.02
7.	Dyeing and printing	41.00
8.	Silk spinning	80.00
9.	By-products utilization	65.00

Source: Shetty (2014)

8.3.5 Employment generating ability

The findings of 61st Round (2004-05) and 68th Round (2011-12) surveys on employment conducted by the NSSO indicate that the share of agricultural workforce in total workforce declined from 56.7 per cent to 48.8 per cent during 2004-05 to 2011-12. This shows, that not only fewer people were added to the workforce in agriculture but also there was a net migration of agricultural workforce to other sectors during this period. Diversification of agriculture to high value items is necessary for raising the rate of employment growth in the agricultural sector as a whole. There are only a few other farm enterprises that can match sericulture for providing employment to rural poor.

Table 8.5 Activity-wise employment generation in mulberry sericulture (per ha)

SN	Activity	Employment generation	
		Man-days	Man-years
1	Mulberry cultivation and silkworm rearing	1255	5.020
2	Reeling of silk cocoons	2250	9.120
3	Twisting	432	1.727
4	Weaving - Hand loom	438	1.752
	Power loom	122	0.486
5	Dyeing and Printing	95	0.380
6	Finishing	1784	7.135
7	Silk waste processing (Degumming and Spinning)	26	0.104
Grand Total		**6402**	**25.724**

Source: Shetty (2014)

Mulberry cultivation and silkworm rearing can provide employment for 1,255 man-days/ha/annum. The other associated non-farm activities generate 5,147 man-days by way of processing and value addition to the cocoons produced from one hectare of the land per annum. Thus, one hectare of mulberry can generate a cumulative employment of 6,402 human-days/annum.

8.4 Annotation

Sericulture farming supports village level cottage based industry. The sector involves four independent activities namely plant food cultivation, silk worm rearing, silk reeling and weaving, printing and dying. India has a unique distinction of being the only country producing all the four types of commercial exploited silks and is the second largest silk producer in the world. India has improved silk production two and half times from the year 1992 to 2017. India produced 30,348 metric tonnes of silk during the year 2017, of which 5,266 metric tonne is of high grade bivoltine silk.

When sericulture economics is compared with other agro-enterprises, farmers gets highest income and this income is spread over to 8 to 10 times in a year unlike other crops wherein farmers get annually ones or two times income. The cost benefit ratio is also quite high (1.47) when compared to other crops.

Key Extracts

- Silk worm farming and associated industry is a model example for developing village scale producer organisations, vertically integrated to village level cottage industry.
- Sericulture is eco-friendly and allows for versatile enterprise models.
- The sector is amenable to participation by women and has high job generating capability.
- Sericulture provides gainful employment and enterprise level opportunity to weaker sections of the society.
- The demand for silk is largely in traditional wear and needs to be promoted in modern textiles and non-textile uses.

Chapter 9
Sericulture Adds Vibrancy to Village Economies

Sericulture allows for flourishing village enterprises, with a larger share of the consumers' spend returning to village level stakeholders. The activities by the stakeholders are co-dependent and the output is spread across multiple and short periods in the year, resulting in sustained incomes.

Silk commodities are mostly consumed by the urban rich and middle-class consumers. In a price spread analysis conducted by Mattigatti *et al.,* (2000) on silk indicated that, about 57 per cent of the final value of silk fabrics flows back to the cocoon producers (the farmer), 6.8 percent to the reelers and 9.1 per cent to the twisters, all of whom normally live in rural areas. The weavers and traders enjoy a share of 10.7 and 16.6 per cent respectively in the chain of fabrics production. Thus, a bulk of money in the value chain system of silk fabrics shared by farmers and rural work force.

9.1.1 Value addition to the by-products

Silk fibres are natural proteins secreted by silkworms and silk contain Fibroin (silk filament) and Sericin (gum) as main components which consists of about 18 different amino acids, such as glycine, alanine and serine. Both fibroin and sericin can be used in various forms for non-textile applications. The application of silk fibroin and sericin in non-textile areas such as Medicine, Pharmaceuticals, Nutraceuticals and Cosmetic sectors would be focused for development of biomaterials, drug formulations, protein supplements and cosmetic products in future. Silk fibroin is a mechanically robust biomaterial that offers a wide range of mechanical and functional properties for biomedical applications such as mechanical properties, environmental stability, biocompatibility and biodegradability. Silk fibroin can be used as biomaterial in forms such as films, membranes, gels, sponges, powders and scaffolds.

Product diversification to bring out silkworm-based by-products for human health benefits, as feed supplements and as raw materials for cosmetic industry is hitherto an unexploited facet of sericulture industry, which has multiple commercial opportunities. Many products such as silkworm powder, silkworm pupae as human food, pupae powder, health drinks, chlorophyll, sericin, fibroin etc., which are extracted from mulberry leaves, silkworm litter, cocoons etc., have a lot of value in the food, cosmetic and pharmaceutical industries and potential valuable foreign exchange earner for the country.

9.2 Economics of Sericulture

Sericulture economics has been studied widely, both under irrigated and rainfed conditions, relating to both bivoltine and crossbreed races. A perusal of sericulture economics indicates, that sericulture under irrigated conditions using improved cross breed (Kolar gold x CSR2) and bivoltine single (CSR2 X CSR4 & reciprocal) and double hybrids (Fc1x Fc2) are not only highly remunerative, but also fetch higher income compared to any other crop grown under irrigated conditions of a given area. Besides higher income, sericulture has distinct advantage of enabling income once in every 40-45 days from two plot systems after 8-9 months of planting. Mulberry being a perennial crop, produce leaves continuously upto 15-20 years at a

regular interval of 60-70 days. This shorter and regular interval at which the mulberry farmer benefits from farm returns is an obvious advantage vis-a-vis other growing conventional field crops. The nature of income returns, shift from seasonal to near perennial.

9.2.1 Sericultural Income

By following the recommended package of practices, large number of farmers are realizing the targeted yield of cocoons and income. In South India and under irrigated conditions, majority of the farmers are practicing two plot systems and taking 10 crops per year regularly at an interval of 30-35 days.

The average income from two acres of irrigated garden is around Rs. 2,00,000 per annum, besides the benefit of regular income, 10 times in a year. Family members get all-time employment and earn additional income over and above the net profit.

The by-products from sericulture, namely, uneaten young mulberry shoots and silk worm litter to the extent of 12-15 tonnes, turns out to be a good source of organic manure after decomposing. Un-eaten foliage and young shoots serve as a good feed for cattle and buffaloes. About 15 tonnes of leftover shoots serve as cooking fuel. Considering all these multiple advantages and recommended technologies, sericulture could be a good enterprise to double the farmers' income.

Table 9.1 Annual Income from Sericulture activities of small farm holding (2 acres) (under two plot/10 crop systems with V1 variety of mulberry)

SN	Details	Cross Breed Kolar Gold x CSR2	Bivoltine Hybrid FC1 x FC2
1.	Leaf yield @ of 60,000 mt/ha/year	48,000 mt	48,000 mt
2.	No. of crops	10	10
3.	Leaf yield per crop	4,800 kg	4,800 kg
4.	DFLs to be brushed per crop	250	200
5.	DFLs to be brushed per year	2500	2000
6.	Cocoon yield per crop	60 kg	65 kg
7.	Cocoon yield per year @ 60 kg/100 DFLs CB and 65 kg/100 DFLs BV	1,500	1,300
8.	Gross income from DFL @ Rs. 300/kg of CB and Rs. 350/kg of BV	4,50,000.00	4,55,000.00
9.	Cost of cocoon production 55% of total income of CB and 60% for BV*	2,47,500.00	2,50250.00
10.	**Net income**	**2,02,500.00**	**2,04,750.00**

*Cost of production includes 60 per cent of labour cost which earned by the family labour and adds to the income of the family.

The analysis of returns across the value chain for various stake holders involved in the industry and price spread is given in Table 9.7. The closer look at the table indicates that, the primary producer (farmer) enjoys a lions share to the extent of 40 per cent in the value chain when compared to other stake holders, which signifies farmer oriented nature of the industry.

Table 9.2 Returns across the value chain and price spread

Enterprise	Raw material cost (Rs.)	Value Addition		Market margin		Price spread	
		(Rs.)	%	(Rs.)	%	(Rs.)	%
Rearers	308.40	1243.61	32.11	858.88	46.72	2410.90	40.07
Reelers		525.30	13.56	92.73	5.05	618.03	10.27
Twisters		211.87	5.50	126.80	6.91	338.67	5.63
Dyers		468.73	12.10	31.87	1.74	500.60	8.32
Weavers		1020.94	26.36	347.67	18.94	1368.61	22.75
Traders		402.24	10.37	377.47	20.57	779.70	12.96
Total		**3872.69**	**100.00**	**1835.42**	**100.00**	**6016.52**	**100.00**

Source: Murtuza Khan, Somashekar, H. and Golya Naik, "Value Chain in Silk Industry". Paper presented at National Conference on Sericulture Innovations: Before and Beyond on 28-29 Jan-2011 at CSRTI..

Note: Price Spread = Basic material cost [leaf +dfls] +Value addition + Market Margins
(6016.52 = 308.41 + 3872.69 + 1835.42)

9.2.2 Sericulture vs other crops

Various studies conducted on growth in area and production across the crops, bring out the importance of price stability and relative profitability that influence the farmers' decision regarding allocation of land and targeted produce. Sericulture generates substantial cash income in short intervals.

Table 9.10 Revenue from sericulture vi-a-vis agricultural crops

Particulars	**Net return (Rs./acre/year)**				
Source	Dandin *et al.*, (2005)	Jayaram (2010)	Srinivasulu Reddy *et al.*, (2010)	Purushotham (2014)	Subrata Trivedi and Kunal Sarkar (2015)
Study area	**Tamil Nadu**	**Karnataka**	**Andhra Pradesh**	**Andhra Pradesh**	**West Bengal**
Banana	51620		168500		
Betel nut			95240		
Citrus			50037		
Coconut		11370			
Gram					8480
Grapes			107825		
Groundnut				3848	
Mango		12670	13930	5733	
Mustard					10640
Paddy		12968			13330

Particulars	**Net return (Rs./acre/year)**				
Source	Dandin *et al.*, (2005)	Jayaram (2010)	Srinivasulu Reddy *et al.*, (2010)	Purushotham (2014)	Subrata Trivedi and Kunal Sarkar (2015)
Study area	**Tamil Nadu**	**Karnataka**	**Andhra Pradesh**	**Andhra Pradesh**	**West Bengal**
Pomegranate			60800	53636	
Ragi		4988			
Sapota			25795		
Sericulture	**47476**	**32154**	**109687**	**62883**	**52900**
Sugarcane	29625	23077			
Sunflower				2567	
Tomato		7887			
Turmeric	25707				
Wheat					5250

It can be inferred from tables above, and the studies conducted by Dandin *et al.*, (2005), Jayaram (2010), Srinivaslu Reddy *et al.*, (2010), Purushotham (2014) and Subrata Trivedi and Kunal Sarkar (2015) as in Table 9.8, that returns from sericulture are comparatively higher vis-a-vis other crops.

Sericulture not only provides a higher valued produce, but also regular income at short intervals, every 40-45 days throughout the year which is otherwise not possible with most of other agricultural crops. An assessment of costs involved is presented in following tables.

Table 9.8 Mulberry leaf production cost

SN	**Particulars**	**Value (Rs./acre)**
A.	**Operational costs**	
1	Farm yard manure	9600.00
2	Fertilizer	13294.00
3	Manure and fertilizer application	5000.00
4	Irrigation water	7500.00
5	Irrigation	4000.00
6	Inter-cultivation	4000.00
7	Inter-cultivation	6000.00
8	Shoot harvest	30000.00
9	Pruning and cleaning of plants	1000.00
10	Miscellaneous (PP chemicals, nutrients, growth promoters, etc.)	1500.00
11	Land revenue	50.00
12	Rental value of land	5000.00
13	Interest on working capital	1638.00
Total variable cost		**88582.00**

SN	Particulars	Value (Rs./acre)
B.	**Fixed costs**	
1	Apportion cost of establishment of mulberry garden	3023.67
Total fixed cost		**3023.67**
Total leaf production cost		**91605.67**

Table 9.9 Cost and return structure in silkworm rearing and cocoon production

SN	Particulars	Cost/returns (Rs./acre/year)	
		BV hybrid	**PM x CSR2**
	Hybrid		
	Chawki rearing system	CRC	CRC
	No of dfls brushed per year	1000	1250
A.	**Variable Costs**		
1	Leaf	91606	91606
2	Chawki reared worms	12000	15000
3	Disinfectants	5010	5010
4	Bed disinfectants	3000	3750
5	Labour	40000	50000
6	Transportation and marketing	3020	4100
7	Other costs	500	1500
8	Interest on working capital	1271	1587
	Total variable costs	**156406**	**172553**
B.	**Fixed costs**		
1	Rearing house	480000	400000
2	Rearing rack	20000	20000
3	Power sprayer	13000	13000
4	Nylon net for uzi fly	2500	2500
5	Mountages	15000	19200
6	Other equipment	5000	7000
	Depreciation on building and equipment	**23100**	**22340**
	Total costs	**179506**	**194893**
	Cost of production/kg cocoon	**256**	**240**
C.	**Revenue**		
	Cocoon yield (kg/100 dfls)	70	65
	Average cocoon price	360	320
	Cocoon production (kg)	700	813
	Income from cocoon	252000	260000
	Income from by-products	12600	13000
	Total revenue	**264600**	**273000**
	Net revenue	**85094**	**78107**
	Benefit: cost ratio	**1.47**	**1.40**

9.3 Technology led development

India has emerged as world leader in development of tropical sericulture technologies taking the advantages of climatic conditions and making it possible to rear the silkworms all- around

the year. The major technologies developed, having the potential to double the income of the farmers are as follows:

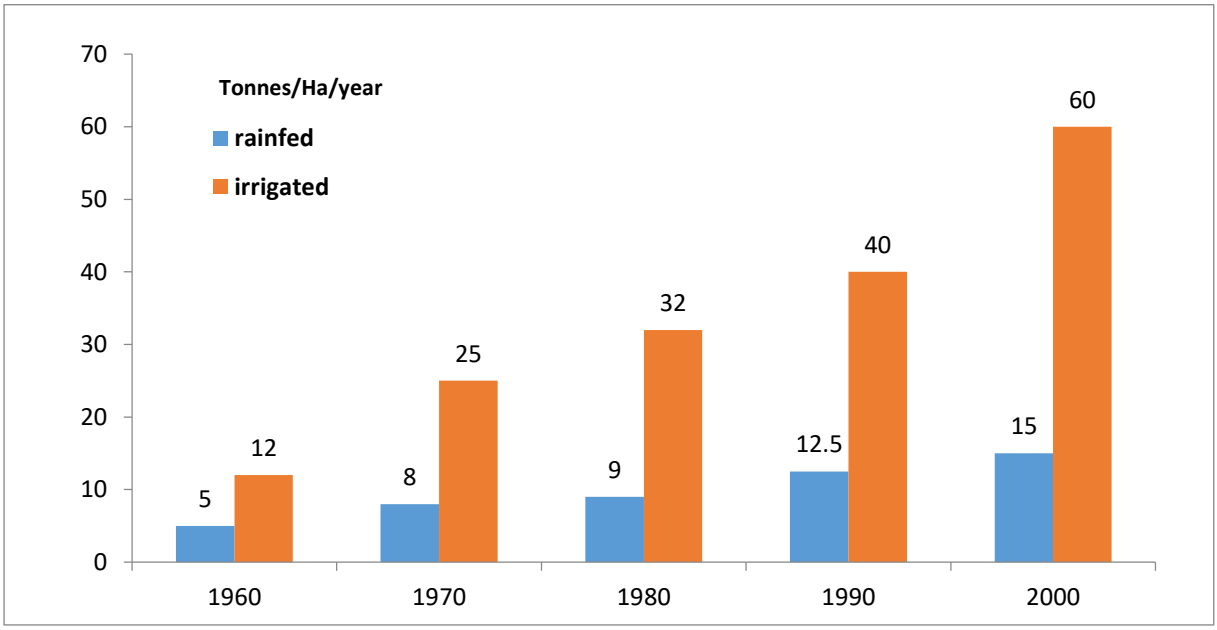
9.3.1 New high yielding mulberry varieties

Mulberry varieties developed in India have proved to be the highest leaf yielder in the world. The leaf yield increase has been an all-time record with increase from 30,000 tonnes per ha in 1970s to 65,000 tonnes per ha in 1990s.

Table 9.31 Popular High Yielding Mulberry Varieties in India

SN	Variety	Region	Developed at	Origin	Approx. yield Mt/ha
1	S-36	South India Irrigated	CSRTI, Mysore	Developed through EMS treatment of Berhampore local	25-30
2	Victory-1	South India Irrigated	CSRTI, Mysore	Hybrid from S30XC776	55-60
3	S-1635	Eastern and NE India Irrigated	CSRTI, Berhampore	Triploid selection	35-40
4	G2 (For young age worms)	South India Irrigated	CSRTI, Mysore	Through hybridization	55-60
5	G4	South India Irrigated	CSRTI, Mysore	Through hybridization	55-60

Figure 9.1 Mulberry yield improvements over the years



Apart from cultivation of improved mulberry varieties, the following package of practices have helped to increase the leaf yield and quality enabling the farmers to rear high quantities of eggs and get more cocoon yield resulting in doubling of their farm income.

9.3.2 Recommended cultivation practices for mulberry

The following is recommended for improving mulberry yield and maintain:

- Wider spacing with pit system of planting namely 90 cm x 90 cm. Paired row system of planting (90cm x 60 cm) x 150 cm
- Using nursery raised rooted plants of 4-5 months age
- Use of higher dose of Farm Yard Manure @20 mt per Ha twice a year
- Application of chemical fertilizer @ 300:120:120 of NPK five times in a year after year crop
- Practicing IPM for control of mulberry pest and disease as per the recommendations
- Five times shoot harvest followed by inter-culture operations
- Basal pruning of plant once in a year during June and middle pruning during October

9.3.3 Recommended silkworm rearing practices

The following is recommended for improving cocoon yield and maintain good quality cocoons:

- Rearing of improved silkworm breeds as indicated in the table
- Construction of exclusive rearing house of recommended size and good ventilation
- Disinfection of rearing house two times before and after every crop
- Self-system of rearing with recommended spacing of 600sqft for every 100dfls
- Rearing of young age worms separately or getting them from chawki rearing centers
- Two times shoot feeding every day during morning and evening hours
- Use recommended bed disinfectant before resuming worms after each moult and 4th day of 5th instar
- Use of activated lime powder during every moulting to keep the bed dry
- Mounting of mature worms for cocooning after full growth giving sufficient spacing
- Harvesting of cocoons on sixth or seventh day of spinning
- Transport of cocoon for marketing in a plastic box after sorting, cleaning and deflossing

9.3.4 Improved silk worm breeds

Research and development programmes have made an excellent contribution to development of high yielding varieties of silkworms by exploiting the hybrid vigour. High yielding varieties of silk worm races combined with disease resistance and better-quality yarn have been evolved both in cross breed and bivoltine hybrids. The cocoon yield has reached a high of 65-70 kg per 100 Dfls with reduced renditta of 6-7.

Table 9.42 Improved Silk Worm Breeds of India

Hybrids	Region	Season
CSR2 x CSR4	South India Temperate/ Sub-Tropical Zones	All season of South India & favourable seasons in other parts
FC1 x FC2	South, North, North-West East and North East	All season of South India & favourable seasons in other parts
SK6 x SK7	East and North-East	Spring & Autumn

The Central Silk Board has also undertaken trials for new silkworm hybrids:

Table 9.5 New Breeds Varieties under Trials

Hybrids	Region
Mulberry sector	
G11x G19	South zone
MV1xS8	
B. con 1 x B. con 4	East and North-East
M6DP (C)x (Sk6 x SK7)	
Vanya Sector	
CTR-14	All regions suitable for tasar culture
CMR-1 and CMR-1	All regions suitable for muga culture

Source: CSB Report, July 2017

9.4 Silk Trade

The Indian silk goods are being exported to the traditional major markets of USA and Europe, as also minor markets of Asian region. The silk goods export earnings decreased over the years due to global recession and reduction in demand for silk goods in western countries. The export earnings during 2016-17 were Rs. 2,093.42 Crores. Export values of silk goods during the years 2013-14 to 2016-17 and for the year 2017-18 (till May-2017) are given in the table below:

Table 9.14 Export of Indian Silk (in Rs. crore)

Silk Item	2013-14	2014-15	2015-16	2016-17	2017-18 (p) (till May-2017)
Natural Silk Yarn	36.26	25.41	30.31	15.33	1.38
Silk Fabrics	1,455.63	1,465.44	1,280.60	1,051.65	60.81
Readymade Garments	874.00	1,214.01	1,078.39	864.33	234.58
Silk Carpet	15.71	15.97	16.88	63.78	1.35
Silk Waste	99.30	109.12	89.80	98.33	11.61
Total	2,480.88	2,829.95	2,495.98	2,093.42	309.73

Source: DGCIS, Kolkata P: Provisional

While India largely exports silk products, the demand for the produce is met from imports of raw silk. This highlights the scope that exists to increase domestic sericulture and enhance production of raw silk.

Table 9.6 Quantity and value of raw silk Imports in recent years and 2017-18 (till May-17)

Year	Quantity (MT)	Value (Rs. in Crores)
2013-14	3,260	896.44
2014-15	3,489	970.82
2015-16	3,529	1,006.16
2016-17	3,795	1,092.26
2017-18 *	644	193.35

Source: DGCIS, Kolkata.

* Figures for the period of April-May, 2017 (Provisional)

Major interventions would be required for achieving self-sufficiency in raw silk production. With a view to giving push to the highly potential sericulture, the interventions being made include: climate resilient sericulture; organic farming; use of non-conventional energy; promotion of automatic reeling technology, strengthening public extension system; cluster approach, strengthening marketing system for Vanya cocoon and silks, Swacchha Resham Adarsh Gram, IT enabled effective monitoring system, product development and diversification etc.

9.4.1 Global scenario of Indian sericulture

Indian sericulture industry has achieved a commendable progress during last two and a half decades through several R&D projects, especially under JICA with Japanese technical cooperation in three phases from 1990-2005. However, still there is lot to achieve to make the country self-sufficient especially in bivoltine quality silk. China is the world's largest producer of mulberry raw silk and India, though the second largest producer falls far short. There is a large gap between the world's two major raw silk producers, but such a gap can be narrowed substantially. In comparing with China's capabilities, the main reasons for the production and productivity gaps are understood as follows:

1. India has less than four and half area under mulberry, in comparison to China.
2. China outputs 95 per cent of its silk through highly productive bivoltine type, while 80 per cent silk produced in India is from low productive cross breed.
3. There is assured irrigation for the majority of the mulberry area in China, whereas in India, irrigation facilities are available only for 50 per cent of mulberry area
4. Organic carbon is more in mulberry growing soils, compared to areas in India
5. Cocoon yield /100 dfls is 10 kg more than those achieved in India

Table 9.7 Comparative mulberry sericulture industry, China vis-à-vis India (2015-16)

Parameter	China	India
Area under mulberry (lakh ha.)	8.31	1.79
Leaf yield (MTs/ha/yr)	30-35	40-45
Races reared	All bivoltine	Mostly crossbreed, only 20% bivoltine
Egg production (crore dfls)	75.962 from a few big producers	25.65 from large number of small producers
Supply system,	Majority chawki reared	40% chawki at CRC and 60% self
Time of supply	Batch-wise as per fixed calendar	Throughout the year
No. of crops per year	2-3: Temperate 6-8: Tropical	5-6 8-12 (Two plot system)
Dfls brushed / ha / yr	1050	2000-2500
Cocoon yield (kg / 100 dfls)	75.00	60.0
Leaf cocoon ratio (kg)	16-18	23-25
Cocoon yield (kg / ha)	736.89	698.0
Avg. Crop loss / year (%)	3-5	10-15
Single cocoon weight (g)	1.9-2.0	1.6-1.9
Cocoon shell percentage (%)	21-23	CB: 17-19, BV: 20-22
Silk reeling	All automatic reeling machines (ARM) with high capacity	All small reelers with different machine types (ARM, Charka, Cottage Basin and Multiend)
Filament length (m)	>1000	CB-750-800, Bv-900-1000
Renditta	6.4	Cb-8.0 Bv-6.5
Grade of silk	2A – 4A and even 6A	CB-Ungraded. BV -up to 3A
Cost of cocoon production (Rs./kg)	100-150	150-200
Prevailing cocoon price (Rs.)	200-300	300-350
Raw silk production (kg/ha/yr)	114.87	CB: 70-80, BV: 85-90
Demand and supply position	90% Export	Self-consumption & 30 % deficit
Raw silk produced (MTs / yr)	1,70,000	20,478

The table demonstrates that both production and productivity of raw silk are much higher in China, compared to India. In regards quality, the raw silk produced in China varies from 3A to 6A grade whereas, in India it is gradeless to 3A grade. The major reason for poor quality of silk being output in the country are as follows:

1. Silk worm eggs are produced in India by small producers, without suitable facilities, resulting in variation of end product - the cocoons.
2. 95 per cent of the eggs produced are distributed after second stage of chawki rearing in China whereas, in India it is only 40-50 per cent.
3. 95 per cent of the silk produced is from highly productive bivoltine races with inherent good quality silk, whereas in India 80 per cent is cross breed with poor quality silk.

4. The mountages used in China are rotary type which result in uniform shape and size of cocoons, with less percentage of defective cocoons, whereas in India, the farmers use different type of mountages without regular shape and size. This results in large variation in cocoon shape and size and not suitable for automatic silk reeling machines.
5. Percentage of defective cocoons is lower in China (<5) than India (5-10).
6. All the cocoons produce in China are reeled in automatic reeling machines whereas, in India only 10-15 per cent of the cocoons are reeled on automatic reeling machines.
7. Renditta (quantity of cocoon required to produce one kg of silk yarn) in China is 15 per cent lower than that India.

9.5 Annotation

Sericulture adds economic and social vibrancy to village economies. The set of activities involved support cluster based development, where mulberry cultivation, silk worm rearing and the silk industry can be developed in a synergistic fashion. The sector is fortunate to have the worlds' largest market within the country, but is subject to external pressure in the form of silk yarn dumping.

Sericulture has been accepted as one of the most important rural industry because of its versatility, eco friendliness, suitability to weaker section and small farming community of the society; high employment potential; women friendliness; value addition through bye products and above all good and frequent income to the farmers who are the primary producers. Farmers get an average income of Rs. two lakhs from 2 acres (0.8 ha) of mulberry area. Farmer gets 40 percent share among all stakeholders in the chain.

China has advantage mainly because of large area under mulberry cultivation, use of bivoltine races, large scale operations in egg production, uniformity in quality, reeling and weaving operations having large economy of scale and reduced cost of production. China is dumping its medium grade silk to India to meet the demand of 2A to 3A grade silk in India which is likely to affect the domestic silk industry.

Key Extracts

- Sericulture offers growth in both farming and post-production activities, which are scalable at village level. A large domestic market supports growth in this sector.
- The economics in sericulture farming are favourable and can be enhanced through technology led development.
- Anti-dumping measures have supported the sericulture sector and need to be maintained. At the same time yield and quality of produce requires improvements.

Chapter 10
Sericulture - Strategic Approach to Development

Sericulture has a well-established market, and therefore, is well positioned to capture greater value from development strategies that will promote higher yields and improved quality. The raw silk, though a marketable produce in itself, is also processed into the final consumable, usually as wearable textile, or other uses. There is a need to diversify into other silk products and develop new products lines.

The import bill of raw silk, which is converted into fabric, is an indicator of the opportunity that exists for the sericulture farmers. For the purpose of enhancing production and productivity, horizontal expansion in non-traditional/drought and salt affected soils, and the continuous development of silkworm breeds by exchange of genetic material, etc., are key areas that need intervention.

As in other agricultural spheres, in sericulture too, infrastructure and equipment play an important role in improving quality, productivity and reducing wastage or post-harvest loss. Rearing houses, seed multiplication infrastructure and automatic reeling units will help all stakeholders in breeding and post-harvest handling and preparation of silk yarn. The Central Silk Board (CSB) intends to take up adaptive research and front-line demonstration of improved technologies, over the next three years.

The use of by-products from mulberry cultivation (leaf and young shoots for cattle feed) silkworm rearing (uneaten leaf and silkworm litter as organic matter), silk reeling (silk waste for spun silk and quilt *etc*.,) such as pupa for fish or poultry as feed, also makes sericulture a useful component in integrated farming systems. The use of silk as a bio-material in medical applications such as sutures, optical devices, adhesive gels, nutraceuticals, cosmetics and others, is another market opportunity for silk farmers and needs to be taken advantage of.

Efforts are already on to raise silkworm food plantation under the National Afforestation Program. These efforts can also be taken up under reforestation of river banks as part of riverside rejuvenation plans. Capacity building of personnel involved in silkworm farming, especially as an integrated farming activity is also emphasised.

Support to the post-yarn sector in silk, such as fabric weaving/dyeing/finishing will also help enhance the demand for raw silk from farmers, increasing their market opportunity. Indian silk marketing must get more conscious of the importance of maintaining, enhancing and competing in the brand sensitive international markets. Demand for Indian silk products translates into demand for raw domestic silk and concomitant need for more cocoons and increasing area under mulberry cultivation and resultant income for farming.

10.1.1 Convergence in Government Support

The Ministry of Textiles which hosts the sericulture wing is extending support to the sericulture sector in the form of CSS & NERTPS. Efforts at mobilizing additional funds through convergence of its own schemes with financial support from other schemes (RKVY,

MGNREGA, NAP etc.) implemented by various other Ministries of Govt. of India are underway. During the financial year 2016-17, States submitted proposals worth Rs. 904.32 crore and received sanction for an amount of Rs. 842.60 crore. A sum of Rs. 329.38 crore was released as against this sanction.

Seven multi-state projects promoted by Central Silk Board (CSB) are supported by Ministry of Rural Development (MoRD). The seven projects envisage to cover 36,117 *mahila kisans* (26,094 in tasar sector) from 23 districts in 8 states with an outlay of Rs. 71.60 crores shared by MoRD and CSB in the ratio of 75:25. The projects envisage to raise 3503 ha of tasar host flora, rejuvenate 9,468 natural tasar flora, establish capacities to produce 6.75 lakh dfls of basic seed, 59.35 lakh dfls of commercial seed & 16.09 crore reeling cocoons.

The North-Eastern States have the unique distinction of being the only region producing all four varieties of commercially available silk viz., mulberry, tasar, muga and eri. Overall, North Eastern region contributes 20 per cent of India's total silk production. The North-East Region Textile Promotion Scheme (NERTPS) for Sericulture aims at holistic development of sericulture in all its spheres from plantation development to production of fabrics with value addition at every stage of production chain.

10.1.2 Policy Initiatives

It is quite an intricate situation for the policy makers to strike a balance between the two distinct sections of the industry viz, the sericulture farmers and reelers who oppose the cheap silk import from China complaining about its cascading effect on the Indian silk industry and on the other hand, the weaving sector standing up with the grievances of inadequate availability of quality raw silk at a reasonable price for running their looms. The Government of India imposes customs duty on imported raw silk and anti-dumping duty, whenever the situation raises, to discourage the imported silk and protect the domestic sericulture industry. At present the basic customs duty on raw silk is 10 per cent and it is exempt from GST. On petition from CSB, the Director General of Anti-dumping & Allied Duties (DGAD) had imposed a definitive anti-dumping duty in the form of fixed duty of US$ 1.85 per Kg on the landed cost of imported raw silk originating in or from China which will be in force till Dec-2020. The current anti-dumping declaration is expected to rationalise the price of raw silk for domestic farmers. This is a good protection of the domestic raw silk production against the unfair dumping practices, that China is prone with a view to strengthen its monopoly.

10.1.3 Background information on dumping of silk yarn

China being the leader of silk production is taking advantage of huge demand of medium grade silk (2A and below grade), used as a warp in improved Indian handloom requirement, and started dumping its lower grade silk to Indian markets at cheaper rate. During 2001-02, there was a large-scale dumping of Chinese raw silk into the country de-stabilizing the Indian silk Industry. In order to safeguard the interest of the domestic silk industry against the cheap imports, an anti-dumping duty was imposed during January 2003 (*for a period of 5 years*) on raw silk of 2A grade & below imported from China with a reference price of US$27.27/kg.

Subsequently, a sunset review was taken up for continuation of anti-dumping duty on import of raw silk. Accordingly, antidumping duty was further continued with an enhanced reference price of US$ 37.32 per Kg. and the same was in force till January 2014.

Based on the requests received from Silk Reelers Associations of Karnataka, Tamil Nadu, Andhra Pradesh and other States, CSB on behalf of domestic silk sector, filed a petition with the Director General of Anti-Dumping & Allied Duties (DGAD) seeking imposition of anti-dumping duty on import of raw silk of 3A grade and below from China, as majority of raw silk import was in 3A grade. On petition from CSB, the Director General of Anti-dumping & Allied Duties (DGAD) has imposed a definitive anti-dumping duty in the form of fixed duty of US$ 1.85 per Kg on the landed cost of imported raw silk originating in or from China, which will be in force till Dec-2020.

As a result of imposition of anti-dumping duty on raw silk along with increase in domestic production of bivoltine silk in the country, the raw silk imports have reduced drastically from 9,258 MT in 2003-04 to 3,795 MT in 2016-17. The anti-dumping duty has helped to stabilise the cocoon and raw silk prices in India and is thereby supported for the growth of the industry.

10.2 Increasing India's share in the world production

India accounts for 14 per cent of the global silk production and is the largest consumer of silk in the world. The silk sector currently caters to the needs of domestic industry, leaving little export surplus to play any significant role in the global market. China is the leading player in silk production. With the increase in the labour and other input costs in China, the raw silk production is comparatively economical for that country. This is expected to result in a reduction in the silk production in China.

The bivoltine cocoon production shows improvement over time, and it is essential to convert good quality bivoltine cocoons into good quality bivoltine raw silk of International grade, which is a substitute to imported silk. This, along with automatic silk reeling technology is an opportunity for Indian silk farmers and industry.

10.2.1 Support factors from the perspective of doubling of farmers' income

1. Corporate participation in silk production: In China, Japan and many countries, while silkworm rearing is taken up by small farmers, silkworm seed production, silk reeling and weaving are carried out in large scale by corporate companies, which brings technology, efficiency, quality and economy of scale in operations. In India, all the activities, from silkworm seed production to weaving, are in micro and small scale leading to variations in quality, inadequate risk bearing capacity and inefficiency in operations.
2. Strengthening marketing system for cocoon and raw silk in the non-traditional areas and for Vanya cocoon and raw silk. The market support can be enhanced.
3. Strengthening of public extension system: Inadequate and ageing of extension workers in the State Sericulture Departments of many states is an important issue.

4. Effective utilisation of by-products is essential for the reeling units to enhance their earnings. Silk based waste generated during the silk reeling operations are utilised in the production of spun silk. There are other by-products, and in order to obtain better earnings from them, the silk reeling can be established with pupae processing / pupae drying units. Use of, silk waste, sericin, etc., for value addition and income generation needs promoting.

10.3 Major challenges

Some of the challenges faced are common to cultivation of plants, and others are specific to cultivation of silk worms and silk production.

- Depleting ground water resources and shortage of irrigation water
- Global warming and climate change/uncertainty effects
- Urbanisation and shrinking cultivated land in traditional areas
- Non-availability of skilled work force
- Declining organic carbon level with adverse effects of excessive use of chemical fertilizers and pesticides on soil health.
- Inadequate supply of quality eggs
- Emergence of new pest and pathogens
- Improper rearing conditions including mounting and post-harvest care
- Inconsistency in cocoon quality
- Non-availability of sufficient automatic reeling units

10.4 Strategies and approaches

10.4.1 Expansion of mulberry area

Due to fast urbanization, majority of the mulberry area has been drastically reduced around major cities in Karnataka, AndraPradesh and Tamil Nadu which are the major traditional states producing mulberry silk especially bivoltine. Hence, there is an urgent need to rehabilitate the lost mulberry area besides horizontal expansion of mulberry cultivation to meet the additional target of raw silk Production. Besides expansions of mulberry cultivation to new districts of traditional Sericultural states, there is in an urgent need to explore large scale cultivation of mulberry in non-traditional states like, Odisha, North Eastern states, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Jammu and Kashmir etc. In the new areas, only high yielding mulberry verities namely, V1, S36, S1635, G4 etc. should be popularised. In addition, there is vast scope for introducing mulberry tree cultivation in the water deficit regions which will help to grow more cocoons. Good number of Kisan nurseries can be started to produce and supply quality planting material of recommended mulberry varieties.

10.4.2 Enhancing the egg production capacity

Assured supply of disease free quality egg (seed) is the pre-requisite for production of the targeted raw silk of desired quality. If this is not in order, all subsequent exercises will prove futile. Current situation of egg production situation in the country is very poor in general and for bivoltine in particular.

The silkworm egg production by CSB, State and private sector during 2015-16 and the seed requirement for 2023-24 is given in table below. Currently the production of State and private grainages in bivoltine seed production is negligible. The CSB grainages have limited capacity to expand the bivoltine seed production. Unless the DOS and private grainages have tie up the production of bivoltine seed, it will be difficult to reach the target set for the year 2022-23 and even beyond.

Table 10.1 Mulberry Silkworm Seed Production in 2015-18 and Target for 2022-23

Particulars	Silkworm seed production (Lakh dfls)	
	2015-16 (Actual)	2022-23 (Anticipated)
A. Cross Breed		
Private	1906	2420
State	225	555
CSB	101	50
Total	**2232**	**3025**
B. BV hybrid		
Private		328
State	78	1171
CSB	310	300
Total	388	1799
Grand Total	**2619**	**4824**

Source: NSSO, CSB

The required quantity of eggs is not produced and supplied. The situation is because state government grainages are functioning much below the built-up capacity. The reasons attributed are poor quality seed cocoon production, lack of sufficient skilled man power and poor financial support, disparity in seed cocoon and commercial seed rate, inadequate storage facilities, etc., besides the policy bottle necks which need to be addressed urgently. Because of the above reasons private seed producers are not coming forward to take up bivoltine seed production.

10.4.3 Enhancement of improved Reeling Capacity

The third important and weakest link in silk production chain is silk reeling. Farmers realise their economic benefits from reelers and this sector needs utmost attention. Unlike in China where almost all silk is reeled by automatic reeling machines with huge capacity, in India most of the silk is reeled by small reelers and majority of them are having traditional devices. As a result, the silk produced is in small lots and shows large amount variation in quality and uniformity. This silk is considered not suitable for high speed shuttleless looms / power looms and weavers prefer to use imported silk of uniform quality. Because of this reason importing of silk becomes inevitable. Unless this system is totally replaced, there is very little chance of bridging the gap between china and India. Realizing this fact, of late the Central Silk Board

and major silk producing states have started installation of imported automatic reeling machines and also promoting indigenously developed improved multi end and automatic reeling machines.

10.4.4 Strengthening extension system and skilled manpower development

Sericulture extension activities are carried out by the State Governments. The ratio between farmers and extension workers is very high in many states implying inadequate grass root level extension staff. Moreover, in many states, most of the extension workers are on the verge of retirement and working with less facilities and inadequate training. Therefore, strengthening of the public extension system with manpower and facilities is a recommended priority.

To meet the task of doubling the import substitute bivoltine silk and difficult terrain/disturbed areas in vanya silk, there is immediate need to recruit extension staff and equip them with training and other facilities. Bringing in a suitable model of private extension system such as Para-professionals, Community Resource Persons, Community Based Organizations (CBO), farmers producer organisation (FPO) etc., may also be explored. Incentivises may be based on outputs and coverage of area/ farmers.

Information Communication Technology (ICT) tools like information portals, App.net, information Kiosks etc. are required to be harnessed to provide right information to the farmers, reelers and weavers and thereby empower them. Besides State Sericulture Department, extension activities would also be promoted through NGOs, Krishi Vigyan Kendras (KVKs), lead farmers, farmers field schools (FFS) and Agricultural Universities.

10.4.5 Building organic linkages

Central Silk Board with the objective of producing international grade silk (3A-4A grade) has supported for establishment of around 35 automatic reeling machines (ARMs) through State Sericulture Departments. It is proposed to establish 24 additional automatic reeling units during 2017-18 to 2019-20. The ARMs require backward linkages with respect to silkworm seed production at grainages, rearing of chawki (young age) silkworms at Chawki Rearing Centres (CRCs), rearing of late age silkworms by farmers, supply of required technical and material inputs to the CRCs and farmers, marketing facilities etc., for the uninterrupted supply of the raw material i.e. cocoon.

Each automatic reeling unit requires around 700 kg of cocoon every day to produce around 100-110 kg bivoltine raw silk. Thus, an ARM requires around 210 MT of bivoltine cocoon per annum (to operate 300 days in a year). To produce 210 MT of bivoltine cocoon, about 3.5 lakh dfls of bivoltine hybrid silkworm seed is required. Two Chawki Rearing Centres (CRCs) with a capacity to rear chawki worms of 1.75 lakh dfls per annum are required to supply of required quantity of chawki worms. Overall, to produce 210 MT cocoon in a year, an ARM requires a market linkage of around 300–400 sericulture farmers.

If the ARMs establish tie-up with 300-400 farmers in its operational area by executing contract to purchase the cocoons based on the set quality parameters, they will get assured supply of cocoons and the farmers would get marketing support and remunerative prices for their cocoons. The number of reeling units required for the production of raw silk in India (2016-17 to 2022-23) is indicated in following table.

Table 10.2 Reeling machineries required for the production of raw silk in India (2016-17 to 2022-23)

Mulberry:

Year	Production in MT (CB)	Reeling Infrastructure for the production of CB Silk				Production in MT (BV)	Reeling Infrastructure for the production of BV Silk			
		Charka	Cottage Basin	MRM	ARM		Charka	Cottage Basin	MRM	ARM
		No. of Basins					No. of Basins			
2016-17	17400	17400	34800	4462	0	5260	0	7890	4091	779
2017-18	17800	17800	29667	9128	0	6100	0	7117	5422	1130
2018-19	18100	15083	27150	13923	0	7200	0	7200	6400	1600
2019-20	18500	15417	27750	14231	0	8500	0	7083	8500	1889
2020-21	18900	12600	25200	16962	788	10000	0	6667	11111	2222
2021-22	19500	13000	26000	17500	813	12000	0	6000	13333	3111
2022-23	20000	10000	23333	20513	1667	12850	0	4283	14278	3807

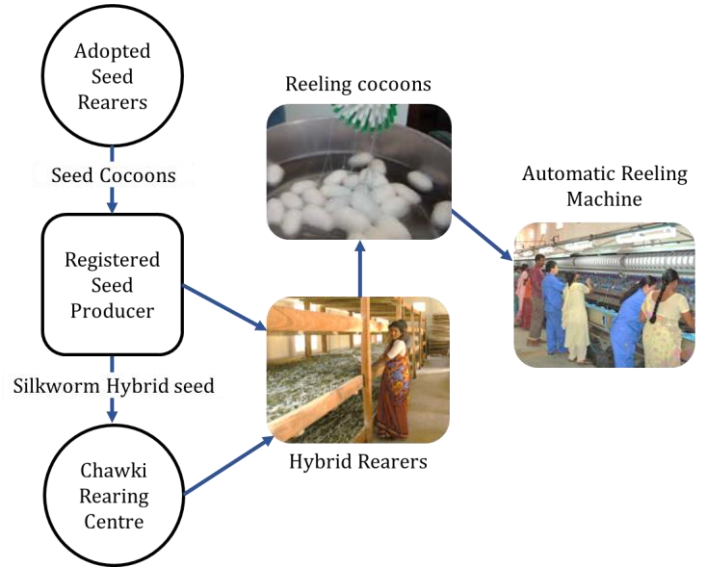
Vanya:

Year	Vanya Silk Production (MT)			Reeling machine requirement	Spinning Machine requirement	Spun Silk Mills
	Tasar	Muga	Eri			
2016-17	3285	220	5835	4000	5000	2
2017-18	3450	240	6250	5250	6750	5
2018-19	3650	260	6750	6850	9113	8
2019-20	3900	280	7350	9000	12302	11
2020-21	4150	300	8000	11500	16608	17
2021-22	4460	340	8700	14300	22420	25
2022-23	4650	350	9000	17400	30267	34

In the contract farming model, the silkworm seed can be produced and supplied either by National Silkworm Seed Organization (NSSO) or by State Sericulture Departments /Registered Silkworm Seed Producers (Private Sector). The CRCs can be owned by ARMs or private CRCs can be roped in by ARMs to supply the chawki reared worms to the adopted/contracted farmers.

The cocoons produced by the farmers can be purchased by the ARMs based on the quality. The technical advice, training, technology and input support can be provided to the farmers and CRCs by the ARM so as to get the required quality cocoons from the farmers. The credit support to the farmers can be arranged through financial institutions. The State Sericulture Departments and Central Silk Board can facilitate the ARMs, which are interested to execute contract farming agreement with the farmers.

Figure 10.1 Organic Linkage between Seed Sector and Automatic Reeling Unit



10.5 Roadmap for Indian Sericulture to double the farmers' income

To improve production, productivity and quality of Indian silk in comparison to China, the three major factors namely expansion of area under mulberry with high yielding mulberry varieties, enhancing the capacity of egg production involving large scale egg producers and establishment of required number of automatic reeling machines needs to be considered on priority, besides addressing above mentioned challenges.

Table 10.3 Year-wise production targets upto 2022– 23

Year	Mulberry area (ha)	Mulberry Silk Production (MT)			Vanya Silk Production (MT)				Grand Total (MT)
		Biv	CB	Total	Tasar	Eri	Muga	Total	
2016-17 (Base year)	216810	5266	16007	21273	3268	5637	170	9075	30348
2017-18	235000	6200	17276	23476	3450	6675	239	10364	33840
2018-19	248897	7200	18100	25300	3650	6750	260	10660	35960
2019-20	255896	8500	18500	27000	3900	7350	280	11530	38530
2020-21	263150	10000	18900	28900	4150	8000	300	12450	41350
2021-22	270670	12000	19500	31500	4460	8700	340	13500	45000
2022-23	278125	12850	20000	32850	4650	9000	350	14000	46850

Source: CSB, Vision Document (Unpublished)

With the availability of technology and knowhow, India has tremendous scope for increasing silk production and emerge as a leading supplier of raw silk and silk products for domestic as well as the international markets. An ambitious target is proposed to produce 48,800 MT raw silk in 2022-23 and 60,000 MT in 2029-30 from the current production level of 30,000 MT.

Table 10.4 State-wise production targets of different types of silks by 2022-23

SN	State	Mulberry Area (ha)	Mulberry Silk Production (MT)			Vanya Silk Production (MT)				Grand Total (MT)
			Biv	CB	Total	Tasar	Eri	Muga	Total	
1	Karnataka	107773	5600	10400	16000					16000
2	Andhra Pradesh	46422	2000	5792	7792	8			8	7800
3	Telangana	4573	210	10	220	25			25	245
4	Tamil Nadu	24781	2550	178	2728					2728
5	Kerala	315	25		25					25
6	Maharashtra	5052	475		475	42			42	517
7	Uttar Pradesh	6430	265	98	363	36	71		107	470
8	Madhya Pradesh	7186	280	65	345	35			35	380
9	Chhattisgarh	1457	15	10	25	516			516	540
10	West Bengal	20636	210	3340	3550	66	21	1	88	3638
11	Bihar	1024	0	29	29	67	16		82	111
12	Jharkhand	481	0	5	5	3665			3665	3670
13	Orissa	1003	9	3	12	179	12		191	204
14	J&K	9707	270		270					270
15	Himachal Pradesh	2483	56		56					56
16	Uttarakhand	3587	56		56	2	1		3	59
17	Haryana	253	7		7					7
18	Punjab	1453	14		14					14
19	Assam	8740	110		110		4250	250	4500	4610
20	Bodoland	1004	40		40		1650	36	1686	1726
21	Ar.Pradesh	510	16		16		90	4	94	109
22	Manipur	8947	310	20	330	10	480	4	494	824
23	Meghalaya	3668	65		65		1425	48	1473	1538
24	Mizoram	4968	120	20	140		22	3	25	165
25	Nagaland	1344	38		38		950	3	953	991
26	Sikkim	389	20		20		12	1	13	33
27	Tripura	3938	90	30	120					120
Total		**278125**	**12850**	**20000**	**32850**	**4650**	**9000**	**350**	**14000**	**46850**

Source: CSB, Vision Document (Unpublished)

To achieve the targets fixed at the end of each plan period, proposed mile stones in various productivity and quality parameters have been visualised.

To achieve these milestones an integrated development plans involving all the partners and stake holders has also been prepared in the vision document of the Central Silk Board, MOT, GOI with the sole aim of making India as the global leader and self-sufficient country for the quality raw silk requirement.

This plan also envisages not only to stop the import the raw silk from China, but also improve the export of raw silk and finished products in the future.

Table 10.5 Milestones fixed for various periods

Production parameters	2017	2023	2030
1. Expansion of mulberry area (Lakh hectares)	2.3	3.00	3.86
2. Mulberry leaf productivity (mt/ha/yr)	45-50	48-52	55-60
3. Seed production (lakhs)	2210		5804
4. Cocoon yield improvement (kg/100dfls)	55-60	58-62	65-70
5. Renditta	7.32	7.00	6.5
6. Raw silk productivity (kg/ha/yr)	98.1	102.00	110
7. Employment (lakh persons)	85.1	100	150
8. Reduction in silk import (mt/yr)	2022	1050	0.00
9. Export earnings per year (crores)	2093	2250	4000

Source: CSB, Vision Document (Unpublished)

10.6 Annotation

Mulberry yield has been improved 5 times and silkworm cocoon yield has been increased three times because of improved mulberry varieties and silkworm breeds. The R&D institutes have contributed with the highest rate of transfer of improved technologies to the field. High crop loss due to disease has become history and the success rate of silk worm crops is about 90 per cent. Similarly, new technologies developed for cocoon rearing has also helped in yield and quality improvement with lesser production cost because of the above innovative technologies, the import of raw silk from China has been reduced considerably. However, the gap between of production and productivity of raw silk between India and China remains large.

Key Extracts

- Central Silk Board and State Department of Sericulture have drawn out a program to establish higher production, productivity and quality of silk output. The program implementation may be expanded into various under tapped areas in the country.
- Special focus on skill development, along with the new rearing and weaving technologies being inducted, have to be coordinated for resource use efficiency.
- Diversification of silk into other material uses, besides meeting traditional demand of sarees, will need to be aggressively promoted.
- Anti-dumping measures have supported sericulture sector and need to be maintained.
- R&D into medicinal and other uses of sericulture by-products need to be promoted. Corporate sector participation in sericulture can be incentivised in such R&D also.

Chapter 11
Sericulture - Observations & Recommendations

Sericulture involves cultivating the host plant, like mulberry and rearing of silk worms, both activities resulting in the final output as animal fibre. The recommendations to promote sericulture, will include those mentioned for horticulture besides others that are specific to rearing of worms and production and marketing of the silk. Capacities must be developed in project mode with a systems approach.

The sericulture sector in India is largely populated by small and medium stakeholders, which also allows this enterprise to be accessible to a large range of farming population. The widening of silk production into other zones and areas is an opportunity to enhance the output and to generate employment across genders and age brackets.

Silk and its uses outside of the traditionally marketed 'saree' have not been fully understood or exploited. This is another area where new research and scaling up of existing demand can be undertaken. The fact that India still requires to import raw silk for its domestic market, is a clear indicator that silk production can be improved to meet the local demand. Protecting the sericulture farming community from indiscriminate imports is therefore an important direction.

The primary recommendations for adding greater impetus to sericulture farming are as follows:

(i) Programmes by Central Silk Board (CSB) and State Department of Sericulture to establish higher production, productivity and quality of silk output can be expanded to implement in various under tapped areas in the country.

(ii) Project based approach must be undertaken by CSB and states to establish and upgrade basic seed production units and in R&D to develop high yielding silk worm breeds. Similarly, new mulberry varieties with higher yield per hectare can be a focus area.

(iii) In post-cocoon stage, there is need to enhance the automatic reeling capacity with integrated twisting, besides strengthening of silk weaving and the wet processing sector. Such strengthening should be designed to build organic linkages among stakeholders, rather than building capacities that have to rely on imported yarn.

(iv) For bringing about improvement in resource use efficiency, there is need to attach special attention on skill development, coordinated with the induction of new technologies on rearing, reeling and weaving technologies.

(v) Diversification of silk into other material uses, new fabrics and utilities, besides meeting traditional demand of sarees, needs to be aggressively promoted.

(vi) R&D into medicinal and other biomaterial applications of sericulture by-products need to be promoted. Corporate sector participation in sericulture R&D can be incentivised.

(vii) Anti-dumping measures taken by the government have supported the sericulture sector and these need to be maintained.

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Volume VIII-D

Animal Husbandry: Livestock, Poultry, Fishery