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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

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

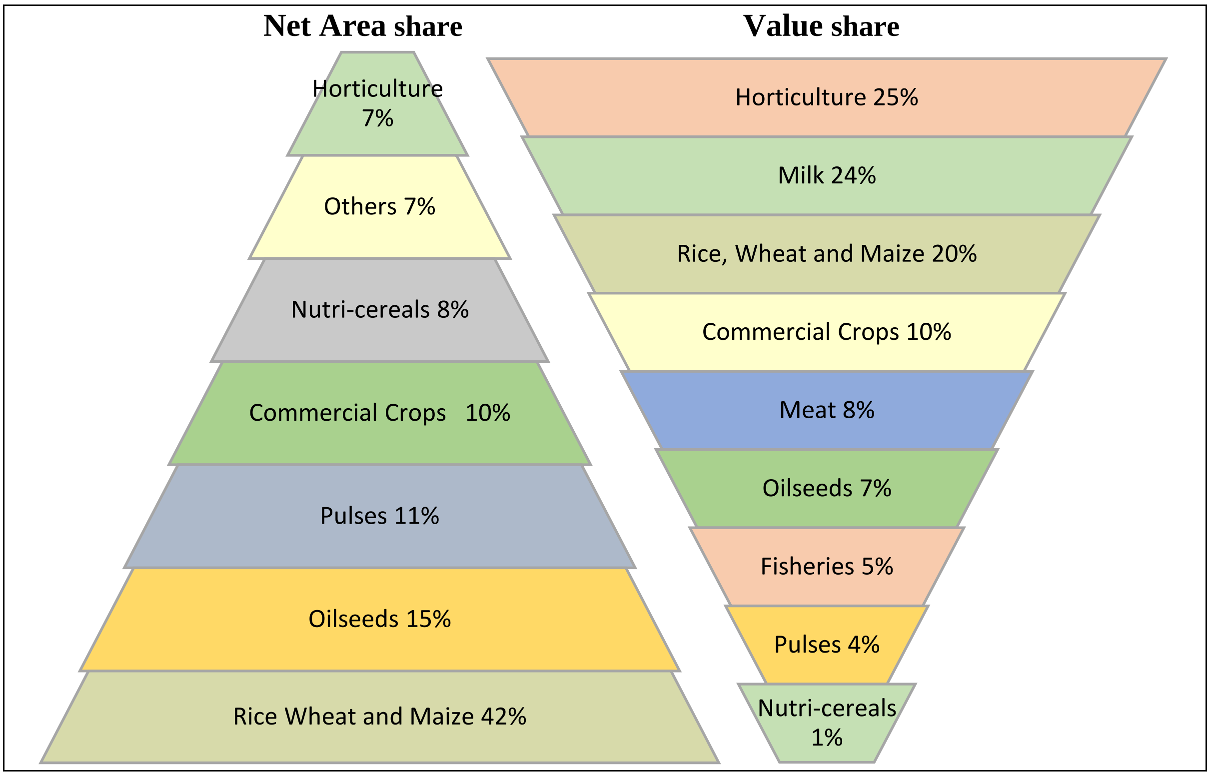
Regional and international networking and contractual research are considered important to quickly resolve a wide variety of constraints in diversification that differs from region to region. The training of farmers in new technologies and processes involved in diversification will improve their technical 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 them most of 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 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 food grains? 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

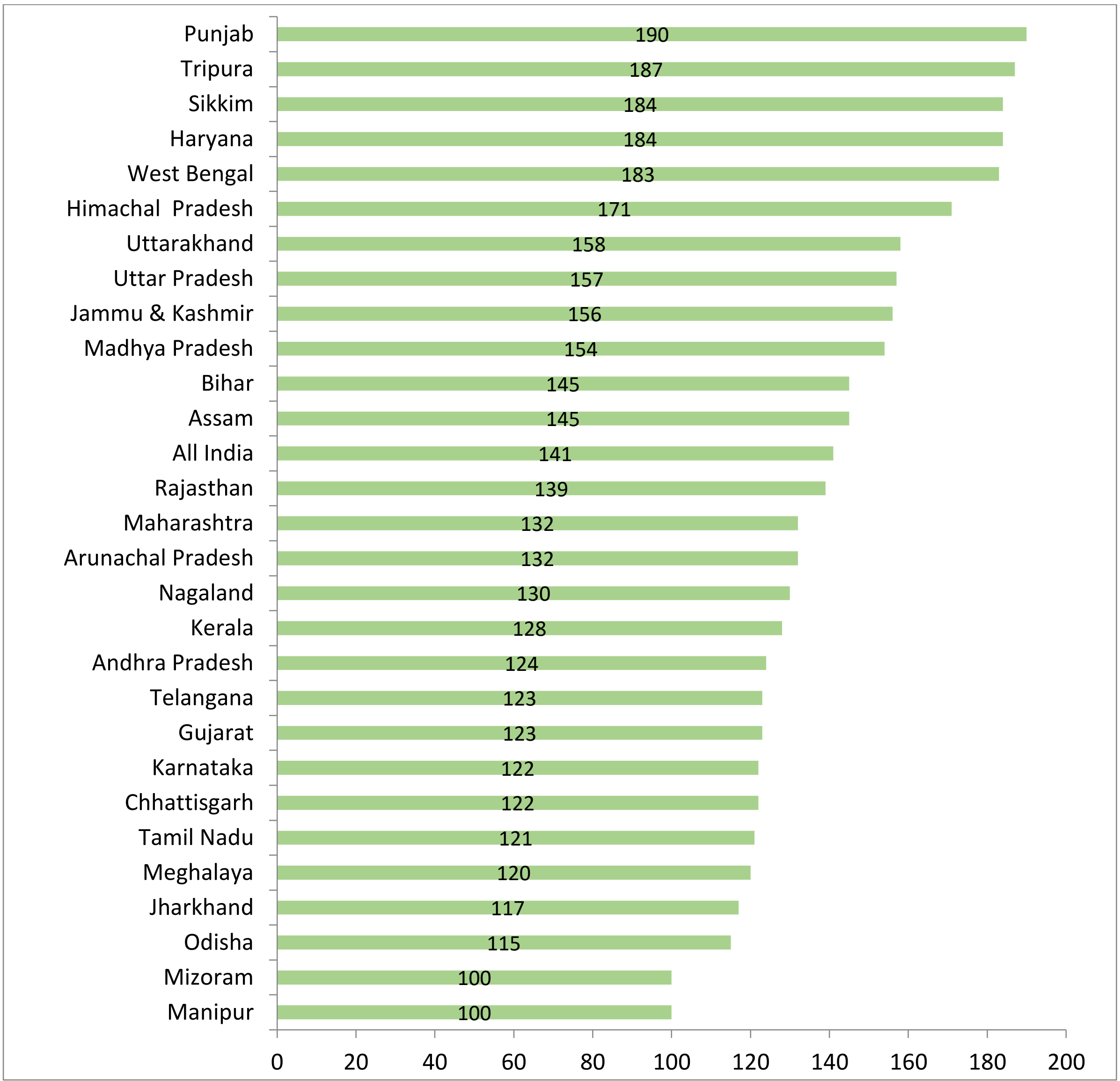
States	Productivity (Kg/animal)	Yield Gap with Maximum Yield State (%)	States	Productivity (Kg/animal)	Yield Gap with Maximum Yield State (%)
Madhya Pradesh	16.6	18.0	Kerala	9.0	26.2
Total	**11.2**	**44.4**	**Total**	**8.9**	**26.3**
Pig-Adult: Best yield Mizoram (86.9)			**Poultry: Best yield Lakshadweep (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	Horticultural Crops
Andhra Pr	**7909**	29.7	0.1	4.0	3.1	14.7	17.5	51.6	13.7
Arunachal P	**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 P	**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
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

States	**GCA (000 ha)**	Rice	Wheat	Maize	Nutri cereals	Total Pulses	Total Oilseed	Total Food-grain	Horticultural Crops
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

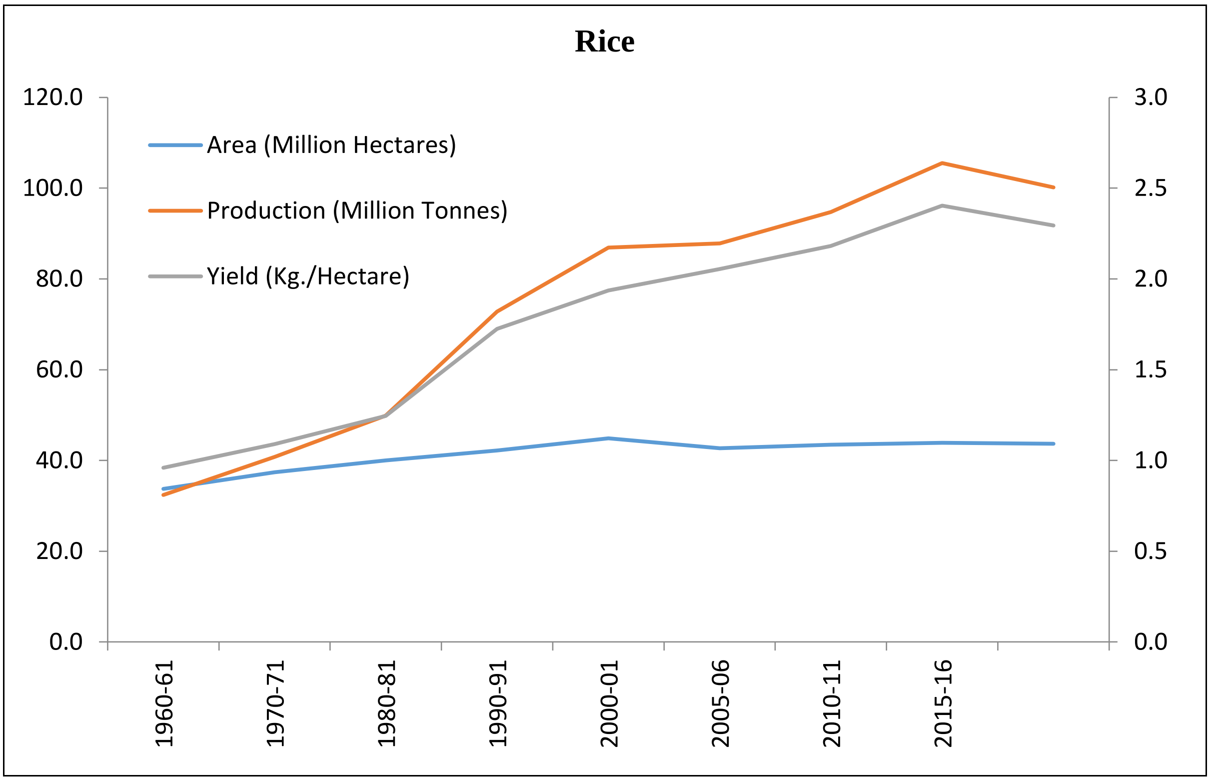
From 1960-61 to 2015-16, rice production increased from around 34 million tonnes to around 44 million tonnes and wheat production increased from 10.4 million tonnes to around 92.0 million tonnes. The yield improved from around 1.0 tonnes per hectare to around 2.4 tonnes per hectare in case of rice and 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)

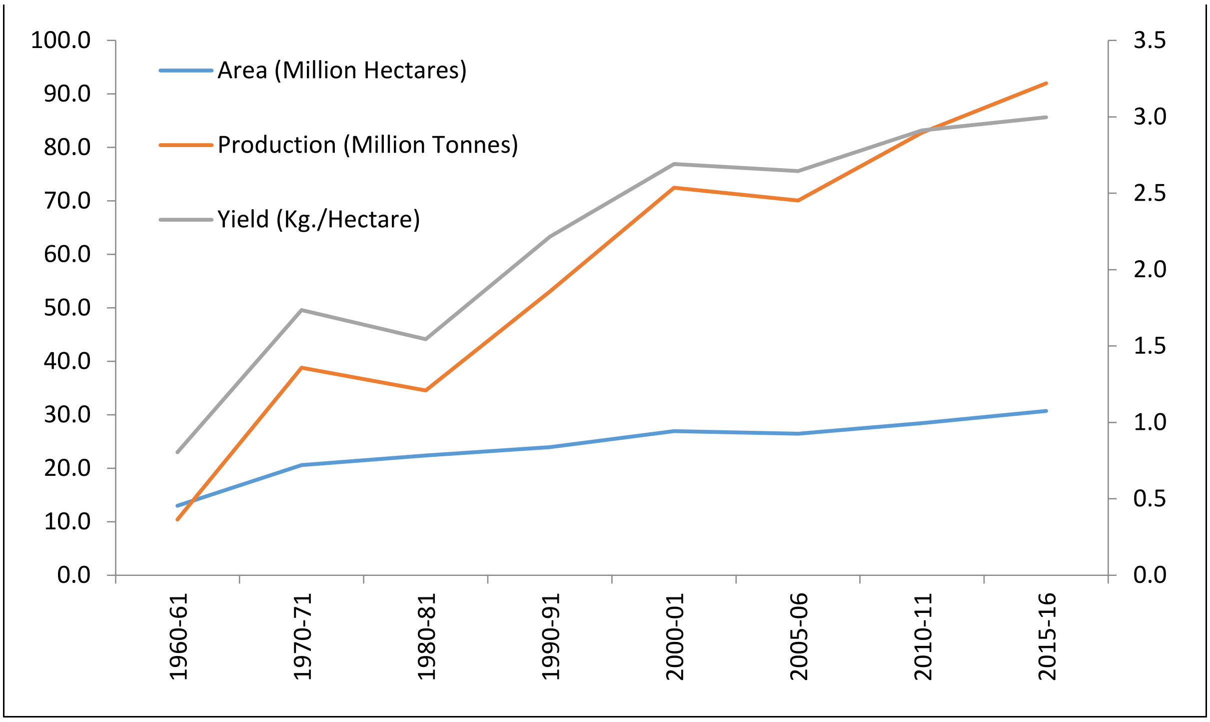
	Rice			Wheat		
Year	Area (mill Hectares)	Production (mill tonnes)	Yield (ton/Ha)	Area (mill Hectares)	Production (mill tonnes)	Yield (ton/Ha)
T.E. 1960-61	33.7	32.4	1.0	13.0	10.4	0.8
T.E. 1970-71	37.4	40.8	1.1	20.6	38.8	1.7
T.E. 1980-81	40.0	49.9	1.2	22.4	34.6	1.5
T.E. 1990-91	42.2	72.8	1.7	23.9	53.0	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



Wheat



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 per cent of the cultivated area in Punjab is irrigated, the highest in the country though only 25 per cent of the area benefits from canal irrigation the remaining 75 per cent 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 per cent area, below 100 feet in 34 per cent area and below 130 feet in 7 per cent 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.

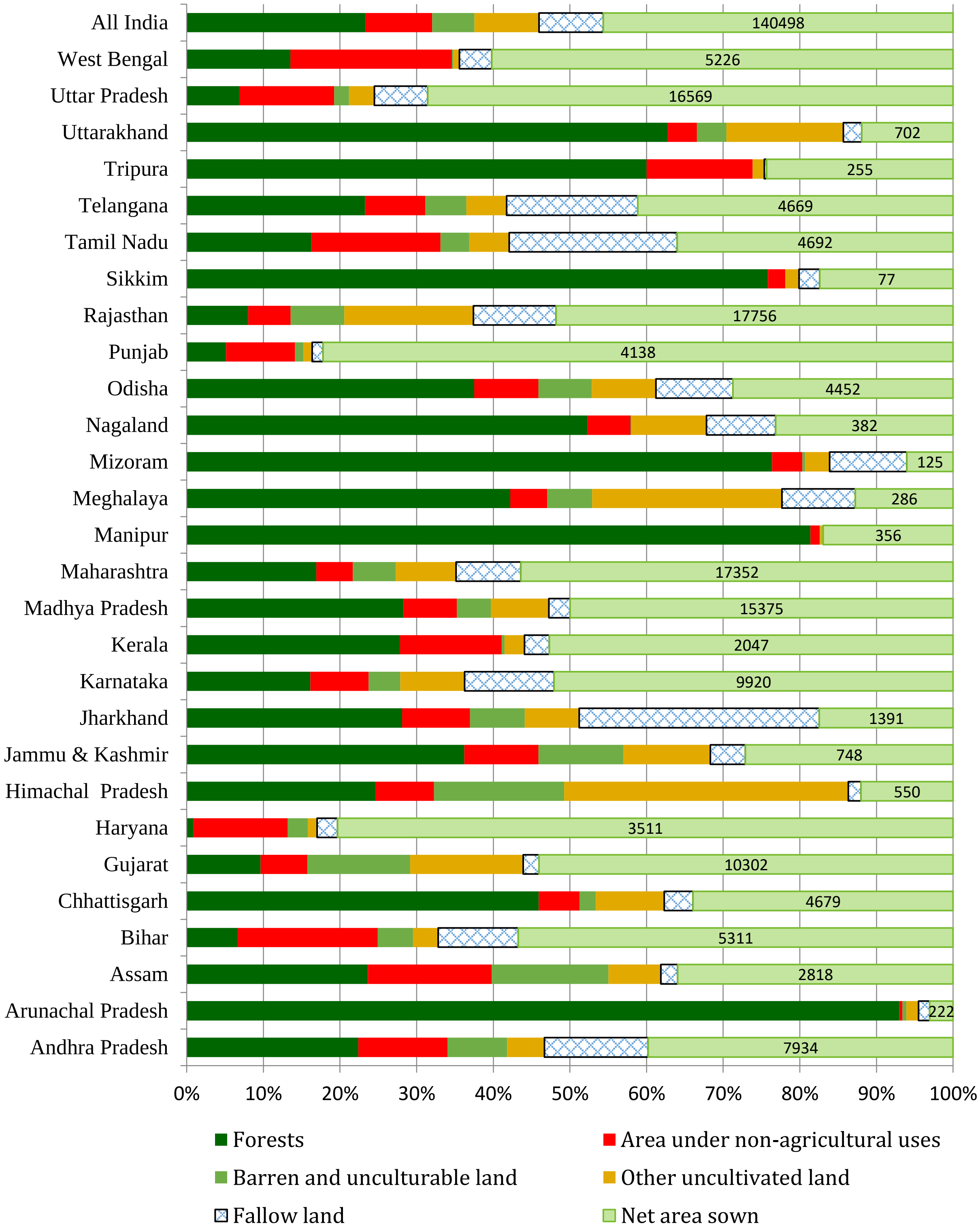
Most of the time major policy response to is problem has always been to disincentivise farmers from growing these crops by making meagre enhancements in the MSP. However, this alone is not sufficient, we need a complete package of agricultural practices that will help the farmers in growing alternative 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 Land			Fallow Lands		Net area Sown	Gross Cropped Area	Agri. Land (Culti-vable / Cultur-able /Arable)	Cultivate d land	Un-cultivable land	Un-cultivated 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 Land			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	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

Chapter 1
Rice

Rice (Oryga sativa) is the most staple cereal of India, that along with wheat forms the major component of India's food security. A bouquet of technology, price support and extension contributed majorly to productivity increases of rice. However, being resource-guzzling, particularly water, indiscreet use of resources has left behind certain negative effects. There also seems to be technology fatigue, as reflected in stagnant yield levels. The challenge now lies in adopting new technologies & practices to realise higher productivity and release surplus land for other crops.

1.1 Rice: An Introduction

Rice is a staple food for more than half of the world population and plays a pivotal role in food security in many countries. It constitutes nearly 26 per cent in total cereal production and nearly 20 per cent in total cereals trade (FAOSTAT 2014). India is the second largest producer and consumer and plays an important role in the global rice economy. The average productivity of rice in India, at present, is 2.55 tonnes /ha, which is far below the global average of 2.7 tonnes/ha. The productivity of India rice is higher than that of Thailand and Pakistan but much lower than that of Japan, china, Vietnam and Indonesia. The highest productivity is 6710 kg per ha in China followed by Vietnam (5573 kg /ha), Indonesia (5152 kg/ha) and Bangladesh (4375 kg/ha) etc.

In India**,** rice is grown in 44 million ha area and the production level is 110 million tonnes with a productivity of 2550 kg/ha. It is grown in India under diverse soil and climatic conditions, and about 90 per cent of the cultivated land belongs to marginal, small and medium farmers. There is ample scope to increase the productivity of rice in the country and score higher levels of production. There are improved technologies and various farm management interventions which could be adapted to increase the productivity in the country. Cultivation of hybrid rice has potential to increase the productivity and needs to be promoted. The rice growing areas in the country can be broadly grouped into five regions as given below:

i. **North-Eastern Region:** This region comprises Assam and north eastern states. In Assam rice is grown in the basin of Brahmnaputra river. This region receives very heavy rainfall and rice is grown under rainfed condition.

ii. **Eastern Region**: This region comprises Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh and West Bengal. In this region, rice is grown in the basins of Ganga and Mahanadi rivers and has the highest intensity of rice cultivation in the country. This region receives heavy rainfall and rice is grown mainly under rainfed conditions.

iii. **Northern Region**: This region comprises Haryana, Punjab, Western Uttar Pradesh, Uttarakhand, Himachal Pradesh and Jammu & Kashmir. The region experiences low winter temperature and single crop of rice from May-July to September-December is raised.

iv. **Western Region**: This region comprises of Gujarat, Maharashtra and Rajasthan. Rice is largely grown under rainfed condition during June-August to October - December.

v. **Southern Region:** This region comprises Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Rice is mainly grown in deltaic tracts of Godavari, Krishna and Cauvery rivers, and the non-deltaic rainfed areas of Tamil Nadu and Andhra Pradesh. The crop is grown under irrigated condition in deltaic tracts.

Growth in population and increasing purchasing power will drive an increase in demand for food in India. The relative demand for high value commodities like vegetables, fruits, milk, fish, meat and egg will increase and that for cereals decrease in years to come. According to the projections of the Population Foundation of India (PFI), India's population will be 1412 millions by the end of 2022. It is estimated that the consumption demand for rice will be about 115 million tonnes (Mt) by that year. In addition to this demand, India's current export of 4 Mts of basmati and 6 Mts of non-basmati rice can also be expected to rise.

Further, due to diversification policies of the government, the area under rice will reduce to make space for other high value crops/enterprises. In order to achieve the consequential enhanced total demand for rice from reduced area, the average productivity of rice has to be increased to the level of 3.0 t ha^{-1} by 2022-23, which is 2.55 t/ha presently. The projected demand, supply and probable gaps in the year 2022-23 are presented in Table 1.1.

Table 1.1 Projected demand and supply of rice upto the year 2022.

Year	Projected demand (Mt)	Projected supply at different growth rates (Mt)		Demand-Supply Gap at different growth rates (Mt)	
		1.64%	0.70%	1.64%	0.70%
2015-16 (base year)					
2016-17	108.49	108.18	107.18	-0.31	-1.31
2017-18	109.55	109.96	107.93	0.41	-1.62
2018-19	110.62	111.77	108.69	1.15	-1.93
2019-20	111.70	113.61	109.45	1.91	-2.25
2020-21	112.66	115.48	110.22	2.82	-2.44
2021-22	113.63	117.38	111.00	3.75	-2.63

Source: DFI Committee Estimates Mt: million tons;
Growth rate for the period 2007-08 to 2016-17 is computed to be 1.64% per year and for the period 2012-13 to 2016-17 to be 0.70%. Base period value (average of 2012-13 to 2016-17) is 106.39 Mt for supply projections.

The present (2012-13 to 2016-17) rate of production growth (0.70 per cent) is below the decadal (2007-08 to 2016-17) production growth of 1.64 per cent and population growth of 1.2 per cent. If the present rate of growth continues, the deficit in production will be 2.6 Mt by the year 2022-23. Therefore, the growth in production has to be accelerated to meet the growing demand and also to enhance exports. Thus, there is no room for business as usual.

An alternate estimate of productivity is also projected, taking into account the actual during the year 2016-17. These estimates are presented in Table 1.2.

Table 1.2 Projected production target and demand of Rice up to 2022 (in million tonnes)

Year	Projected production target *	Increase in productivity Per ha	Projected demand**	Percent increase in Demand	Gap between Production and demand
2015-16 (Base year)	104.41	2400	101.25	-	+3.16
2016-17	110.00	2550	104.00	2.71	+6.00
2017-18	112.00	2605	105.50	1.44	+6.50
2018-19	113.50	2640	107.00	1.42	+6.50
2019-20	115.00	2674	108.50	1.40	+6.50
2020-21	117.00	2721	110.00	1.38	+7.00
2021-22	119.00	2767	111.00	0.91	+8.00
2022-23					

* NFSM target of Rice production in EFC Memo
** Based on actual consumption in 2011 NSS Family Budget Survey

1.2 Income from Rice-based Systems

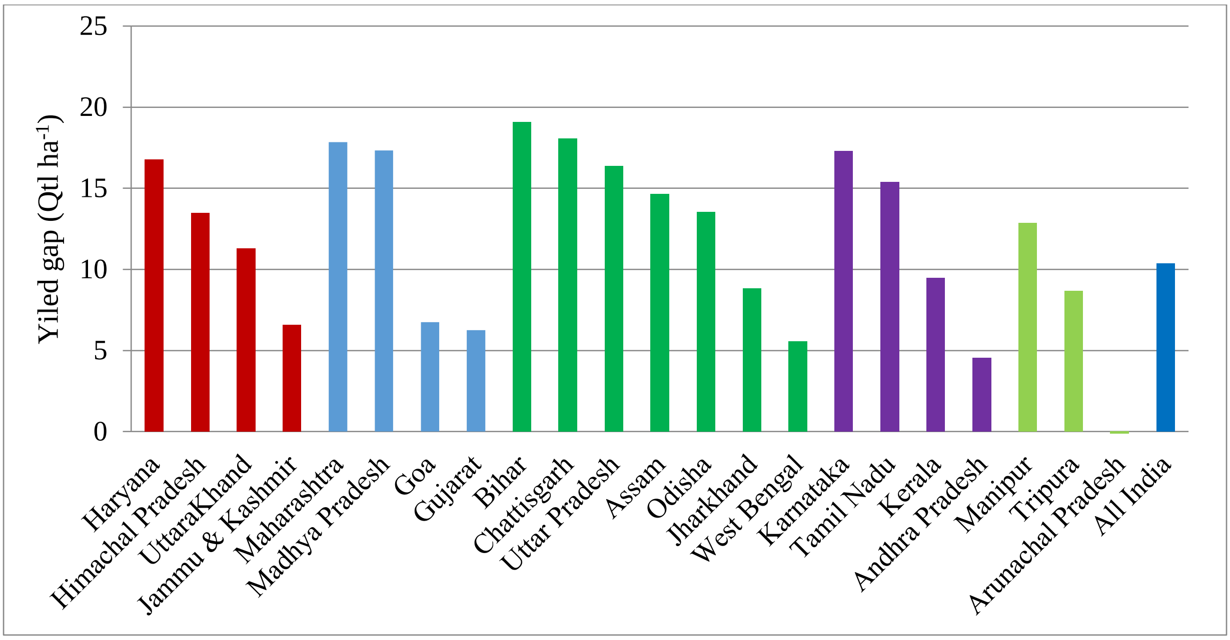
Of the 141 million hectare (Mha) of net cultivated area in India, rice occupies the maximum i.e., about 44 Mha (30 per cent). In eastern India, about 60 per cent of the cultivated area is rice (Table 1.3). Therefore, doubling of farmers' income by 2022, calls for special emphasis on the rice farmers of eastern India. However, doubling of income from rice farming is much more challenging than that of any other commodity-farming. The challenges in case of Eastern India rice-farmer are more intense, because of the region's dependence on monsoon, small land-holdings, subsistence nature of farming and poor infra-structure for storage and marketing, besides 'for agriculture' infrastructure. To compound the problems, the credit absorption by the region's farmers is below par, when compared to other regions.

Table 1.3 Income contribution of rice compared to other commodities.

Region	% Rice in Various Regions	%Rice among Cereals	% Rice among all Crops	% Rice among all Crops, Livestock and Fish
Eastern Region	**50.5**	55.5	18.8	12.9
Western Region	5.4	21.0	2.9	2.0
Northern Region	17.2	40.2	21.6	14.2
Southern Region	21.1	68.7	14.2	8.6
NE Region	5.8	94.1	23.2	17.1
All India	**100**	**50.9**	**14.1**	**9.5**

Further, region-wise analysis of yield gap between Front Line Demonstration (FLD) and Average State Yield (SAY) shows, that most of the eastern states have larger yield gaps as compared to other regions (Figure 1.1). Of the 11 states suffering from yield gaps of more than 1 t/ha, five belong to eastern region. Eastern region accounts for 25.94 m ha (61.16 per cent) of area under rice. Therefore, if technological intervention is intensified in this region to achieve FLD level of rice productivity, then this region can produce 35.59 Mt of additional rice. On an average, the increment in production per hectare would be 1.37 ton, which will result into an additional income Rs. 20,139 per hectare for the farmers, which accounts for 68.5 per cent increase in their income.

Figure 1.1 Gaps between front line demonstration and average yield in various states.

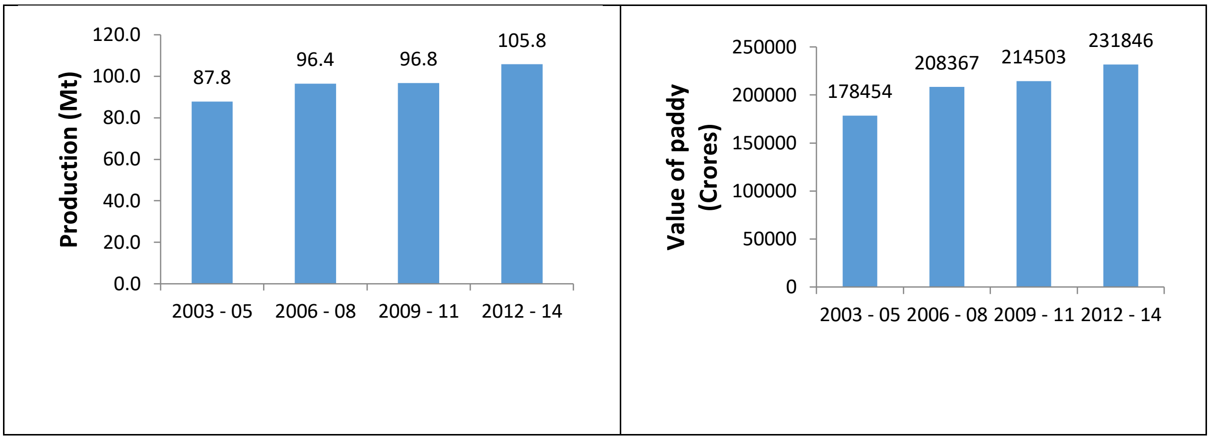


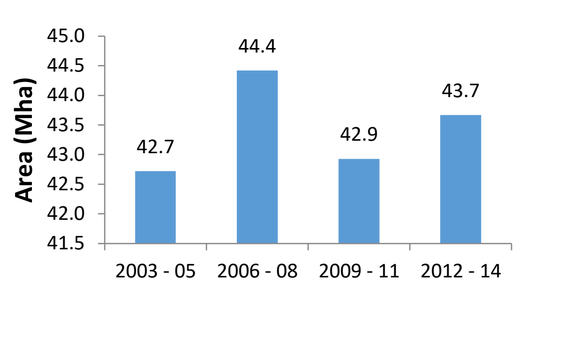
Source: DFI Committee Estimates based on data compiled from NFSM website (nfsm.gov.in)

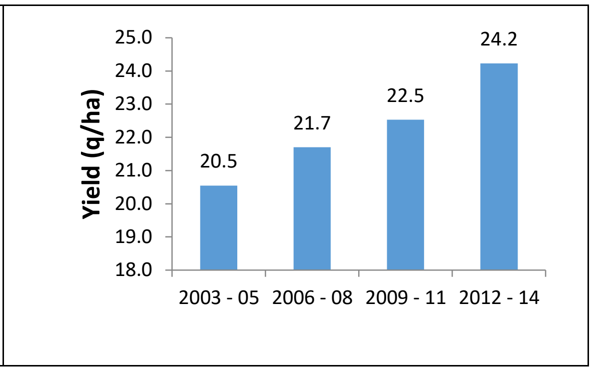
1.2.1 Trends in increase in area, production, yield and price of rice

Rice production in India has been increasing continuously due to consistent technological improvements. The production has increased from 87.8 Mt during the triennium ending 2005-06 to 105.8 Mt during the triennium ending 2014-15. The corresponding values of the production were Rs. 1.78 lakh crore and Rs. 2.32 lakh crore during the triennium ending 2005-06 and 2014-15 respectively. The production growth was due to growth in both area and yield. The scope for growth in area for rice has been exhausted and the future production growth will have to come from increase in yield alone through further technological improvement and adoption of these by farmers, who are yet to do so. The yield has increased from 2.05 t ha^{-1} (triennium ending 2005-06) to 2.42 t ha^{-1} (triennium ending 2014-15).

Figure 1.2 Trends in Production, Value, Area and Yield of Paddy in India





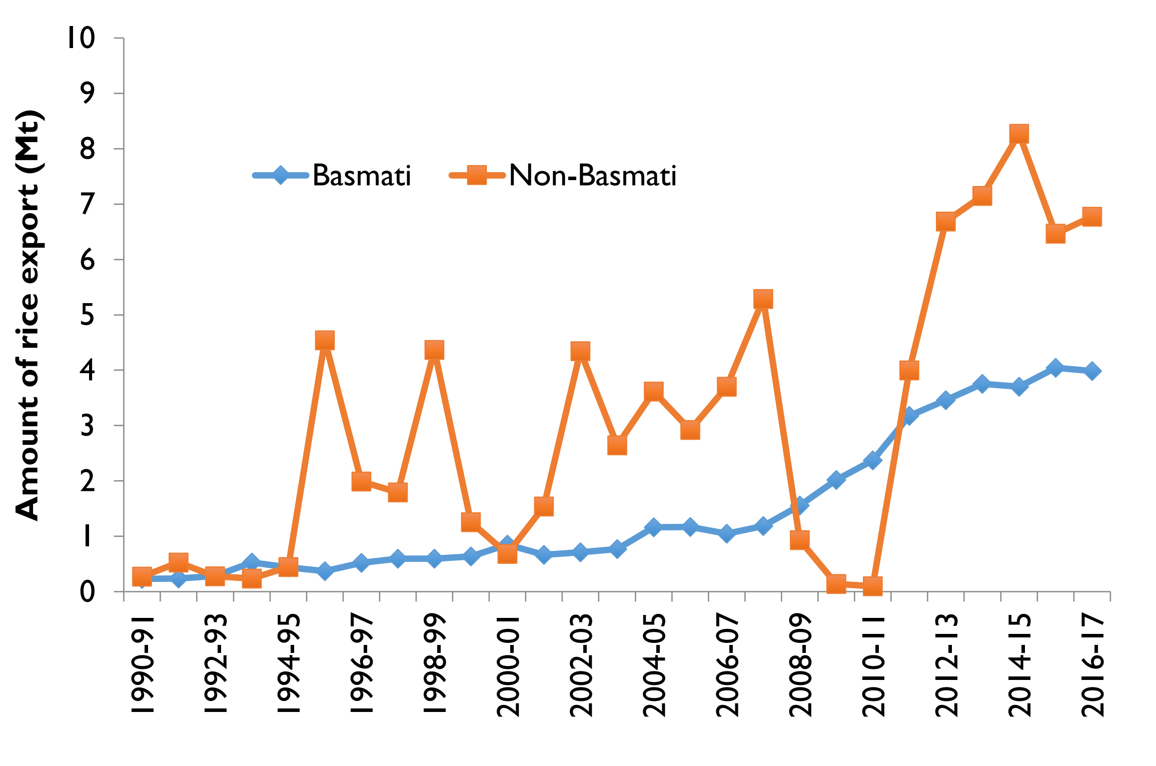


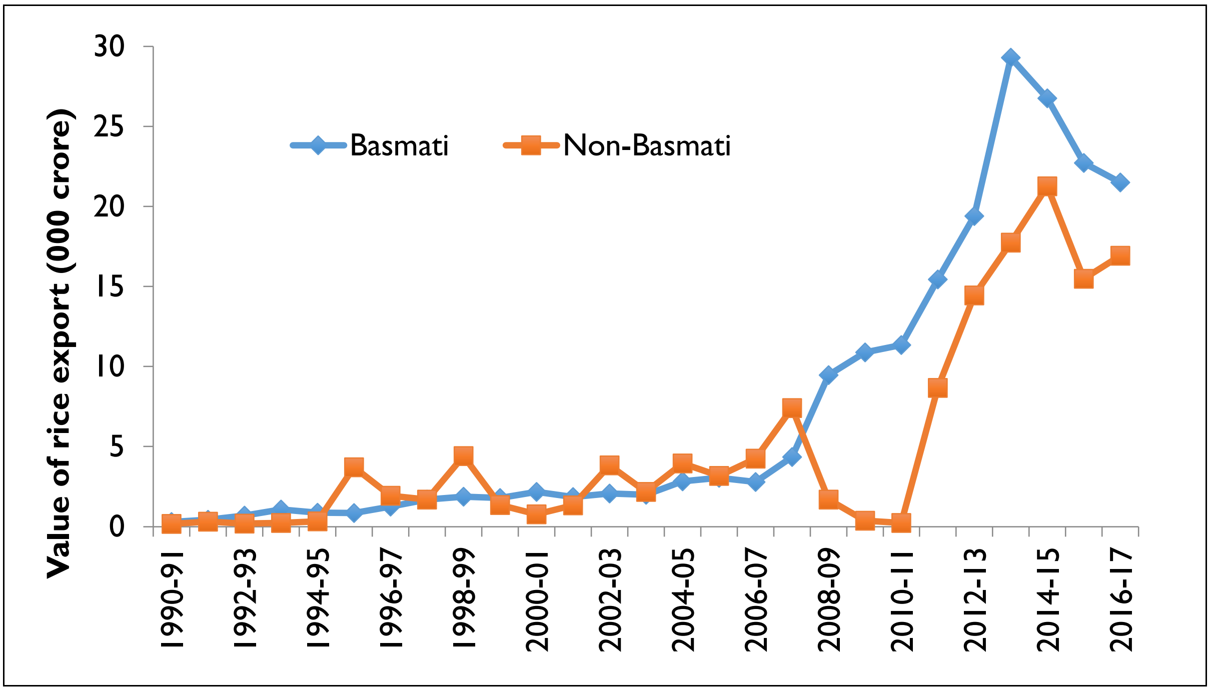
Source: DFI Committee Estimates based on data compiled from DACNET

1.2.2 Trends in rice exports

The export of rice has increased dramatically since the Uruguay Round Agreement on Agriculture was signed (Fig. 1.3). The annual export of rice before 1995 was only 0.68 Mt valuing Rs 3,354 crore. After the Agreement, exports of rice increased very rapidly and reached more than 10 million tonnes during the year 2016-17, thus, earning valuable foreign exchange of more than Rs 38,700 crore. The basmati export increased from the earlier 0.36 million tonnes, to more than 4.0 million tonnes, netting an earning of more than Rs 22,700 crore for the country during the year 2015-16. Similarly, the non-basmati export has increased from 0.32 Mt to more than 6.0 Mt during 2015-16.

Figure 1.3 Trends in export of rice (a) quantity of export and (b) value of export.





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

1.3 Options for improving Farmers' Income

Farmers' income can be improved when productivity goes up, cost of production comes down, risk is reduced, post-harvest loss is minimized and commodities produced get a remunerative price. Additional income should flow from allied activities of agriculture too. The strategy will have to integrate all these avenues in a meaningful manner, by building on supplementary and complementary relations. In this context, the options available for increasing farmers' income in rice-based systems are discussed in the following sub-sections (State-specific options are presented in Annexure).

1.3.1 Strategies for increasing production and productivity of Rice crop

(i) Promotion of latest High Yielding Varieties (HYVs)/Hybrids of rice and increase of seed replacement rate (SRR) upto 80 per cent in coming years in HYVs, and 100 per cent in case of hybrids.

(ii) Promotion of bio-fortified high nutrient rich varieties, such as high protein & zinc content rice varieties for nutritional security Over the years, Research Institutes in the country have developed several varieties for increasing per cent yields. Additionally, there has also been, the emphasis on improving the nutritional quality of rice varieties, leading to varieties with improved quality attributes such as high protein content (CR Dhan 310, CR Dhan 311); high zinc content (DRR Dhan 45; Chhattisgarh Zinc Rice 1); and low glycemic index (Improved Sambha Mahsuri).

The variety, CR Dhan 310 released for irrigated ecology has a maturity duration of 125 days and an average grain yield of 4.5 t/ha. The grain protein content of the variety is 10.3 per cent. It has also high zinc content of 21 ppm in grain. High zinc rice DRR Dhan 45 is a bio-fortified semi-dwarf, non-lodging, medium duration (125 days), long slender, high yielding (>5 t/ha) variety for irrigated conditions. It has been developed through conventional breeding methods using material from Harvest Plus. It is the first high zinc rice variety to be notified at national level with an overall mean zinc content of 22.6 ppm in polished rice. It has good cooking quality with desirable amylose content (20.7 per cent). This bio-fortified variety can address the hidden hunger or mineral malnutrition and contribute to nutritional security of the nation.

Similarly, Chhattisgarh Zinc Rice-1 is an early maturing type variety with maturity duration of 110 days. The expected grain yield from the variety is 50 q/ha. The zinc content in the grains of this variety is 22-24 ppm, which is 8-9 ppm higher than that of a common variety.

(iii) Promotion of high yielding basmati and aromatic non-basmati varieties of rice especially for export purpose.

(iv) Promotion of salt tolerant/stress tolerant/climate resilient/semi-cum-deep water/upland varieties in specific areas for higher productivity. Several crop varieties with enhanced tolerance to biotic and abiotic stresses have been released. A list of such varieties of rice is listed in table 1.4. Recently, a climate-smart variety. CR Dhan 801 has been released which is tolerant to both submergence and drought situations. It is in the background of very popular variety Swarna with maturity duration of 140 days.

Table 1.4 Varieties tolerant to biotic and abiotic stresses

Variety	Ecology	Duration
1. CR Dhan 409	Shallow Water lowland	160
2. CRDhan 507	Deepwater	160
3. CR Dhan 209	Aerobic	110
4. CR Dhan207	Aerobic	110
5. CR Dhan 508	Deep water	160
6. CR Dhan506	Semi-deep	160
7. CR Dhan 101 (Ankit)	Upland	110
8. CR Dhan 408 (Chakaakhi)	Shallow lowland	165
9. CR Dhan 205 (IET 22737)	Aerobic	110
10. CR Dhan 203 (Sachala)	Aerobic	110
11. CR Dhan 202	Aerobic	115
12. CR Dhan 206 (Gopinath)	Aerobic	115
13. CR Dhan505	Deep water	162
14. CR Dhan407	Rainfed shallow lowland	150
15. CR Dhan201	Aerobic	118
16. CR Dhan204	Aerobic	120
17. Luna Sankhi(CR Dhan 405)	Coastal Saline	105-110
18. Luna Barial(CR Dhan 406)	Coastal Saline	150-155
19. Jayantidhan (CR Dhan 502)	Deep Water	160
20. Jalamani (CR Dhan 503)	Deep Water	160
21. Sumit (CR Dhan 404)	Sh.Low land	145-150
22. Pyari (CR Dhan 200)	Aerobic	115-120

Variety	Ecology	Duration
23. Satyabhama(CR Dhan 100)	Upland	110
24. CR Dhan 500	Deep Water	160
25. CR Dhan 601	Boro	160
26. CR Dhan 501	Semi-deep	152
27. Luna Sampad	Coastal Saline	140
28. Luna Suvarna	Coastal Saline	150
29. Reeta (CRDhan 401)	Shallow low land	145-150
30. Sahbhagidhan	Rainfed upland	105
31. CR Dhan 40 (Kamesh)	Bunded Upland	110
32. Swarna Sub1	Flood prone shallow lowlands	145
33. HanseswariCRDhan 70	Rainfed Semideep	150
34. Chandan (CR BoroDhan 2)	Boro	125
35. Varshadhan	Semi-deep	160,
36. Virendra	Upland	95
37. Chandrama	Boro	130
38. Sadabahar	Upland	105
39. Anjali	Upland	95
40. Durga	Deep water	155
41. Sarala	Medium Deep	150
42. Pooja	Shallow low land	150
43. Sonamani	Coastal saline	155
44. DhalaHeera	Upland	80
45. Vandana	Upland	95
46. Sneha	Upland	70
47. Seema	Rainfed Shallow Lowland	150
48. Lunishree	Coastal Saline	145
49. CR 1002	Rainfed Shallow Lowland	145
50. Vanaprabha	Upland	90
51. Tulasi	Medium Deep	170
52. Tara	Upland	100
53. Panidhan	Medium Deep	180
54. Padmini	Rainfed Shallow Lowland	145
55. Moti	Rainfed Shallow Lowland	145
56. Kalyani II	Upland	62
57. Kalashree	Medium Deep	160
58. Heera	Upland	68
59. Gayatri	Medium Deep	160
60. Dharitri	Rainfed Shallow Lowland	150
61. CR 1014	Medium Deep	160
62. Annada	Upland	110
63. Neela	Upland	90
64. Utkalprabha	Deep	155
65. Kalinga-III	Upland	80
66. Savitri/ Ponmani	Rainfed Shallow Lowland	150
67. Sattari	Upland	70
68. Samalei	Rainfed Shallow Lowland	150
69. Ramakrishna	Rainfed Shallow Lowland	130
70. Anamika	Rainfed Shallow Lowland	145
71. Bala	Upland	105

(v) Promotion of System of Rice Intensification (SRI) technique

The basic principles of SRI are transplanting of young seedlings of around 8-15 days in age; transplanting of one seedling per hill at under wider spacing; controlling weeds by mechanical means, initially with rotary pushed weeder or conoweeder; maintaining moist soil under non-saturated conditions during the vegetative phase; and use of organic manure (compost) instead of chemical fertilizer for maintaining optimum biological activity of the soil. This technique has been widely tested in states like Odisha and Andhra Pradesh transferring higher yields and incomes to the farmers. This technology helps in realizing higher per unit yields at loer cost of cultivation. However, it is labour intensive, and is therefore, optimal in case of family farms, wherein all members of the family engage themselves as labour on their farm.

(vi) Promotion of Direct Seeded Rice (DSR) for increasing production and productivity.

Rice is commonly established by transplanting in puddled soil. It is labour, water and energy intensive and is less profitable. These factors demand a major shift from transplanting to direct seeding of rice (DSR). There are 3 principles of DSR i.e., dry seeding (sowing dry seeds into dry soil), wet seeding (sowing of pre germinated seeds in wet puddle soils), and water seeding (seeds sown into standing water). However, high weed infestation is a major constraint for adoption of DSR. Application of post-emergent recommended herbicide at proper time and/or application of early post-emergent herbicide followed by mechanical weed control by motorized weeder in heavy infested areas can successfully control the weeds.

(vii) Promotion of farm implements

For rice crop, pre-germinated seed sowing by drum seeder is a good option compared to broadcasting method of seed sowing. Sowing with drum seeder saves seed, fertilizer and other inputs and also provides uniform row to row spacing to perform subsequent field operations. In order to promote drum seeder for sowing of pre-germinated paddy seeds, ICAR-NRRI has developed manually operated four and six row drum seeder and power operated eight row drum seeder, which reduce cost of sowing substantially.

Suitably designed farm machinery deployed at various cultivation. Stages will improve farming efficiency, reduce cost of cultivation and enhance net returns. Promoting use of renewable energy in farm equipment segment such as solar-powered pumps can improve efficiency of farm operations and also create alternate source of revenue for the farmers who can sell the additional power. However, a suitable policy will be required for this purpose.

(viii) Application of balanced nutrient fertilization on soil test base including bio-fertilizers.

Soil test based nutrient management can result in higher productivity and sustainability. Site-specific use of micro/secondary-nutrients combined with soil amendments would result in greater benefit. Green manuring, as also bio-manures need encouragement to improve soil structure and fertility. Customized five-panel leaf colour chart (CLCC) for nitrogen management in rice developed at NRRI Cuttack, is an effective, low-cost, easy to use diagnostic tool which can be used by the farmers to monitor the relative greenness of rice leaf as an indicator of the leaf N status, and decide when and how much N should be applied to the crop. Customized leaf colour chart (CLCC) based N application enhanced yield by 10.3-13.3 per cent and 9.9-10.9 per cent over conventionally applied urea (RDF urea) in direct seeded (DSR) and transplanted rice (PTR), respectively. The CLCC based N application produced 11.2-18.7 per cent more yield. Farmer's feedback data obtained from deputy directors of agriculture (DDA) from different district indicated yield advantage of 5-20 per cent due to use of CLCC.

(ix) Adopting plant protection measures to protect the crops from weeds, insects pests and diseases.

There is need to promote latest generation agro-chemicals so that residual effect may not occur. IPM (Integrated Pest Management) may also be promoted among the farmers. The stem borer, brown plant hopper (BPH), leaf folder, gundhi bugh are the major insect pests of rice. The major diseases of rice are brown spot, bacterial leaf blight and blast. It is essential to deploy a pest and diseases monitoring surveillance system which will check the spread and the resultant crop loss. To improve the effectiveness of surveillance, use of technology is very important collection of data in real time, its analytics and interp-relation followed by sharing of the advice with the farmers will ensure timely management of pests and diseases.

World-wide yield loss due to various types of pests in rice is about 35 per cent. Of all the diseases, bacterial blight is emerging as a serious threat due to increase in global temperature. It is also gaining more virulence is able to break the genetic resistance. ICAR institutes have developed gene-pyramided lines with more than 3 genes (in Indian condition Xa21, Xa5 and Xa13) for effective control of this disease.

Brown spot disease is re-emerging as a serious threat to rice cultivation, especially in the upland condition. However, proper fertilization management and timely sowing can control the disease. A number of new generation fungicides are also available for its management.

In recent years, brown plant hopper (BPH) has become major threat causing huge yield loss in rice. Scientists have identified BPH resistant varieties and also developed breeding lines having tolerance to BPH. Though excellent management technologies are available, adoption at farmers' level is low. Major effort is need for synchronization of action among the different KVKs, SAUs and State Extension so that monitoring is effective.

1.4 Critical Issues relating to Paddy Cultivation

(i) Crop residue burning:

The rice-wheat cropping system (RWCS) is dominant in the Indo-Gangetic Plains covering nearly 10.5 million hectares, including 4.1 million hectares of the north-western (NW) states comprising Punjab, Haryana, Uttarakhand and Western Uttar Pradesh. RWCS in NW states produces about 34 million tonnes of rice residues, of which Punjab alone contributes about 65 per cent. The mechanized harvesting and threshing of rice using combine harvesters is a common practice in NW India. In the process, straw residue is left behind the combine harvesters in a narrow strip in the field. Disposal or utilization of the leftover residue in the short window of ten to twenty days for timely planting of rabi wheat crop is a difficult task. Therefore, the farmers commonly opt for burning of rice residue in the combine harvested fields due to lack of access to user–friendly, cost and time–effective options.

Estimates indicate that up to 80 per cent of rice residues are burnt by farmers in Punjab. In other NW states also, rice burning is practiced in a sizable area. It is estimated that in NW states of India about 23 million tonnes of rice residues are burnt annually. Collection and storage of such a huge quantity of residue is neither practically feasible nor economical. Therefore, the need for providing a cost-effective and farmer friendly option for the management of rice residue is both an urgent need, as well as an opportunity for the sustainability of the intensive RWCS in NW India.

The options open for utilizing rice residue, include livestock fodder, livestock bedding, in-situ incorporation, composting, generating electricity, mushroom cultivation, roof thatching, bio-gas (anaerobic digestion), furnace fuel, bio-fuel, and paper and pulp board manufacturing. Presently these options together utilize <15 per cent of the total rice residue produced in NW India. Of the various available options, electricity generation, production of bio-oil and on-farm utilization of rice residue are the major current practices.

However, it would be more beneficial to promote in-situ incorporation/ decomposition of rice residue is necessary to improve soil fertility and productivity. Therefore, it is necessary to promote crop residue management implements /machineries (Rotavator, Happy Seeder, Zero till Seed Drill, Straw Reaper, Rake, Paddy Straw Chopper Shredder/Mulcher/Loose Straw Chopper, Baler, SMS for Combine) through custom hiring centres in these states.

Heavy smoke rises from the paddy fields of Punjab and Haryana in particular post-the harvest in October. It is intense during the period of one of one month, when farmers are racing against time to complete sowing of rabi wheat, which period ends around November 20^{th} of the year. It is the period when cold has already arrived. The smoke that diffuses towards Delhi mixes up with the already heavy pollution over the city and creates an unbearable pall of smog. The situation has only been worsening over the years, and has ended up with legal redressal in the Supreme Court.

Government of India constituted high level committee has recommended short term interventions to improve matters by the 2018 rabi season, and has suggested an allocation of a sum of Rs.1000 crore to support promotin of happy seeder, rotavator etc. The proposed subsidy is 50 and 75 per cent in case of individuals and cooperatives respectively. This would help the farmers to undertake wheat sowing without the hassle of crop residue or putting it to fire.

In the long run however, an institutional way of aggregating the crop residue and using it in bio-energy and bio-methane plants may be a better option, as it would provide an opportunity to the farmers to generate additional income. Simultaneously, considering the benefits of in-situ conservation of paddy straw, the required quantum should be used for this purpose. National Centre for Organic Farming (NCoF), Ghaziabad has developed a decomposer, which is demonstrating its ability to decompose crop residue in quick speed. This may be tried out in the rice straw fields.

(ii) Water use efficiency

Paddy is a water guzzling crop. An output of 1 (one) kg of rice consumes an average of 3000-5000 litres of water. Continuous cultivation of paddy in the Indo-Gangetic Plains has resulted in over-exploitation of ground water. The water table has gone down, threatening sustainability. Export of rice has been termed as export of valuable water from India.

A critical intervention needed, therefore, is to promote water use efficient varieties, technologies and practices. Widespread deployment of micro-irrigation systems is necessary.

(iii) Crop substitution

Crop substitution by diversifying from paddy should also form an important part of the long term strategy, from the perspective of water management. However, considering the major position that rice occupies in the food security strategy of the country, the substitution has to be guided by a comprehensive and cautious roadmap. This includes:

a. achieving high productivity across the rice cultivation zones, particularly in eastern India, where average yields are lower than national average;
b. achieving higher area and production of nutri-cereals, along with higher productivity, so as to broaden the base of foodgrain basket, and reduce high reliance on rice and wheat;
c. promoting and facilitating consumption of high value commodities – fruits, vegetables, milk, meat, fish etc. to effect relatively lesser consumption of carbohydrates.

It may be noted, that diversification of paddy will be required in Indo-Gangetic Plains, as also uplands of eastern India, where paddy is highly vulnerable to vagaries of monsoons. One of the primary reasons for lower average yields in eastern states, is on account of upland paddy cultivation, where per ha. yields are much below normal.

(iv) Promotion of bio-fortified and special quality paddy

From the perspective of enhancing nutritional intake of the citizens, it is necessary to promote cultivation of various bio-fortified varieties. The intake of minerals like Zinc (Zn), Iron (Fe) etc. is required.

Further, from the view point of increasing income returns of paddy farmers it would help promoting special varieties like basmati rice, which fetch much higher prices compared to common varieties. In the export market too, the demand for basmati rice is higher. Cultivation of such varieties will need to be incentivized by offering higher MSP/bonus along with procurement.

(v) Strengthening of market forces

While paddy along with wheat are the two principle crops, that have enjoyed the benefit of MSP and procurement, since 1965, this may not be enough. The combined procurement of these two staple cereals is around 33 per cent per annum. Happily, over the last decade, the procurement of paddy has gone beyond the boundaries of Punjab, Haryana and western Uttar Pradesh, thanks to decentralized procurement system adopted in states like Odisha, Madhya Pradesh, Chhattisgarh etc. However, there still remain marketable surplus, that depends upon market forces for its monetisation. Hence, creation of an efficient market environment will always be important. This must be taken care of.

Key Extracts

- Average productivity in rice is low compared to most of the major rice-growing countries. Quality and judicious use of inputs such as water, seeds, fertilizer and pesticides with efficient use of modern technology is needed.
- There is need is to transform the current production-driven to income-driven rice-farming system and reduce the disparity among farmers of different regions of India.
- Agricultural research should be re-oriented with farmers' participatory approach and fulfil the aspirations of resource-poor, smallholder farmers. Higher investments in agricultural R&D to specifically address the challenges of resource degradation, escalating input crisis and costs with overarching effects of climate change.
- Region and state-specific action plans are required keeping in mind inherent ecological suitability and ability to sustain rice production. Emphasis is needed on water use efficiency by adopting appropriate varieties, technologies and practices.
- Crop substitution by diversifying from paddy is needed in Indo-Gangetic Plains and uplands of eastern Indian states. However, substitution strategy has to follow substantive increases in productivity, so that food security is not compromised.
- Government should review procurement operations in the five eastern states, viz., Bihar, Jharkhand, Odisha, Uttar Pradesh and West Bengal, where the support price mechanism is not effective, on priority.
- The insurance institutions in the region have to be strengthened and made effective to stabilize farm income.

Chapter 2
Wheat

Wheat (Triticum aestivum) is second most important staple cereal and constitutes a critical component of India's food security basket. It has recorded impressive growth rate in productivity and production since mid-1960s. It is a winter season rabi crop, that is vulnerable to climate change implication of temperature rise. This chapter examines, the existing yield gaps and the needed strategy to enhance productivity by adopting new technology.

2.1 Introduction

Wheat is the largest cultivated crop in the world occupying an area of 222.35 million hectares (mha) with an estimated production of 753.89 million tonnes (Mts) in 2016-17 (Source: USDA). It is a staple food in more than 40 countries and finds a significant share (35 per cent) in the consumption basket of millions across the world. This cereal has been under cultivation in several countries, bearing a close association with their civilization.

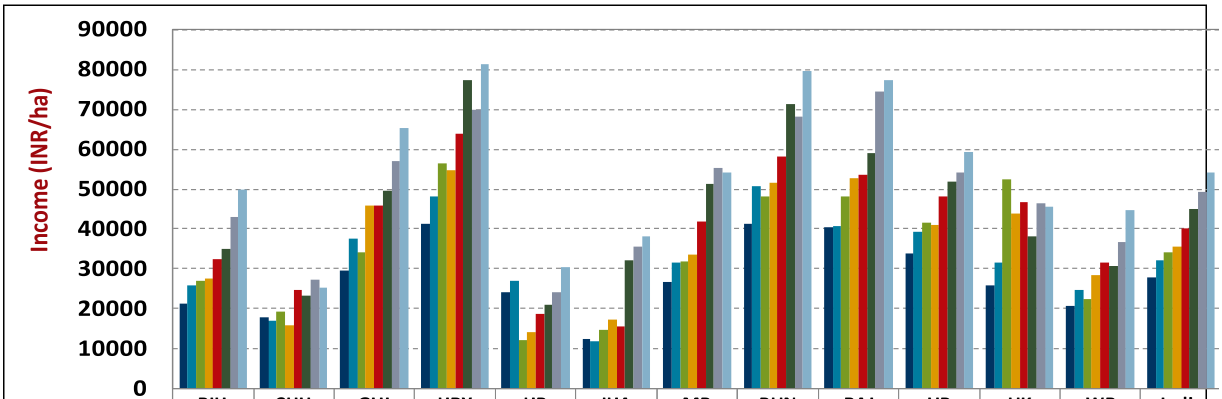
Among the major producers, China tops the list with an annual production hovering around 130 Mts, followed by India (98.38 mt) and Russia (73 Mts). However, in terms of wheat acreage India ranks first (30.60 mha), followed by Russia (27 mha) and China (24.19 mha). Wheat being one of the major staple foods is crucial to India's food and nutrition security as well as agricultural development. The nutritious grain holds a 35 per cent share in the total foodgrains produced in India and supplies a significant share to the total of proteins (20 per cent) and calorie intake (19 per cent). The country trades a significant amount of wheat, with marketed surplus: output ratio ranging from 53 to 85 per cent across states. This indicates that it is a prominent source of income among the wheat growing farming community. India has emerged as a net exporter since 1978, which has been sustained over the years. India exported 2.66 lakh tonnes of wheat worth about Rs 448 crore during 2016-17 (Source: DGCIS Annual Export). The supply of wheat has a strong association with the minimum support price due to its high correlation with the crop acreage (Sendhil et al., 2012), and is also a major contributing factor to the realised income of wheat producers. India has witnessed a remarkable progress in wheat production, reaching an all-time high of 98.38 million tonnes in 2016-17, harvested from 30.60 million hectares. This translated into a record productivity of 3216 kg/ha which is on par with the world average.

2.2 Trends and Dynamics of Wheat Producers' Income and Yield

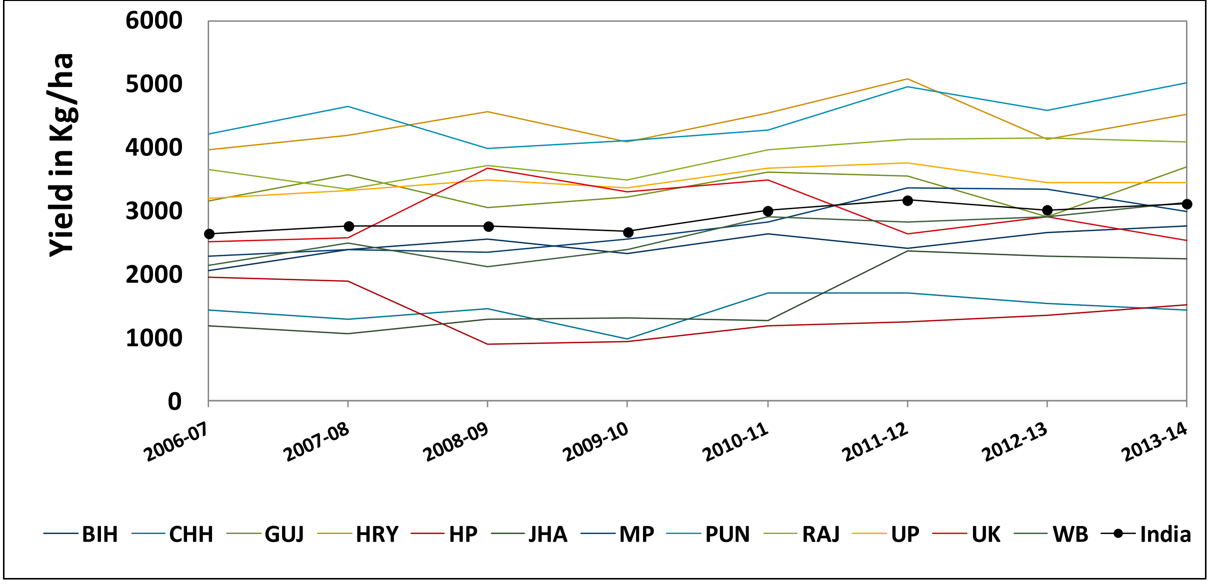
Deciphering the trends across states, and over time provides a peep into the dynamic income behaviour from wheat production in different regions (Fig. 2.1), facilitating an understanding of economic implications and setting geographical priorities. In doing so, both the main-product (grain) as well the by-product (straw) are accounted for in wheat production. The gross income between 2006-07 and 2013-14 has doubled in a majority of the states including Bihar, Gujarat, Jharkhand, Madhya Pradesh and West Bengal. The source of income is productivity (grain+straw) and its value is, price x total output. On an average, the country as a whole is close to income doubling in case of wheat with an estimated ratio of 1.94. The rising price is one of the favourable factors for the increased income apart from the productivity increases.

Agriculture being biological in nature with geographical concentration, wheat productivity exhibits spatial and temporal variations across the cultivating regions. The yield levels across the states have shown a positive growth barring Chhattisgarh (0.99) and Himachal Pradesh (0.78). The yield ratio was highest in the case of Jharkhand (1.88) (table 2.1). State-wise productivity trends reveal that only a few states like Punjab, Haryana and Rajasthan have registered more than the national average. The divergence was more in Jharkhand, Himachal Pradesh and Chhattisgarh. The change in yield from 2006-07 to 2013-14 was highest in the case of Jharkhand (+1048 Kg/ha), followed by West Bengal (+995 Kg/ha) & Punjab (+813 Kg/ha).

Figure 2.1 Spatial and temporal trends in the gross income (INR/Ha) from wheat production and productivity trend for major wheat producing states



	BIH	CHH	GUJ	HRY	HP	JHA	MP	PUN	RAJ	UP	UK	WB	India
2006-07	21307	17710	29505	41333	24262	12407	26822	41212	40441	33826	25854	20797	27956
2007-08	25696	16839	37513	48077	26884	11866	31472	50693	40837	39197	31573	24665	32109
2008-09	27092	19290	34061	56403	12231	14570	31777	48127	48104	41566	52438	22450	34009
2009-10	27676	15777	45856	54838	14212	17134	33595	51536	52770	41131	43809	28479	35568
2010-11	32458	24822	45901	63914	18648	15676	41728	58133	53551	48104	46619	31695	40104
2011-12	34889	23271	49716	77295	20936	32142	51266	71233	59154	52010	38110	30802	45069
2012-13	42995	27159	56923	69812	24037	35514	55416	68092	74476	54226	46562	36795	49334
2013-14	49891	25343	65335	81387	30359	38249	54279	79665	77400	59294	45597	44615	54285



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

Table 2.1 Ratio and growth rate of income and yield (2006-07 to 2013-14)

States	Income		Yield	
	Ratio	CAGR (%)	Ratio	CAGR (%)
Bihar	2.34	11.9	1.34	3.1
Chhattisgarh	1.43	7.3	0.99	2.23
Gujarat	2.21	11.03	1.17	0.72
Haryana	1.97	9.61	1.14	1.51
Himachal Pradesh	1.25	3.5	0.78	-2.51
Jharkhand	3.08	20.47	1.88	12.67
Madhya Pradesh	2.02	11.86	1.31	5.79
Punjab	1.93	9.19	1.19	2.25
Rajasthan	1.91	10.23	1.12	2.85
Uttar Pradesh	1.75	7.89	1.08	1.23
Uttarakhand	1.76	6.16	1.01	-0.32
West Bengal	2.15	10.52	1.46	5.52
India	1.94	9.67	1.18	2.55

Source: DFI Committee Estimates.
 # CAGR: Compound Annual Growth Rate

2.3 Yield Gaps in Wheat

Despite significant improvement in yield levels over the years, there still exist yield gaps between those realised on farmers' fields and under Frontline Demonstrations (FLDs), indicating the lag in technology adoption. Table 2.2 to 2.4 present the level of yield gaps across different centres, states and zones, where wheat has been under cultivation.

The significant yield gap in North Hill Zone (NHZ) was 34.91 per cent at Almora followed by Khudwani, Anantnag (22.88 per cent), Dhaulakuan Sirmour (20.78 per cent), Hamirpur (18.10 per cent), Malan Kangra (14.07 per cent) and Bajaura Kullu (13.73 per cent).

In North Eastern Plain Zone (NEPZ), the yield gap varied from 4.60 per cent at Pundibari Coochbehar to 66.61 per cent at Sonitpur. The percentage yield gaps varied from 59.64 (Kanke Ranchi) to 52.02 (Pusa Samastipur) to 44.57 (Kalyani Nadia), 26.33 (Dhubri) to 26.31 (Darrang Mangaldai) to 26.24 (East Champaran), to 21.70(Madhubani), 20.32(Varanasi) to 19.85(Morabadi Ranchi.

In North Western Plain Zone (NWPZ), the yield gap was highest at Saharanpur (31.36 per cent), followed by Ajmer (29.75 per cent) and Kathua Jammu (15.40 per cent).

In Central Zone (CZ), there was significant yield gap at Indore (47.49 per cent), followed by Ratlam (32.72 per cent) and Panna (21.91 per cent).

In Peninsular Zone (PZ), significant yield gap of 33.29, 18.90, 18.61, 17.01 and 14.94 per cent were recorded at Parbhani, Pune, Niphad Nasik, Dharwad and Belgaum centers, respectively.

In Sothern Hill Zone (SHZ), the average yield of improved varieties as introduced to farmers under demonstration was 23.86 q/ha at Wellington Center.

Table 2.2 Centre-wise yield gaps (2016-17)

Zone & Centre	Demonstrated varieties mean yield (q/ha)	Check varieties mean yield (q/ha)	Yield gap (%)
Northern Hills Zone (NHZ)			
Almora	30.84	22.86	34.91***
Bajaura, Kullu	25.92	22.79	13.73***
Malan, Kangra	33.65	29.50	14.07**
Dhaulakuan, Sirmour	35.75	29.60	20.78***
Tutikandi, Shimla	30.00	27.00	11.11^{NS}
Khudwani, Anantnag	27.50	22.38	22.88***
Hamirpur	25.12	21.27	18.10***
North Eastern Plains Zone (NEPZ)			
Faizabad	50.53	42.27	19.54***
Kanpur	62.74	53.76	16.70***
Varanasi	39.50	32.83	20.32***
Sohna, Sidharthnagar	44.73	41.34	08.20***
Sultanpur	40.77	35.28	15.56***
Kalyani, Nadia	39.80	27.53	44.57***
Pundibari, Coochbehar	35.69	34.12	04.60*
Dimapur	10.40	08.95	16.20*
Shillongani	23.62	20.87	13.18^{NS}
Darrang, Mangaldai	29.09	23.03	26.31***
Dhubri	25.19	19.94	26.33***
Tinsukia			
Sonitpur	19.86	11.92	66.61***
Chirang	22.00	17.00	29.41^{NS}
PusaSamastipur	46.20	30.39	52.02***
Nawada	42.50	37.70	12.73***
Vaishali	50.64	46.77	08.27***
Kaimur, Bhabua	39.23	35.41	10.79***
Madhubani	32.41	26.63	21.70***
East Champaran	45.65	36.16	26.24***
West Champaran	41.20	33.17	24.21^{NS}
Kanke, Ranchi	34.10	21.36	59.64***
Morabadi, Ranchi	37.56	31.34	19.85***
West Singhbhum	31.40	27.53	14.06***
North Western Plains Zone (NWPZ)			
Una	32.43	29.67	09.30**
Kathua-Jammu	35.36	30.64	15.40***
Ludhiana	57.52	55.13	04.34***
Gurdaspur	50.64	44.93	12.71***
Ropar	55.87	54.42	02.66**
Amritsar	53.18	51.88	02.51**
Agra	56.92	53.50	06.39*
Muzaffarnagar	42.81	37.47	14.25***

Zone & Centre	Demonstrated varieties mean yield (q/ha)	Check varieties mean yield (q/ha)	Yield gap (%)
Bijnor	48.86	44.49	09.82**
Saharanpur	57.34	43.65	31.36***
Meerut	50.75	47.19	07.54**
Noida	59.56	54.62	09.04***
Pantnagar	54.50	53.93	01.06^{NS}
IARI, New Delhi	52.16	48.66	07.19**
KVK, Ujwa, Delhi	42.99	39.70	08.29***
IIWBR, Karnal	57.23	55.43	03.25^{NS}
CSSRI, Karnal	49.97	47.93	04.26*
Hisar	58.33	57.08	02.19^{NS}
Bhiwani	58.70	53.13	10.48***
Ambala	50.40	47.10	07.01***
Kaithal	54.50	53.25	02.35^{NS}
Durgapura, Jaipur	53.25	48.13	10.64***
Ajmer	61.63	47.50	29.75***
BanasthaliTonk	48.10	45.20	06.42^{NS}
Sriganganagar	51.40	44.80	14.73**
Central Zone (CZ)			
Udaipur	44.87	40.87	09.79***
Banswara	43.47	37.71	15.27***
Kota	53.69	46.25	16.09***
SawaiMadhopur	50.81	45.60	11.43***
Junagarh	53.25	49.75	07.04^{NS}
Vijapur, Mehsana	44.51	41.36	07.62^{NS}
Jabalpur	24.33	23.00	05.78^{NS}
Indore	63.54	43.08	47.49***
Panna	39.50	32.40	21.91***
Ratlam	35.21	26.53	32.72***
Neemuch	65.40	54.72	19.52***
Mandsaur	45.00	38.00	18.42***
Ujjain	53.56	51.72	03.56^{NS}
Lahar, Bhind	47.69	40.50	17.75***
Jagdalpur, Bastar	22.47	19.08	17.77***
Sarkanda, Bilaspur	34.80	30.50	14.10***
Peninsular Zone (PZ)			
Akola	25.39	22.09	14.94^{NS}
Niphad, Nashik	42.70	36.00	18.61***
Parbhani	41.88	31.42	33.29***
Pune	51.47	43.29	18.90***
Dharwad	40.25	34.40	17.01***
Belgaum	22.00	19.14	14.94***
Southern Hills Zone (SHZ)			
Wellington, Nilgiris	23.86	-	-

Source: DFI Committee Estimates

*** Significant at 1 per cent level, ** Significant at 5 per cent level, * Significant at 10 percent level, NS– Non-significant

State-wise yield gap (table 2.4) due to farmers' practice shows that maximum percentage of yield gaps were observed in West Bengal (33.82) followed by Uttarakhand (29.25), Jharkhand (27.12), Assam (26.04), Bihar (22.40), Maharashtra (22.01), MP (20.05), J&K (16.79), Karnataka (16.64), HP (16.38), Nagaland (16.20), Chhattisgarh (15.81), UP (13.77), Delhi (7.72), Gujarat (7.38), Haryana (5.09) and Punjab (4.44).

Similarly, the percentage yield gaps due to farmers' practice (table 2.5) over demonstrated variety and technologies was highest in NHZ (25.80, followed by NEPZ (23.54, PZ (20.00), CZ (16.28) and NWPZ (9.19).

Table 2.3 State-wise yield gaps (2016-17)

State	**Mean yield (q/ha)**		**Yield Gap (%)**
	Improved	**Check**	
Uttarakhand	32.70	25.30	29.25***
Himachal Pradesh	30.84	26.50	16.38***
Jammu & Kashmir	33.45	28.64	16.79***
Uttar Pradesh	50.98	44.81	13.77***
West Bengal	38.86	29.04	33.82***
Nagaland	10.40	8.95	16.20*
Assam	25.22	20.01	26.04***
Bihar	41.42	33.84	22.40***
Jharkhand	34.92	27.47	27.12***
Punjab	54.84	52.51	4.44***
Delhi	47.29	43.90	7.72**
Haryana	54.12	51.50	5.09***
Rajasthan	50.19	43.90	14.33***
Gujarat	47.87	44.58	7.38^{NS}
Madhya Pradesh	47.79	39.81	20.05***
Chhattisgarh	27.61	23.84	15.81**
Maharashtra	40.69	33.35	22.01***
Karnataka	35.04	30.04	16.64**
Tamil Nadu	23.86	-	-

Source: DFI Committee Estimates

*** Significant at 1 percent level, ** Significant at 5 percent level, * Significant at 10 percent level, NS– Non-significant

Table 2.4 Zone-wise yield gaps (2016-17)

Zone	**Mean yield(q/ha)**		**% Gain**
	Demonstrated variety	Check	
NHZ	30.62	24.34	25.80***
NEPZ	39.15	31.69	23.54***
NWPZ	50.99	46.70	09.19***
CZ	45.49	39.12	16.28***
PZ	38.46	32.05	20.00***
SHZ	23.86	-	-

Source: DFI Committee Estimates

*** Significant at 1 percent level

2.4 Reasons for Yield Gaps/Low Productivity

The yield gaps arise due to differences in farmers' practices and recommend practices at any point of time, which is farm-specific and region-specific. Analysis of yield gaps across wheat growing states/zones revealed the following reasons:

- Non-availability of seed of newly released varieties.
- High cost of inputs, discouraging farmers from adhering to recommended package of practices.
- Small land holding, making operations costly.
- Non-availability of labour, in time and at affordable cost.
- Non-remunerative price realisation in the market.
- Lack of knowledge among farmers about recent technologies & practices.
- Lack of irrigation facilities and vagaries of monsoons, combined with declining water table.
- Problem of *Chenopodium album* (Bat*hua) and Phalaris minor* weeds.

The following section presents the major constraints in different wheat growing zones which need interventions through science & technology, institutions and polices apart from capacity building of farmers.

Table 2.5 Constraints impeding wheat productivity across various regions

Constraints	Score	Rank
All India(n=1113)		
Non-availability of seed of newly released variety	1353	I
High cost of inputs	1276	II
Small land holding	1205	III
Non-availability of labour	1160	IV
Low price of wheat	1141	V
Lack of knowledge among farmers about recent technologies	1029	VI
Lack of irrigation facilities	1014	VII
Declining water table	968	VIII
Chenopodium album (Bathua)	953	IX
Untimely rain	933	X
Northern Hills Zone (NHZ) (n=162)		
Non-availability of seed of newly released variety	287	I
Rodents	252	II
High cost of inputs	247	III
Non-availability of farm machinery	235	IV
Small land holding	230	V
Untimely rain	224	VI
Lack of training facility	221	VII
Lack of extension literature	218	VIII
Non-availability of labour	213	IX
Poor Quality herbicides/pesticides	210	X
North Eastern Plains Zone (NEPZ) (n=324)		
Constraints	**Score**	**Rank**
Non-availability of seed of newly released variety	484	I

Constraints	Score	Rank
Small land holding	441	II
High cost of inputs	430	III
Lack of knowledge among farmers about recent technologies	428	IV
Non-availability of labour	423	V
Low organic matter	405	VI
Lack of irrigation facilities	389	VII
Chenopodium album (Bathua)	387	VIII
Poor quality seeds	385	IX
Poor information delivery by state extension machinery	379	X
North Western Plains Zone (NWPZ) (n= 287)		
Constraints	**Score**	**Rank**
Phalaris minor	343	I
Low price of wheat	312	II
High cost of inputs	305	III
Small land holding	269	IV
Declining water table	267	V
Non availability of seed of newly released variety	261	VI
Chenopodium album (Bathua)	232	VII
Low organic matter	228	VIII
Erratic power supply	224	IX
Higher custom hiring rate of land levelling, field preparation, sowing & harvesting	223	X
Central Zone (CZ) (n=225)		
Constraints	**Score**	**Rank**
Declining water table	241	I
Imbalanced use of fertilizers	227	II
Low organic matter	208	III
High cost of inputs	205	IV
Non-availability of seed of newly released variety	199	IV
Lack of facility of canal irrigation water	198	V
Small land holding	194	VI
Non-availability of labour	193	VII
Lack of irrigation facilities	193	VII
Temperature fluctuation during crop growth	183	VIII
Peninsular Zone (PZ) (n= 82)		
Constraints	**Score**	**Rank**
Low price of wheat	117	I
Erratic power supply	114	I
Non-availability of seed of newly released variety	102	II
Non-availability of labour	76	III
Non-availability of electricity	72	IV
Problem in marketing of wheat	71	V
Lack of knowledge among farmers about recent technologies	67	VI
Lack of training facility	67	VII
Poor participation in kisanmelas/field days/kisangosthi/training	63	VIII
Non-availability of crop loan	63	IX

Source: DFI Committee Estimates

- In Northern Hills Zone (NHZ), non-availability of seed of newly released wheat variety, rodents, high cost of inputs, non-availability of farm machinery and small land holding were perceived as top five major constraints.
- In North Eastern Plains Zone (NEPZ), major constraints were non-availability of seeds of newly released variety, followed by small holding size, high cost of inputs, lack of knowledge among the farmers about recent technologies and non-availability of labour. Farmers need to be educated and trained on recent wheat production technologies to harvest potential yield in their fields.
- In North Western Plains Zone (NWPZ), *Phalaris minor* followed by low price of wheat, high cost of inputs, small land holding and declining water table were perceived as major constraints in this mega zone.
- In Central Zone, declining water table, imbalanced use of fertilizers, low organic matter, high cost of inputs, and non-availability of seed of newly released wheat variety were identified as the major constraints as perceived by the farmers.
- In Peninsular Zone, low price of wheat, erratic power supply, non-availability of seeds of newly released variety, non-availability of labour, and non-availability of electricity were perceived as the major constraints faced by the wheat growers.

Farmers need to be educated and trained on recent wheat production technologies, complete package of practices and soil health management. There is need for priority attention to ensuring of quality seeds as well as quality inputs. Farmers need to be updated on impact of climate change on wheat cultivation and about the coping strategies they should be adopting to mitigate it. For instance, the delay in onset of winter in 2015 rabi season and the temperature not dipping as desirable for a good wheat crop caused lower wheat yield that year. A rise of temperature by 1^{o} C is reported cause a yield drop of 5 per cent in wheat. The concept of conservation agriculture and adoption of resource conservation technologies at farmers' field can be propagated on larger scale. Farmers have to adopt quality standards to demand and fetch better prices. Various constraints identified will have to be addressed to improve productivity.

2.5 Strategies for Doubling the Income of Wheat Producer

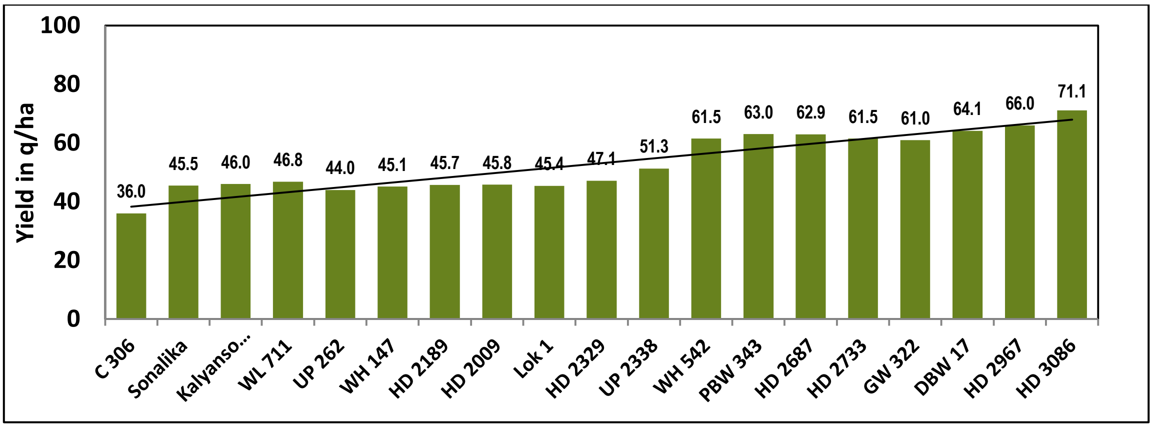
The targeted doubling of farmers' income over a span of six years requires a compound annual income growth rate of 10.4 per cent. Some key drivers that will help transform wheat productivity are discussed

2.5.1 Science & Technology

Application of science by researchers results in technologies like cost reduction and/or yield enhancement in case of a crop like wheat. It helps to increase the output with the same level of resource use and resource services; or to produce the same quantum of output with reduced usage of inputs. Alternatively, there may be increased performance through deployment of more efficient technologies and techniques. The technology (an improved wheat variety) derived from the wheat improvement programme pushes the production frontier upward by increasing yield trends (Fig. 2.2) over a period of time. Additional average gross income of Rs

11,255/ha and a net income of Rs 11,024/ha after deducting operational costs shall be obtained as evident from the demonstrations conducted across India in 2016-17.

Figure 2.2 Trends in Yield Level of Potential Wheat Varieties



Source: ICAR-IIWBR (2017)

Table 2.6 State-wise additional profit from adoption of newly released wheat varieties

State	Additional profit in Rs/ha	Additional profit in %
Assam	8572	32.59
Bihar	15176	43.05
Chhattisgarh	7260	22.11
Gujarat	7178	11.07
Haryana	2153	3.08
Himachal Pradesh	7944	28.96
Jammu & Kashmir	10785	29.62
Jharkhand	12319	66.91
Karnataka	7168	20.54
Madhya Pradesh	16764	39.14
Maharashtra	21329	46.15
Nagaland	3583	42.61
New Delhi	5827	12.51
Punjab	6658	7.15
Rajasthan	11896	22.10
Uttar Pradesh	10154	15.83
Uttarakhand	14717	45.39
West Bengal	19747	108.16

Source: ICAR-IIWBR (2017)

On the other hand, validated scientific techniques/technologies like conservation agriculture practices facilitate realisation of increased income at various magnitudes (table 2.7) by reducing the cost of resource use.

For instance, zero tillage, a conservation agriculture practice reduces the operational costs by Rs 2,137/ha apart from yield enhancement and restricting resource damage on farmers' field. The additional profit realised on farmers field through adoption of zero tillage has been estimated at Rs 4,451/ha (+ 10.61 per cent).

Table 2.7 Technology wise additional profit by adoption at farmer's field

Technology	Additional profit in Rs/ha	Additional profit in %
Bio-fertilizer	6046	10.87
Drip Irrigation	5800	9.75
Durum	26643	56.05
Happy Seeder	7500	9.11
Hydrogel	3788	5.69
Rotavator	6138	8.67
Improved Variety	13420	30.93
Improved Variety (late sown)	8423	16.24
Improved Variety (restricted irrigation)	9914	27.63
Improved Variety (salt tolerant)	3440	5.65
Zero Tillage	4451	10.61

Source: ICAR-IIWBR (2017)

Consolidating existing research and sharing the area specific technologies with farmers will make help bridge yield gap between research farms and farmers' field. Regions like Madhya Pradesh and Uttar Pradesh having high yield gaps can get specific focus, to meet any production gaps. In these states there is greater scope to augment the yield, and given the context of large number of wheat growers, the importance of production through productivity enhancement cannot be over stated.

Table 2.8 Yield gap vis-à-vis yield matrix*

Parameter	Low yield gap	High yield gap
Low yield	Bihar, Himachal Pradesh, Maharashtra and West Bengal	Assam, Chhattisgarh, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Tamil Nadu, Uttarakhand
High yield	Delhi, Haryana, Punjab and Rajasthan	Uttar Pradesh

Source: ICAR-IIWBR (2017)

** indicates that the triennium ending national average has been taken as slab*

2.5.2 Projected Production Target and Demand Targets of Wheat:

Table 2.9 Projected production and demand targets of wheat

(Figure in million tonnes)

Year	Projected production target *	Increase in productivity Per ha	Projected demand**	Percent increase in Demand	Gap between Production and demand
2015-16 (Base year)	92.29	3034	87.75	-	+4.54
2016-17	98.00	3215	91.00	3.70	+7.00
2017-18	99.00	3235	92.50	1.65	+6.50
2018-19	100.00	3268	94.00	1.62	+6.00
2019-20	101.20	3307	95.50	1.60	+5.70
2020-21	102.40	3346	97.20	1.78	+5.20
2021-22	103.60	3386	99.00	1.85	+4.60
2022-23					

* NFSM target of Wheat production in EFC Memo

*** Based on actual consumption in 2011 NSS Family Budget Survey*

The projected surpluses (gap between production and demand) can be upset with decline in productivity, unless better production and management practices, climate resilient technologies and sustainability aspects are prepared.

2.5.3 Increasing Productivity of Wheat crop

The productivity level has to be increased across the wheat growing zones through higher use of improved varieties, coupled with adoption of resource use efficient technologies. These include balanced use of fertilizers, focus on secondary and micro-nutrients and soil amendments. There has been increasing non-response to nitrogen due to imbalance in usage of external inputs, including neglect of secondary & micro-nutrients. This is manifest in yield plateaus in a majority of the states demanding amelioration through soil health management and quality seeds.

The concern here is to increase the productivity per day in performance to yield per unit area. This will be a more profitable approach to achieving higher total output on an annual basis. Specific recommendations towards this are discussed below under a comprehensive strategy comprising crop improvement, crop protection and resource management.

2.5.4 Bridging regional variations of yield gaps

To bridge the existing region-wise and state-wise yield gaps of wheat crop, Table 2.10 presents the wheat growing zones and recommended/improved varieties for adoption on farmers' field. The recommended seed varieties need to be produced by the state level institutions, research farms and organisations like SAUs, Seed Corporations, KVKs etc. and made available to the farmers in sufficient quantities for capitalizing the economic benefits of these varieties. It is critical to promote usage of region-specific recommended varieties to bridge or narrow inter-regional yield gaps.

Table 2.10 Wheat growing regions and recommended improved varieties

Zone	Area covered/ Region for Promotion	Improved/recommended varieties
Northern Hills Zone (NHZ) 0.90 mha wheat area	Western Himalayan regions of J&K (except Jammu and Kathua district); H.P. (except Una and Paonta Valley); Uttarakhand (except Tarai area); Sikkim and hills of West Bengal and N.E. States.	***Early sown, Rainfed:*** HS 542, HPW 251, VL 829. ***Timely sown, Rainfed/Restricted irrigation***: HPW 349, HS 507,VL 907, VL 804. ***Late sown, Restricted irrigation:***HS 490, VL 892, HS 420. ***Higher altitude:*** VL 832, HS 375.
North Western Plains Zone (NWPZ) 12.59 mha wheat area	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and Western UP (except Jhansi division), parts of J&K (Jammu and Kathua district) and parts of HP (Una district And Paonta valley) and Uttarakhand (Tarai region).	***Timely sown, Irrigated:*** WB 2, PBW 723, HPBW 01, HD 3086, HD 2967, DBW 88,WH 1105. ***Late sown, Irrigated***: DBW 90, DBW 71, WH 1124, HD 3059, PBW 590, WH 1021, DBW 16. ***Timely sown, Rainfed***: PBW 644, HD 3043, PBW 396.
North Eastern Plains Zone (NEPZ) 8.82 mha wheat area	Eastern UP, Bihar, Jharkhand, Orissa, West Bengal, Assam and plains of NE States.	***Timely sown, Irrigated***: NW 5054, K 1006,HD 2967, DBW 39, CBW 38, Raj 4120, K 307, HD 2824. ***Late sown, Irrigated***: DBW 107, HD 3118, HD 2985, HI 1563, NW 2036, DBW 14, HD 2643. **Timely sown,*Rainfed:***HD 2888, MACS 6145, K8027.

Zone	Area covered/ Region for Promotion	Improved/recommended varieties
Central Zone (CZ) 7.18 mha wheat area	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh.	***Timely sown, Irrigated:*** *Bread Wheat:* WH 1142, HI 1544, GW 366, GW 322, GW 273. *Durum Wheat:*HI 8737, HI 8713, MPO 1215. ***Late sown, Irrigated:***MP 3336, MP 1203, HD 2932, HD 2864, MP 4010. ***Timely sown, Rainfed/Restricted irrigation***: *Bread wheat:*DBW 110, MP 3288, MP 3173, HI 1531, HI 1500. *Durum Wheat:* HD 4672.
Peninsular Zone (PZ) 1.10 mha wheat area	Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu.	***Timely sown, Irrigated:*** *Bread Wheat:*MACS 6478, UAS 304, MACS 6222, NIAW 917, Raj 4037, GW 322. *Durum Wheat*: UAS 428, WHD 948, UAS 415.*Dicoccum Wheat*: MACS 2971, DDK 1029, DDK 1025. ***Late sown, Irrigated:*** HD 3090, AKAW 4627, HD 2932, Raj 4083, HD 2833. ***Timely sown, Rainfed/Restricted irrigation:*** DBW 93, NIAW 1415, HD 2987, HD 2781, UAS 446.
Southern Hills Zone (SHZ) < 0.01 mha wheat area	Hilly areas of Tamil Nadu and Kerala comprising the Nilgiri and Palni hills of southern plateau.	***Timely sown, Restricted Irrigation:*** HW 5216, COW(W) 1, HW 2044, HW 1098 (dicoccum).
All Zones	Marginal Areas	***Saline/ Alkaline Soils*** ***Timely sown, Irrigated:*** KRL 210, KRL 213, KRL 19.

2.5.5 Promotion of climate resilient varieties:

The varieties of wheat tolerant of heat stress and moisture stress recommended for different growing zones are as under and their adoption on farmers' field will prove beneficial.

Table 2.11 Terminal heat stress tolerant varieties of wheat for normal and late sown

SN	Variety Name	Year of Release	Duration	Yield potential (q/ha)	Recommended Region
1	RAJ 4238	2016	114	62.8	CZ
2	HD 3117	2016	146	50.1	Delhi
3	PBW 658	2014	121	60.7	NWPZ
4	WH 1124	2014	121	56.1	NWPZ
5	HD 3118	2015	112	66.4	NEPZ
6	DBW 107	2015	109	68.7	NEPZ
7	MP 3336	2013	107	64.4	CZ
8	DBW 71	2013	119	68.9	NWPZ
9	DBW 90	2014	121	66.6	NWPZ
10	HD 3090	2014	101	63.1	PZ

Table 2.12 Moisture stress tolerant varieties of wheat for normal and late sown

SN	Variety Name	Year of Release	Duration	Yield potential (q/ha)	Recommended Region
1	HS 562	2016	175	62.2	NHZ
2	UAS 347	2015	96	24.6	PZ
3	PBW 660	2016	154	49.3	NWPZ
4	WH 1142	2015	122	36.4	CZ
5	HD 3171	2017	122	51.4	NEPZ

SN	Variety Name	Year of Release	Duration	Yield potential (q/ha)	Recommended Region
6	DBW 110	2015	124	50.5	CZ
7	HI 1605	2017	105	44.0	PZ
8	DBW 93	2015	122	39.0	PZ
9	MPO 1255	2016	-	34.5	MP
10	HS 542	2015	192	49.3	NHZ

2.5.6 Promotion of Zinc and Iron rich bio-fortified varieties

For assuring nutritional security and to cater for demand of nutritional wheat, bio-fortified varieties of wheat can be produced by farmers. These varieties also have high yield potential and should be promoted aggressively. The following Zinc and Iron rich bio-fortified varieties of wheat have been released recently for North Western Plane Zone (NWPZ) for adoption.

Table 2.13 Bio-fortified (Zinc and Iron rich) varieties of wheat

SN	Name of varieties / hybrids	Year of release	Maturity (days)	Yield potential (q/ha)	Area of adaptation
1	WB 2	2017	128	58.9	NWPZ
2	HPBW 1	2017	127	64.8	NWPZ

2.5.7 Adoption of new technologies

These include adoption of durum wheat, micro-irrigation system, bio fertilizer, and salt tolerant varieties. The income can be increased though enhanced output by consolidating the validated scientific techniques/technologies along with usage of improved varieties. The table 2.14 presents the level of additional profit attained at farmers' field in 2016-17 by adoption of different technologies including wheat varieties. Cultivation of durum wheat has resulted in additional profit to the tune of Rs 26,643/ha (+56.05 per cent) owing to the grain demand for exports as well as diverse manufacture of products. However, the durum wheat has been under cultivation only in certain pockets of India, especially in Central Zone and Peninsular Zone. Therefore, there is need to promote this package and approach in other zones of the country.

Barring the establishment cost in micro-irrigation system which takes years for the investment to be offset, the drip irrigation helps to improve water use efficiency and results in additional profit. Even, micro irrigation systems like drip and sprinkler enhance water use efficiency to an extent of 16.33 per cent by foregoing one irrigation equivalent of water as consumed under conventional irrigation. Enhanced use efficiency of water results in higher productivity, as well as cost reduction resulting in increased income at the rate of Rs 5800/ha (+9.75 per cent).

The application of bio-fertilizer, hydrogel and salt tolerant improved variety have also given additional profit as presented in the table:

Table 2.14 Technology-wise potential of additional profit by adoption at farmers' field (2016-17)

Technology	Additional profit in Rs/ha	Additional profit in %	Intended region/Class of farmers
Bio-fertilizer	6046	10.87	**All regions (small farmers)**
Drip Irrigation	5800	9.75	**Punjab, Haryana (Large farmers)**
Durum	26643	56.05	**Madhya Pradesh**
Hydrogel	3788	5.69	**Punjab, Haryana**
Improved Variety	13420	30.93	**All regions**
Improved Variety (late sown)	8423	16.24	**Rice-wheat & sugarcane-wheat areas**
Improved Variety (restricted irrigation)	9914	27.63	**Rajasthan**
Improved Variety (salt tolerant)	3440	5.65	**Haryana, Uttar Pradesh**

2.5.8 Conservation agriculture practices

Apart from the varietal improvement and technologies, income can be increased by adoption of conservation agriculture (CA) practices, which facilitate to reduce the operational costs at various magnitudes. For instance, zero tillage, a conservation agriculture practice reduces the operational costs by Rs 2137/ha apart from yield enhancement and containing resource damage at farmers' field.

The additional profit realised on farmers' field through adoption of zero tillage has been estimated at Rs 4451/ha (+10.61 per cent). Similarly, rotavator and happy seeder practices result in additional profit to the tune of Rs 6138/ha (+8.67 per cent) and Rs 7500/ha (+9.11 per cent), respectively. For small and marginal land holders, the use of CA machines can be materialized on custom hiring basis, which still will place them under profitable zone.

Table 2.15 Technology-wise additional profit by adoption at farmers' field (2016-17)

Technology	Additional profit in Rs/ha	Additional profit in %	Intended region/Class of farmers
Happy Seeder	7500	9.11	Punjab, Haryana and Western UP for medium and large scale farmers (sufficient machines have to be made available at sowing time)
Rotavator	6138	8.67	
Zero Tillage	4451	10.61	

2.5.9 Diversification/ intensification/ relay cropping for higher profitability:

Diversification is one of the most reliable and suggested interventions for all holding size groups, being a popular risk management strategy. It is explicit from Table 2.16 that diversification / intensification / relay cropping results in higher profit in comparison to the conventional rice-wheat system which is predominant in the Indo-Gangetic plains of India.

In the case of marginal and small land holders, furrow irrigated raised bed planting system (FIRBS) of wheat along with vegetables like cucurbits as relay cropping in alternate furrows will yield higher profits in comparison to sole wheat cultivation.

Table 2.16: Level of profit realized under diversification/intensification/relay cropping

Cropping system (Wheat based)	Profit (Rs/ha)	Intended region/Class of farmers
Rice (TP) – Wheat (CT)	24400	Punjab, Haryana, UP, Bihar
Rice (TP) –Wheat (ZT)–green gram (ZT)	46923	
Rice (TP) –Wheat (bed)– green gram (bed)	49351	
Rice (TP) –Wheat (bed)–cowpea (bed)	39256	
Maize– vegetable pea –wheat	33400	
Pigeon pea (bed)–wheat (bed)	32800	UP, Bihar
Wheat (bed)+bottle guard (Relay cropping in alternate furrows)	132547	Small and marginal farmers
Wheat (bed)+cucumber (Relay cropping in alternate furrows)	76977	
Wheat (bed)+bitter guard (Relay cropping in alternate furrows)	64601	
Wheat (bed)+ridge guard (Relay cropping in alternate furrows)	70506	

TP= Transplanted, ZT= Zero tillage, CT= Conventional tillage, Bed= Bed planting

2.5.10 Nutrient management on soil test base

There is a need to promote site specific use of macro / micro-nutrients / soil amendments for increasing production and productivity of crop and to reduce the cost of cultivation. The soils over an extent of about 59 per cent area were found low in available nitrogen, while 36 per cent were medium and 5 per cent high. Similarly, soils over an extent of about 49 per cent area were low, 45 per cent medium and 6 per cent were high in available phosphorus.

Available potassium status showed that the soils over an area of about 9 per cent area were low, 39 per cent were medium and 52 per cent were high in available K status. An extent of 39.9 per cent soil samples were found deficient in zinc, 32.9 per cent in sulphur and 22.9 per cent in boron out of 1,69,290 samples taken from different states.

2.5.11 Disease control in wheat crop

i. **Yellow rust management:** Yellow rust is predominant in North Western Plains Zone (NWPZ) and Northern Hills Zone (NHZ). Generally, the disease appears in the months of January and February, but sometimes its appearance is also reported in December.

Usually, it is observed that the early infection of stripe rust begins in wheat fields under the shades like that of poplar trees, in early sown crop (i.e. October). Hence, strict watch is needed by the farmers and extension officers to control it.

Table 2.17: Yellow rust resistant varieties of wheat for Northern states

SN.	Name of varieties / hybrids	Year of release	Maturity (days)	Yield potential (q/ha)	Area of adaptation
1	PBW 723	2017	146	63.2	NWPZ
2	HD 4728 (d)	2016	120	75.1	CZ
3	DBW 90	2014	121	66.6	NWPZ
4	PBW 644	2012	153	44.8	NWPZ
5	WH 1080	2011	151	44.4	NWPZ
6	WH 1142	2015	154	62.5	NWPZ
7	DBW 71	2013	119	68.9	NWPZ
8	TL 2942	2006	194	55.4	NHZ
9	TL 2969	2012	165	53.8	NHZ
10	HS 507	2011	165	60.1	NHZ
11	HS 542	2014	192	49.3	NHZ
12	VL 829	2003	151	48.9	NHZ
13	VL 892	2008	143	48.9	NHZ
14	KRL 210	2009	143	49.3	Salinity
15	HD 3171	2017	122	51.4	NEPZ
16	K1317	2017	125	54.2	NEPZ
17	WB 02	2017	128	58.9	NWPZ

Management

- Grow only those varieties recommended for the zone.
- Discourage growing of single variety and opt for at least 3-4 diverse stripe rust tolerant varieties.
- Use balanced and recommended quantity of fertilisers – avoid high dose of nitrogen.
- Keep strict watch on appearance of stripe rust, and immediately spray the affected crop with recommended fungicides, viz., Propiconazole @ 0.1 per cent.
- Suitable varieties for NWPZ and NHZ which will check loss on account of stripe rust are: WB 02, PBW 723, HD 4728, DBW 90, PBW 644, WH 1080, WH 1142, DBW 71, TL 2942, TL 2969, HS 507, HS 542, VL 829, VL 892, KRL 210, HD 3171 and K1317.

ii. Karnal bunt management: The disease mainly occurs in parts of Northern Plains, especially in Punjab, Haryana, foot hills of J&K and HP, tarai region of Uttrakhand, and in lesser severity in Rajasthan, Bihar and UP. The disease severity is high in situations when ear head (spike) emergence – coincides with rainfall. Karnal bunt is difficult to diagnose in the field and can only be seen after threshing of grains

Management

- Use of certified or disease free seed will help to check spread of disease in new areas.
- Follow crop rotation and avoid growing wheat for 2-3 years in highly infected fields.
- Zero tillage helps in reducing Karnal bunt incidence.
- In Karnal bunt-prone areas, spray Propiconazole @ 0.1 per cent at the time of 50 per cent flowering.

- To minimize losses due to Karnal bunt, grow resistant/tolerant varieties in disease prone areas:
    - PBW 502 and PDW 223, PDW 291, PDW 314 (Durum) in Northern Western Plains Zones;
    - HPW251, HS 490, HS 507 in Northern Hills Zone; and
    - GW 366, HD2864, MP 3336 and HI 8498 (Durum) in Central Zone.

iii. Blast disease management: Blast disease resistant varieties of wheat need to be promoted in blast-prone areas specially North Western Plane Zone and North Eastern Plane Zone of the country. The blast resistant varieties of wheat are as in table 2.18 :

Table 2.18: Blast resistant varieties of wheat

SN	Name of varieties / hybrids	Year of release	Maturity (days)	Yield potential (q/ha)	Area of adaptation
1	HD 2967*	2011	143	66.0	NWPZ/NEPZ
2	HP1633*	1992	-	34.1	NEPZ

2.5.12 Timely and integrated weed management strategy:

It has been observed that *Phalaris minor* (Gehua ka Mama/Gulli Danda) and *Chenopodium album* (Bathua) are noxious weeds in wheat crop, and compete for nutrients, moisture, sunlight, aeration, space etc. with the crop plants. There is a need to control both type of weeds i.e. broad leaved weeds and gassy (narrow leaved) weeds in time, by adopting integrated weed management package comprising manual, mechanical and herbicidal interventions.

2.6 Climate Change and Challenges to Production

Wheat is next only to rice in terms of its importance, so far as India's food security is concerned. It is a winter crop, and thrives well in Indo-Gangetic Plains of North India, that enjoy a cold winter from November to February-March which is well suited to wheat cultivation. The climate change linked to rising levels of greenhouse gas (GHG) emissions, is expected to cause a rise in temperature during the 21st century.

All efforts linked to Inter-Parliamentary Panel on Climate Change (IPCC) commitment are to contain the rise to a maximum of 2ºC. This alone is expected to adversely impact the productivity of wheat. As per studies, a rise in temperature by 1ºC causes a yield decline of wheat in the range of 5 per cent. This is a visible drop. Hence, the wheat crop is expected to face productivity and production challenges and it would be important to adopt coping strategy. As a long term strategy, R and D will need to focus on evolving heat-tolerant varieties, besides working on appropriate technology package and management practices to counter the probable negative impact of temperature rise on yield. Parallelly, it would help buffer the food security by strategising to increase output of climate-resilient crops like millets, and popularize them on the food plates of the consumers.

Key Extracts

- The gross income of the wheat growers doubled between 2006-07 and 2013-14 in a majority of states like Bihar, Gujarat, Jharkhand, Madhya Pradesh and West Bengal.
- FLDs (Front Line Demonstrations) conducted across various regions in 2016-17 suggested an additional average gross income of Rs 11255/ha and a net income of Rs 11024/ha for wheat growers, after deducting operational costs.
- Despite substantial improvement in yield levels over earlier periods, there remains yield gaps at farmers' field and research fields. Non-availability of HYV seeds, labour, lack of knowledge among farmers about recent technologies, declining water table, lack of irrigation and untimely rain, weed (Bathua), are major factors hampering productivity.
- Yield levels have become stagnant in most regions. Scope for intervention by cutting-edge and high throughput genomics approach to harvest the genetic potential.
- Researchers suggest that, zero tillage, reduces the operational costs by Rs 2137/ha apart from yield enhancement and restricting resource damage on farmers' field.
- Overall better price realisation through improvements to the agri-value system, i.e. market competition, agri-business hubs, market linkage will augment income.
- Climate change is likely to cause a dip in the average yield of wheat. Hence, R&D support to evolve tolerant varieties in the long run. Parallelly, the foodgrains basket needs to be broadened by enhancing the output of millets.

Chapter 3
Maize

Maize (Zea mays) is the most versatile crop and being a C4 pathway species, possesses huge yield potential. However, compared at the global level, Indian yields are very low. Focus is necessary on adopting improved technologies to bridge the yield gaps. If specialty corns are cultivated, farmers can benefit from higher incomes. Further, it is a suitable substitution crop for paddy in Indo-Gangetic Plains, where such a need has arisen, due to increasing temperature and declining water table.

3.1 Introduction

Maize is the most versatile crop among cereals with respect to its adaptability, types and uses. It is cultivated across various climates ranging from tropics to sub-tropics to temperate, and there are several types like field corn, sweet corn, baby corn; and within field corn it has several other types like quality protein maize (QPM), waxy maize, high-oil maize etc. thus offering wide latitude for multiple uses and options. Maize is used as the raw material for several food, feed and non-food based industries including as a source of bio-fuel. The consumption pattern of maize (feed-64 per cent, food-16 per cent, industry-19 per cent, seed and other miscellaneous 1 per cent) in India largely matches with the global pattern (feed-61 per cent, food-17 per cent and industry-22 per cent). It has attained a position of industrial crop globally as 83 per cent of its production in the world and 76 per cent in India are used as feed, and in starch and bio-fuel industries.

Maize is being grown in over 166 countries, over 184 million ha of arable land producing 1,034 million tonnes (Mts), registering an average productivity of 5.5 tonnes per hectare (t/ha). Three countries, namely USA, China and Brazil together represent close to 47 per cent of global maize area and around 65 per cent of global maize output; the average maize productivity being 5.2 (Brazil), 6.1 (China) and 9.9 (USA) t/ha. The recent reports indicate that USA's productivity has moved up further to almost 12 tonnes per ha. India ranks fourth in maize area with 9.5 million ha and sixth in production with an output of 27 million tonnes (2016-17). The current five year average area under maize in India is 8.9 million ha producing 23.0 Mts with an average productivity of 2.5 t/ha. Even though maize area, production and productivity have increased continuously since 1950s, a substantial increase was registered only in the last decade, mainly due to adoption of hybrid technology.

The Indian maize improvement programme started with the establishment of All India Coordinated Maize Improvement Project (AICMIP) in 1957 and over the last six decades has brought about increase in area, production and productivity. The establishment of AICMIP has paved the way for strengthening agricultural research and development of maize research and its continuity. The efforts have led to development and release of more than 200 cultivars.

The increased maize production has triggered maize based industrial growth encompassing livestock & poultry feed, beverages/alcohol, starch etc. With burgeoning growth rate of poultry, livestock & fish; and wet and dry milling industries, maize demand is expected to increase to 45 million tons by 2030 registering an annual demand increase of 5-9 per cent.

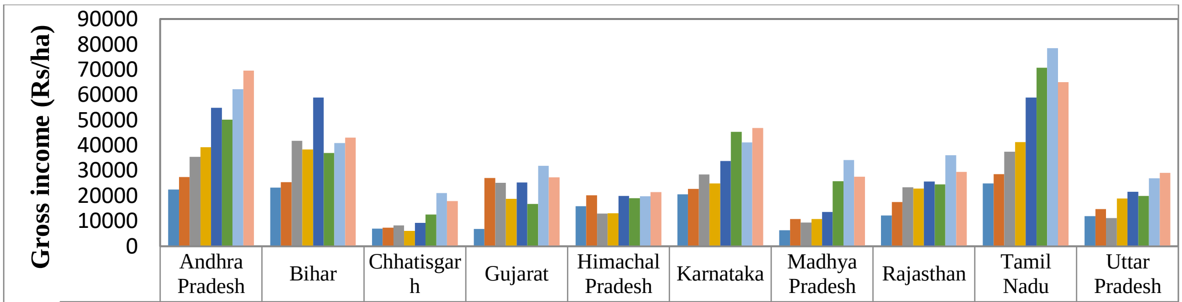
India has large number of people, suffering from protein malnutrition. Quality Protein Maize (QPM) is the cheapest source of protein that the poor can be provided access to. Its biological value is higher than that of all other cereals and is comparable to that of milk. QPM is rich in lysine and tryptophan content. The prices of meat, egg, milk and their products are higher relative to QPM based proteins, which therefore can serve as a good nutritional substitute. QPM is also a good solution to the challenge of Kwashiorkar, a protein deficient disease. High biological value of QPM will also reduce food/feed cost and its requirement, which benefit poultry, livestock, pig, fish etc. enterprises by reducing cost of production.

Maize is an important industrial raw material and more than 3,500 products are manufactured using maize directly/indirectly, thus offering large opportunity for value addition. Maize being a C4 plant, not only is a high yielder, but also is well suited to meeting the challenges of biotic and abiotic stresses, lowering water table, food security, employment generation and to climate change. Further, with changing patterns of consumption in urban and peri-urban areas, where ready to eat foods are in demand, speciality corn has gained significant importance. The projected requirement of maize can only be met by focused research on high yielding single cross hybrids (SCHs) and adoption of novel molecular tools and techniques like introgression of superior alleles (genes) into best available single cross hybrids. The surplus maize can further enhance nations' export potential of agri-commodities.

3.2 Trends and Dynamics in Maize Income and Yield

The gross income of maize farmers, at all India level, for the period 2006-07 to 2013-14 increased by a ratio of more than or near 2 times in various states (Table 3.1).

Table 3.1 Gross income from maize production during 2006-07 to 2013-14



	Andhra Pradesh	Bihar	Chhatisgarh	Gujarat	Himachal Pradesh	Karnataka	Madhya Pradesh	Rajasthan	Tamil Nadu	Uttar Pradesh
2006-07	22458	23284	7009	6771	15798	20581	6299	12182	24830	11894
2007-08	27467	25433	7313	27084	20220	22704	10741	17535	28540	14657
2008-09	35371	41727	8177	25132	12979	28457	9344	23400	37519	11174
2009-10	39265	38338	6098	18771	13060	24908	10788	22891	41250	18923
2010-11	54881	58922	9228	25205	19887	33745	13565	25633	58907	21532
2011-12	50142	36887	12526	16774	19026	45321	25806	24521	70783	19961
2012-13	62191	40841	21053	31916	19733	41153	34213	36122	78523	26974
2013-14	69579	42992	17923	27233	21497	46799	27516	29461	65080	29112

Source: DFI Committee Estimates

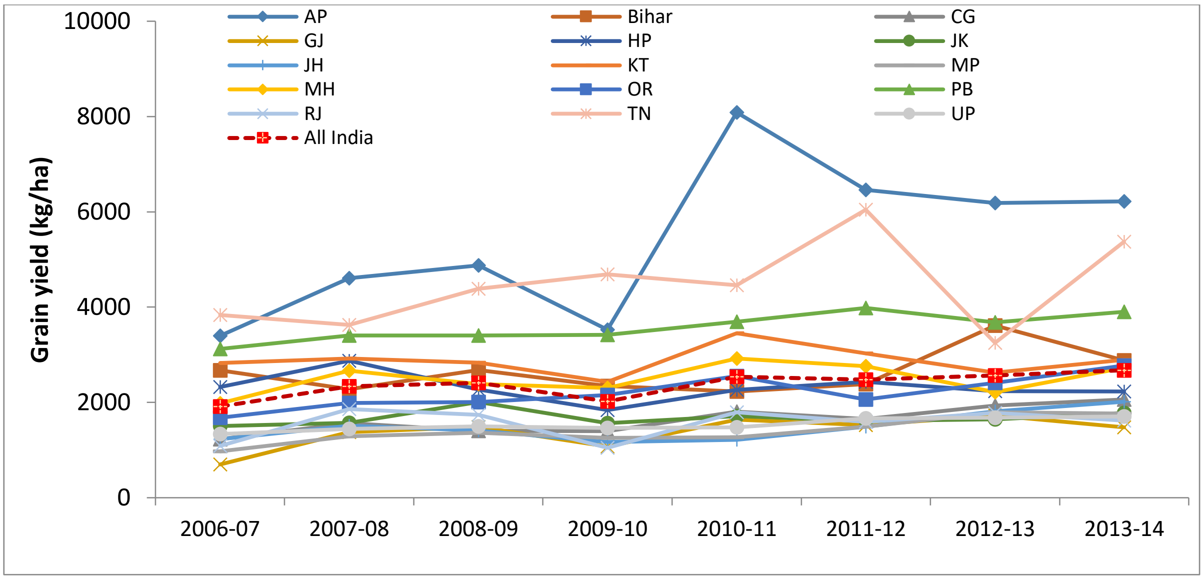
Based on crop production and value (from grain + straw) as the source of income, the data shows that the income enhancement ranged from 1.4 (Himachal Pradesh) to 4.4 (Madhya Pradesh) times during this period (2006-07 to 2013-14). In most of the states including Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Madhya Pradesh, Rajasthan, Tamil Nadu and Uttar Pradesh gross income of the maize cultivators doubled during this period. In the states like Bihar and Himachal Pradesh the income increased by 1.8 and 1.4 times respectively in these eight years, respectively.

Table 3.2 Gross income and productivity growth for maize during 2006-07 to 2013-14

State	Gross income		Yield	
	Ratio Increase	CAGR (%)	Ratio Increase	CAGR (%)
Andhra Pradesh	3.10	15.18	1.83	7.85
Bihar	1.80	7.97	1.08	0.96
Chhattisgarh	2.60	12.45	1.68	6.73
Gujarat	4.00	19.00	2.12	9.82
Himachal Pradesh	1.40	3.92	0.96	-0.54
Karnataka	2.30	10.81	1.02	0.28
Madhya Pradesh	4.40	20.24	1.81	7.71
Rajasthan	2.40	11.67	1.49	5.14
Tamil Nadu	2.60	12.80	1.40	4.29
Uttar Pradesh	2.40	11.84	1.28	3.09
All India	**2.70**	**12.11**	**1.40**	**4.29**

Source: DFI Committee Estimates

Figure 3.1 Productivity trends in major maize growing states of India



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

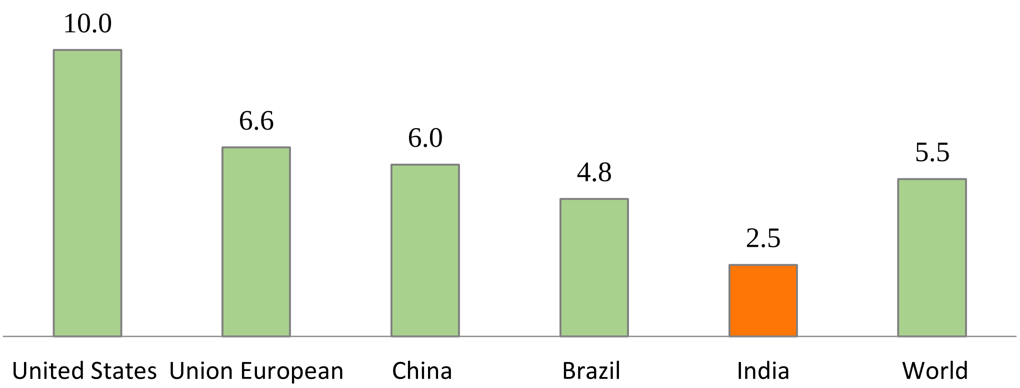
Evaluation of yield levels across the states shows growth in all the states except Himachal Pradesh (-0.54), but did not double anywhere except in Gujarat. The yield enhancement ratio was highest in Gujarat (2.12), followed by Andhra Pradesh (1.83) and Madhya Pradesh (1.81). Productivity across states showed that only a few states like Andhra Pradesh, Tamil Nadu and Karnataka registered more than the national average. The change in yield from 2006-07 to

2013-14 was highest in case of Andhra Pradesh (+2822 Kg/ha), followed by Tamil Nadu (+1535 Kg/ha) and Odisha (+1094 Kg/ha). The technological intervention of single cross hybrids (SCH) supported by government's pricing policy helped in doubling gross income of the farmers. Despite the absence of government purchase, the market prices of maize grain remained high due to increasing demand from fast growing poultry and starch industries.

3.3 Reasons for Low Productivity in India

In India the yield of maize is half of the global average of 5.5 mts/ha. (Figure 3.2). Productivity is highest in USA because of its temperate climate and long duration crop. EU nations too enjoy high average yield of 6.6 Mt/hectare due to 100 per cent of area being under single cross hybrid (SCH) seeds, temperate climatic conditions and long duration crop. The yield in China is comparatively low due to sub-tropical climate and medium duration crop; and Brazil has lower yield principally because of its dependence on rainfall. The reasons for low crop productivity in India are multiple, encompassing environmental, technological, economic and organizational factors. In developed countries with temperate climate, the use of inputs is also high and cultivation is mechanised, all of which contribute to high per unit yields.

Figure 3.2 Productivity comparison of maize (tonnes/ha), 2013-14



Source: DFI Committee Estimate compiled from USDA

Factors for low productivity of maize in India:

- Climatic vagaries resulting in drought/excess water associated with increased pressure of diseases/pests. Cultivation in kharif is mainly under rainfed conditions on marginal lands with inadequacy of irrigation support.
- Limited adoption of improved production-protection technologies. Small farm holdings and limited resources do not facilitate adoption of recommended package of practices.
- One of the prime reasons for low productivity is non-availability of quality seeds in right quantity and at right time. Use of quality seeds can effect a yield progress of 10 to 20 per cent.
- Water stress during critical reproductive stages of growth in maize can result in adverse yields. For instance, corn is very sensitive to water stress from flowering to grain filling stage. Therefore, agronomic management of corn under limited irrigation or rainfall is very critical.

- Only about 30 per cent of the area in the country is under single cross hybrids (SCH). States like Tamil Nadu and Bihar, which have brought 100 per cent of their maize area under SCHs have been able to register higher productivity.

3.4 Production and Demand Projections

The projected production target and demand of maize crop upto the year 2022-23 along with the details of productivity enhancement per ha have been presented in table 3.2.

Table 3.3 Projected production target and demand of maize

(Figure in million tonnes)

Year	Projected production target *	Increase in productivity Per ha #	Projected demand**	Percent increase in Demand	Gap between Production and demand
2015-16 (Base year)	22.57	2563	23.09	-	-0.52
2016-17	26.00	2664	23.90	3.50	+2.1
2017-18	26.50	2687	24.70	3.35	+1.8
2018-19	27.00	2738	25.50	3.24	+1.5
2019-20	27.50	2794	26.40	3.53	+1.1
2020-21	28.00	2840	27.40	3.79	+0.6
2021-22	28.50	2890	28.30	3.28	+0.2
2022-23					

* NFSM target of Maize (59 per cent of nutri cereals) production
** Based on actual consumption in 2011 NSS Family Budget Survey
# Area of 2016-17 is 9.86 million ha

3.5 Maize Production Zones

The major maize growing regions in India have been delineated into five production zones and cultivation status discussed in the following paragraphs:

i. **Northern Hill Zone (NHZ):** The maize in the western and eastern Himalayas spread over 8.46 lakh ha of area shows very low productivity due to non-adoption of hybrids and largely rainfed production in slopy areas. In this zone, only 0.6 per cent of area is under assured irrigation in rabi season.

ii. **North Western Plain Zone (NWPZ)**: It comprises states of Punjab, Haryana, Western UP and foothills of Uttarakhand. This zone has only 3.74 lakh ha under maize and the productivity levels are low. The spring season cultivation is increasing.

iii. **North Eastern Plain Zone (NEPZ)**: This zone represents the Eastern UP, Bihar, West Bengal, Assam, Odisha, Chhattisgarh and Jharkhand states. It has 18.6 lakh ha of maize area, out of which 1/3rd is in the *rabi* season. However, due to very low level of adoption of hybrids, productivity is too low in this sleeping giant.

iv. **Peninsular Zone (PZ)**: This is the non-traditional maize growing area, which has recently picked up well and covers highest acreage of 37.3 lakh ha, out of which 1/4th is in *rabi* season. This region has higher productivity as well but the *kharif* season productivity is low specially in Maharashtra, Karnataka and Telangana. If hybrids tolerant to moisture stress are adopted and associated rainfed technologies are deployed, yield levels can rise.

v. **Central Western Zone (CWZ):** This is the traditional maize growing belt with high acreage (22.6 lakh ha), but low productivity, as only 6.1 per cent of the area is in the assured irrigated *rabi* season. This is the fragile ecology of maize production that suffers from vagaries of monsoon. The development and adoption of climate-resilient hybrids suited to rainfed areas and expansion of irrigation facility could help in enhancing yields and incomes in these states of Rajasthan, Gujarat and Madhya Pradesh.

3.6 Importance of Maize in Indian Agri-business Eco-system

Maize ranks third in terms of cereal output next to paddy and wheat in India. While its total output of 27 million tonnes (2016-17) is far lesser than that of paddy (110 million tonnes) & wheat (97 million tonnes), the importance of maize lies in it being predominantly an industrial crop. This characteristic provides an opportunity for broad-basing the mandate of agriculture as a provider of raw material to the industrial sector. With its feasibility in the manufacture of 3,500 numbers of industrial products, already 90 per cent of the output is being used in the industrial sector. Even as of now, 64 per cent of the total output in the country is used as feed, supporting a large number of feed industries. Cumulatively the feed and other industrial activities contain the potential to absorb greater quantum of maize output, considering that the poultry and dairy sector is growing robustly and the need of the hour is to create large number of non-farm jobs to absorb the surplus manpower engaged in agriculture today. Maize is an appropriate crop that can meet these new agriculture sector environments.

Maize production in India at 27 million tonnes compares very poorly with that of an output of 370 million tonnes achieved in United States of America. US, China and Brazil account for 38, 23 and 9 per cents of the total world output of maize, while India shares a small percentage of 2. Maize is an appropriate crop for rainfed and less endowed production environments and it is, therefore, highly suited for large tracts of India particularly when adverse impact of climate change is probable. It therefore, makes sense that a crop like maize which has multiple advantages like fitting as a climate resilient crop and feasibility in poultry/dairy and industrial sectors needs to be given due emphasis for achieving high production. This will help in increasing the income of the farmers, and as well help in generating on-farm and off-farm employment opportunities.

Some factors that further strengthen this view are delineated below:

(i) **Employment generation and value creation**: As on date close to 15 million farmers are engaged in maize cultivation in the country. Assuming a human labour requirement of an average of 75 person days/ha., the estimated employment generation is more than 650 person days at the farm and the downstream levels of agriculture and industry. Maize contributes about 2 per cent to the total value of output from all the agriculture crops.

(ii) **Scope for harvesting the yield potential**: the average yield level in India at about 2.7 tonnes per ha. is much lower than those achieved in countries like USA (12 tonnes per ha.), France (10 tonnes per ha.), Argentina (6.8 tonnes per ha.), China (5.8 tonnes per ha.) and Brazil (5.2 tonnes per ha.). The world average is as high as 5.6 tonnes per ha. It works out to a difference of roughly 130 per cent. With improved genetic potential, good agronomic practices, precision farming, supported by post-harvest management (inclusive of marketing), farmers can be incentivised to bridge the yield gaps. Thus, without bringing additional area under maize, it is possible for India to realize higher total output.

(iii) **Potential of maize in improving farmers' income**: Tables 3.1 and 3.2 show that it is possible to achieve higher gross income from cultivation of maize in India. The ratios of change in gross income between the years 2006-07 and 2013-14 were 4.40 (Madhya Pradesh), 4.0 (Gujarat), 3.10 (Andhra Pradesh), 2.60 (Tamil Nadu & Chhattisgarh), 2.40 (Rajasthan & Uttar Pradesh) and 2.30 (Karnataka). This implies that gross income of the maize farmers more than doubled over a period of eight years. Table 3.1 shows that States of Andhra Pradesh, Tamil Nadu, Karnataka and Bihar were able to achieve high gross income per hectare from maize cultivation over the period 2006-07 to 2013-14. Maize being a crop whose output has multiple uses as food, feed, fodder and industrial raw material, the demand for it is only bound to grow. The estimated demand is 45 million tonnes by 2030 and hence can contribute to farmers' income.

(iv) **High nutritional value**: That maize has high contents of starch (71-72 per cent), protein (9-10 per cent), fat (4-5 per cent), fibre (9-10 per cent), sugar (2-3 per cent) and minerals (1.4 per cent). The biological value of quality protein maize (QPM) is much higher than that of other cereals and even that of milk. QPM is a good answer to Kwashiorkar, a protein deficient disease. Additionally, the cost of maize protein is much cheaper than that of meat, egg etc. It is, therefore, a good source of nutrition under Indian conditions.

(v) **Crop resilience**: Maize is a C4 plant having edge over other cereals that possess C_3 pathways. C_4 plants use three-fold less water making them highly suited to conditions of drought, high temperature and carbon dioxide limitation. It is well known that C_4 plant species like maize possess a higher optimal temperature for undertaking photosynthesis on account of operation of a CO_2 – concentrating system that inhibits Rubisco oxygenase activity. Hence, maize in India can be taken under less endowed environments of rainfed systems.

(vi) **An alternative to rice and wheat based farming**: Maize a C4 plant yields higher per hectare of output even in a shorter period compared to other foodgrains. Being a day-neutral crop it can be grown in any season. With climate change implications and anticipated temperature rises, winter maize or spring maize can replace wheat particularly where assured and sufficient irrigation facilities are not available. It is estimated that maize farmers can benefit from degrading soil quality, save water by 90 per cent and power by 70 per cent vis-a-vis paddy and also earnings can be better than in case of both paddy and wheat.

(vii) **Multiple uses of maize**: Compared to other cereals, maize is amenable to multiple uses and is, therefore, capable of earning higher income for the farmers. An inter-crop comparison in respect of various uses shown in the table below, demonstrate the superiority of maize.

Table 3.4 Inter-crop comparison in respect of various uses

Crop	Food	Feed	Fuel	Industrial Use
Maize	7 Mn MT	14 Mn MT	1.2 Mn MT	1.8 Mn MT
Paddy	97 Mn MT	0	0	0
Wheat	94 Mn MT	4.8 Mn MT	0	0
Other coarse, nutri-cereals	16 Mn MT	1 Mn MT	0	1 Mn MT

Source: Grain and Feed Annual 2017, GAIN Report; (0 ~ very low amount)

(viii) Maize is also a crop, every part of which has economic value. The grains, leaves, stalk; tassel and cob can all be used to produce a variety of food and non-food products. With growing poultry sector and largest livestock population, maize can meet the increasing demand for feed and fodder in the country. Indian poultry industry, specifically eggs and poultry meat are growing at a CAGR 6 and 9 per cent respectively.

(ix) **Maize and global trade**: by and large Indian maize prices are not competitive in the global trade and can be improved by creating robust supply chain. Even now there exists a huge marketing opportunity in countries like Bangladesh and traditional destinations in south-east Asia (Malaysia, Singapore and Vietnam) Maize production in India needs to improve with respect to both quality and price.

3.7 Value System Approach to Maize Cultivation

Integration of multiple value chain actors, into a cohesive supply chain, is a primary driver for growth of Indian agriculture including maize. The organising of each economic activity unit, into a global supply chain has resulted in impressive productivity levels in countries like USA and Argentina. Technology is key to creating high impact and sustainable initiatives for improving productivity, competitiveness, entrepreneurship, and growth of small & medium enterprises (SMEs) in agriculture. The technological interventions have been influencing the larger supply chain of maize at both backend and frontend, and further robustness can be imparted to this. The value system or supply chain comprises:

- Backend – seed units, farm mechanisation services, fertilizers supply, agro-chemicals, irrigation system, etc.
- Frontend – post-harvest management (PHM), procurement storage and processing.

- Across all activities in the chain – information, research and development, credit, policy and other institutional support.

3.7.1 Value System development initiatives: backend

3.7.1.1 Seed

(i) Hybrid seeds – fostering maize production

The Indian seed industry has over the years evolved by adopting and innovating upon research in variety development and quality seed production. In the seed market of India maize contributes 11 per cent in terms of value. Further, hybrid maize is dominated by private sector consisting of about 6 multi-national (accounting for more than three fourth of the size) and 250 private sector players (accounting for the balance size). After adoption of New Seed Policy in late 1980s large number of private seed companies have got into operation and have been producing and marketing hybrid maize. Hybridization in maize crop in India varies from 23 to 100 per cent. It is 100 per cent in Bihar and Tamil Nadu and lowest in Madhya Pradesh (23 per cent).

The seed units have their specific markets and each entity operated its own value chain. However, they depend on the other set of actors for their growth and hence their own activities integrate with the demands of others in the larger value system. As a result, seed units have competed to capture a larger share of their market and maize varieties have transitioned from composites to double cross hybrids (DCH) to single cross hybrids (SCH) over the years. These have resulted in marked improvement in yields for the farmers. However, India ranks 5th in maize hybridization indicating the vast scope that exists for expansion of area under hybrids.

Yield levels and gross income returns are higher in Andhra Pradesh, Tamil Nadu, Karnataka and Bihar, where the percentage of maize area under hybrids is high. If hybridization is improved in other states like Madhya Pradesh, Rajasthan, Gujarat and Chhattisgarh the total output of India will climb up substantively. The higher yields in turn support the other units in the supply chain, such as farmers, the various industries users and other users of the output.

(ii) Seed production hubs – promoting seed production in clusters

There are more than 500 seed companies operating at different levels in India. The private seed companies which dominate the hybrid production are located in Andhra Pradesh, Karnataka and Maharashtra where the farmers have graduated into seed producers on contract basis and thus large stretches of villages have turned into "seed production hubs" and "seed production villages".

With the Government commitment to offering income tax exemption to farmer producer companies on their profit and emphasis on promoting farmer producer organisations, cluster based seed production hubs can be further strengthened. With the proposed Contract Farming Act seed production contracts can also be promoted. It is now possible to promote seed producer companies (SPCs) and seed producer's organisations (SPOs).

(iii) Dedicated seed cold storages

These are necessary to store commercial maize seeds under controlled temperature of 10 to 15 °C with relative humidity of 40 to 50 per cent evenly distributed under one roof. If all the operations of seed palletization and racking are handled by the Material Handling Equipment (MHE), the physical damage to the seed will be minimised. In Andhra Pradesh which is the hub of the private seed companies, dedicated cold storages for high value seed, mostly hybrid maize have come up and are comparable to global standards in respect of the state-of the-art facilities they have adopted. Such cold storages can also offer third party services to other seed companies on the lines of co-hosting facilities that large data centres offer in I.T. sector.

It may, therefore, be useful for government to promote such dedicated seed cold storages for maize along with other crops by providing financial and other support.

3.7.1.2 Farm mechanisation

Maize is well suited to farm mechanisation. In some of the States like Andhra Pradesh, Bihar and Gujarat, farm mechanisation has gone beyond the traditional use of tractors for field cultivation to include maize based combined harvesters and maize planters etc.

(i) Maize based skill development centres

While government has been promoting custom hiring services, the key constraint is absence of adequate number of skilled hands to serve as technical service providers. In Madhya Pradesh, as also a few other states, some private sector initiatives in this regard have been made. This can be scaled up across the country.

(ii) Maize silage

Since maize is high in nutrition value several dairy farmers in Punjab have mechanised maize based silage from end to end. The farmer use specialised tractors of high HP (more than 65) in maize silage preparation. This initiative is being promoted by Punjab Government by providing special incentives on such high HP tractors. Such lateral avenue provided in dairy sector will also in turn benefit in maize industry. This deserves replication in other states and scale up across the country.

(iii) Promoting PPP model

Government of Gujarat has introduced a PPP model and assigned a Service Lease Agreement (SLA) with farm equipment major "John Deere India Private Limited" (JDIPL) on BOOT (Build, Own, Operate, Transfer) principle. Instead of subsidising implements Government of Gujarat has been subsidising user fee or rental charge of equipment. This is a good approach that can be replicated in other parts of the country too.

(iv) Management of other inputs

Due emphasis is required in management of irrigation, credit, crop insurance and extension to bridge the yield gaps and achieve the potential.

(v) Research and Development

Maize being a C4 crop that adapts better to the vagaries of the climate, it is well suited to less endowed areas of India. Technological innovations can help in increasing productivity and sustainability of maize based production systems. These innovations include single cross hybrids technology and application of novel molecular tools. Some thrust areas in research and innovation are molecular breeding and targeted mutagenesis for developing traits for biotic and abiotic stresses.

At global level, maize is one of the most extensively researched crops by the MNCs (seed producers) as it allows maximum value capture due to prevalence of hybrids. Unfortunately, Indian seed industry lags behind substantively and as a consequence has to scout for 'technology providers' to stay competitive.

3.7.2 Value System development initiatives: frontend

Front end initiatives in the crop's supply chain are very critical. Some of these are discussed:

3.7.2.1 Storage and post-harvest management – minimising losses

(i) Maize dryers – emerging need for better price realisation

Manual handling and poor storage infrastructure at farm level results in increased moisture content of maize upto 20 per cent as against the ideal of 13 per cent. It would therefore help to install maize dryers in the proximity of farm and used for reducing the moisture before storage. Apart from government investments, PPP models may be also good initiatives.

(ii) Maize silos – modern storage techniques

Commonly the farmer uses Sun – drying method which adversely affects the quality and marketability of maize, since it suffers from Aflatoxin issues and gets rejected. Proper Dryers attached to silos will help in over-coming this. Silos are more efficient and cost effective compared to flat warehouses and they need to be promoted. This will reduce the need for intermediaries in the supply chain and enhance the overall efficiency of supply chain.

3.7.2.2 Marketing and procurement

Efficient marketing including using online trade platform like e-NAM will help the farmers in realising remunerative prices. To the recent (Union Budget 2018) government commitment to increase the minimum MSP by one and half times the cost of production coupled with commitment to procure all commodities including maize, the crop will stand to benefit whenever markets fail.

After the introduction of commodity derivative markets in 2003, maize was the first crop for which the first commodity derivative contract was launched by various commodity derivative exchanges. The maize is amenable to such derivative trading because of long shelf life of grain and ease of standardisation of gradation. Further, since it is considered as non-food cereal the control and regulation by the government is limited. Both food and feed – industrial grade maize can be traded in futures market.

3.7.2.2. Processing for value addition

Over the last two decades use of maize is increasing as feed and industrial raw material, particularly as poultry feed and starch. The poultry industry has been growing at the rate of 4 to 5 per cent per annum supported by higher consumer demand for animal based proteins.

The starch industry, mainly catering to textile production (besides food, paper & pharmaceutical industry) is growing at the rate of 3 to 4 per cent triggered by domestic and export demand. Maize is also used to produce traditional food, snacks and savouries.

(i) Maize and small feed industry

The feed industry is growing rapidly in India at a CAGR of 8 per cent with emergence of poultry, cattle and aqua-feed sectors as major growth drivers. The demand has increased to 28 million tonnes by 2017-18 as per industry estimates.

(ii) Maize and starch small bio-fuel industry

In the year 2015, global sales of starches and derivatives were estimated at US $ 62.9 billion and is expected to rise to US $ 77.4 billion in 2018 growing at a CAGR of 7.1 per cent. During the last two decades, there has been a positive growth of wet milling industry. India has an installed starch manufacturing capacity of 13,000 tpd (tonnes per day), and the industry is witnessing further investments. The demand for starch arises as a raw material for various industrial sectors as shown below:

Pharmaceutical	Textile industry	Paper industry	Food industry
• Dusting media for various types of coating as well as binder & filler for capsules & tables. • An efficient dry-binder in dry granulation techniques.	• Provides stiffness & adds weight to clothes. • Used in conjunction with thermoplastic or thermosetting resins to obtain a permanent finish.	• Used for sizing as well as to increase the paper strength. • Used as adhesive in pigmented coating for paper and paper board to enhance the printability and appearance of the paper.	• Used for thickening sauces, gravies, puddings and pie fillings. • Used in baking industry, provides strength to ice cream cones.

The per capital starch consumption in India is 1.5 kg as compared to global average of 6.1 kg, indicating the enormous scope that exists for growth. There is increasing consumer preference for products using maize starch and derivatives due to their nutritional superiority.

The demand for starch is also expected to arise due to new industrial applications. These include modified starch suited to various specific applications leading to higher efficiency and better quality of end products. Examples include application of cationic starch in paper industry which results in lower fiber loss, better printability and use for starch in manufacturing ethanol.

In general, there is tremendous scope for using maize in industry, as it can be processed into a variety of food and industrial products including starch, sweeteners, oil, beverages, glue, industrial alcohol and fuel ethanol.

In the last ten years, the use of maize for fuel production has increased significantly. As listed earlier, maize starch which is a dominant raw material is used as an adhesive in textile industry, as a thickener in food industry, as a filler in pharmaceutical industry, as feed stock in manufacturing glucose, dextrose, ethanol etc for increasing paper strength in paper industry.

As on date 14 per cent of maize production is used as a raw material for starch manufacturing pharmaceutical starch etc. The Indian starch industry is still at a nascent stage and derives about 40 products of maize as against more than 800 products of starch and its derivatives in the global arena. Starch is manufactured from maize by wet are dry milling and the recovery is around 60 to 65 per cent.

As per 2015-16 industry estimates 3 million metrics tonnes of maize is used for industrial purpose which includes 2 million mts in starch 1 million mt in ethanol and beverage industry. Maize will find greater demand if the product portfolio from Indian maize starch is expanded, recovery percentage is improved, cross alacrity advantages harvested during times of high sugar prices and rising consumption from beverage industry.

3.8 Strategies for Doubling the Income of Maize Producers

The potential pathways to accomplish the targeted doubling of farmers' income have been discussed under three major categories of science & technology, institutions and policies that would help to transform maize production.

3.8.1 Science & Technology

Following initiatives must be encouraged so as to enhance the income of maize farmers:

(i) Adoption of improved maize hybrids: Genetic uniformity can lead to vulnerability of the crop to pathogens, insects, and abiotic stresses, thereby compromising maize yields in the long run. Therefore, there is a need to continuously infuse newer germplasm from diverse sources, mostly from temperate genetic background into maize breeding programmes.. Crossing different inbred lines belonging to different heterotic groups would introduce high heterosis and break genetic uniformity. Resistance to pathogens etc will increase. The strengthened germplasm base would provide much needed support for continued development of better hybrids, leading to enhanced maize production in coming years. Besides upgraded logistics and reduced costs, use of DCH (double cross hybrid) lines in conjunction with molecular markers will significantly improve genetic gains and breeding efficiency. At present in India, only one third of the area is under single cross hybrid (SCH) cultivation. Yields and incomes can increase significantly if area under SCH is increased.

Table 3.5 Details of high yielding maize hybrids released for cultivation in India since 2000

SN	Cultivar	Nature of Hybrids	Organization/ Center	Year Released/ Notifiied	Maturity	Area of adaptation	Cropping season
				Normal Maize			
1	KNMH-4010141	SCH	PJTSAU, Telangana State	2017	Medium	MH, Karnataka, AP, Telengana &TN	Kharif
2	DMRH1301	SCH	ICAR-IIMR, Ludhiana	2017	Medium	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Rajasthan, Gujarat, Madhya Pradesh & Chattishgarh	Rabi
3	DMRH1308	SCH	ICAR-IIMR, Ludhiana	2017	Late	Rajasthan, Gujarat, Chattishgarh & Madhya Pradesh	Rabi
4	Central Maize VL 55 (FH3605	SCH	ICAR-VPKAS Almora	2017	Medium	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, NE Hills, Maharashtra, Karnataka, Tamil Nadu, Telangana and Andhra Pradesh	Kharif
5	Pant Sankar Makka- 4 (PSM -4)	SCH	GB Pant University of Agriculture and Tech. Pantnagar	2017	Early	Uttarakhand	Kharif
6	GAYMH-1 (1H0461/G YH-0461	SCH	AAU, Godhra, Gujarat	2016	Early	Gujarat	Kharif
7	NAH-1137	SCH	UAS ,Bengaluru	2016	Late	Karnataka	Kharif & Rabi
8	CoH (M) 10 (CMH 08-433)	TWC	TNAU, Coimbatore	2015	Medium	Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh and Chhatisgarh	Kharif
9	HM-13 (HKH-317)	SCH	HAU, Hissar	2015	Early	Jammu and Kashmir, Himachal Pradesh and Uttarakhand	Kharif
10	PMH 10	SCH	PAU Ludhiana	2015	Medium	Punjab State	Spring
11	PMH 6 (JH 31292)	SCH	PAU, Ludhiana	2015	Medium	Bihar, West Bengal, Jharkhand, odisha and Uttar Pradesh	Kharif
12	CoH (M)7 (CMH 08-287)	SCH	TNAU, Coimbatore	2014	Late	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra and Karnataka	Kharif
13	CoH (M)8 (CMH 08-292)	SCH	TNAU, Coimbatore	2014	Medium	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh, Punjab, Haryana, Delhi and Maharashtra	Kharif
14	CoH (M) 9 (CMH 08-350)	SCH	TNAU, Coimbatore	2014	Medium	Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Kharif
15	DHM 121 (BH 41009)	SCH	PJTSAU, Telangana State	2014	Medium	Odisha, Bihar, Jharkhand, West Bengal , Gujarat, Rajasthan, Chhattisgarh and Madhya Ptradesh	Kharif
16	GH 0727 (Shrushti)	SCH	ARS, Arabhavi	2014	Late	Karnataka	Kharif
17	Vivek Maize Hybrid 47 (FH 3513)	SCH	VPKAS, Almora	2014	Early	Uttrakhand, Himachal Pradesh, Jammu & Kashmir, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim	Kharif
18	Vivek Maize	SCH	VPKAS, Almora	2014	Extra-early	Uttrakhand, Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh,	Kharif

SN	Cultivar	Nature of Hybrids	Organization/ Center	Year Released/ Notifiied	Maturity	Area of adaptation	Cropping season
	Hybrid 53 (FH 3556)					Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim	
19	Vivek Maize Hybrid 51 (FH 3554)	SCH	VPKAS, Almora	2014	Extra-early	Gujarat, Rajasthan Chhattisgarh and Madhya Pradesh	Kharif
20	CMH 08-282	SCH	TNAU, Coimbatore	2013	Late	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Kharif
21	Pant Shankar Makka-1	SCH	GBPUA&T, Pantnagar	2013	Early	Uttarakhand	Kharif
22	PMH7(JH 3956)	SCH	PAU Ludhiana	2013	Medium	Punjab State	Spring
23	Vivek Maize Hybrid 45 (FH 3483)	SCH	VPKAS, AImora	2013	Extra-early	Uttarakhand, Himachal Pradesh and Jammu & Kashmir	Kharif
24	HM-12 (HKH 313)	SCH	HAU, Hissar	2012	Medium	Uttar Pradesh, Bihar, Jharkhand and Orissa	Kharif
25	CO 6	SCH	TNAU, Coimbatore	2012	Late	Tamil Nadu	Kharif
26	Vivek Maize Hybrid 43 (FH 3358)	SCH	VPKAS, Almora	2012	Medium	Uttar Pradesh, Madhya Pradesh and Rajasthan	Kharif
27	Vivek Maize Hybrid 39 (FH 3356)	SCH	VPKAS, Almora	2012	Extra-early	Uttarakhand and Himachal Pradesh	Kharif
28	DHM 119 (BH 4062)	SCH	ANGRAU, Hyderabad	2011	Medium	Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka	Kharif
29	PMH 4 (JH 31153)	SCH	PAU, Ludhiana	2011	Medium	Delhi, Punjab, Haryana and Uttar Pradesh	Kharif
30	PMH 5 (JH 31110)	SCH	PAU, Ludhiana	2011	Early	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Kharif
31	KMH-22168	SCH	MPKV, Kolhapur	2010	Late	Maharashtra	Kharif & Rabi
32	BH-40625 (DHM-117)	SCH	PJTSAU, Telangana State	2010	Medium	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu	Kharif & Rabi
33	BH-1620 (DHM-113)	SCH	PJTSAU, Telangana State	2010	Late	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu	Kharif & Rabi
34	BH-1576 (DHM-111)	SCH	PJTSAU, Telangana State	2010	Medium	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu	Kharif & Rabi
35	HM-11 (HKH-1237)	SCH	HAU, Hissar	2009	Late	Across the country except Himalayan belt	Rabi
36	EH-434042 (DH1)	TWC	ARS, Arbhavi	2009	Late	Karnataka	Kharif & Rabi
37	NAH-2049	SCH	ARS, Naganahalli	2009	Late	Karnataka	Kharif & Rabi
38	HM-10 (HKH-1200)	SCH	HAU, Hissar	2008	Medium	Across the country except Himalayan belt	Rabi
39	PMH-3 (JH 10704)	SCH	PAU, Ludhiana	2008	Late	Delhi, Punjab, Haryana and Uttar Pradesh	Kharif

SN	Cultivar	Nature of Hybrids	Organization/ Center	Year Released/ Notifiied	Maturity	Area of adaptation	Cropping season
40	Vivek Maize Hybrid 33 (FH 3352)	SCH	VPKAS, Almora	2008	Extra-early	Himachal Pradesh, Jammu & Kashmir and Uttarakhand	Kharif
41	Vivek Maize Hybrid-27 (FH 3288)	SCH	VPKAS, Almora	2007	Extra-early	Uttar Pradesh, Bihar, Jharkhand, Orissa, Chattisgarh, West Bengal, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu	Kharif
42	Vivek Maize Hybrid-25 (FH 3248)	SCH	VPKAS, Almora	2007	Extra-early	Uttarakhand, Himachal Pradesh, Jammu & Kashmir and NEH	Kharif
43	Malviya Hybrid Makka-2 (V-33)	SCH	BHU, Varanasi	2007	Medium	Uttar Pradesh, Bihar, Jharkhand, Chattisgarh, West Bengal and Orissa	Kharif
44	HM-8 (HKH-1188)	SCH	HAU, Hissar	2007	Medium	Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka	Kharif
45	HM-9 (HKH-1191)	SCH	HAU, Hissar	2007	Medium	Bihar, Jharkhand, Orissa, Eastern Uttar Pradesh and Chattisgarh	Kharif
46	PAU-352 (JH-3982)	SCH	PAU, Ludhiana	2007	Early	Punjab, Haryana, Delhi and Western Uttar Pradesh	Kharif
47	COH(M) 5	SCH	TNAU, Coimbatore	2007	Late	Tamil Nadu under irrigated & rainfed ecology	Kharif
48	PMH-1 (JH-10655)	SCH	PAU, Ludhiana	2007	Late	Irrigated areas of Punjab, Haryana and Uttar Pradesh	Kharif
49	Vivek Maize Hybrid-21 (FH-3211)	SCH	VPKAS, Almora	2007	Extra-Early	Uttaranchal and Himachal Pradesh	Kharif
50	Vivek Maize Hybrid-23 (FH-3529)	SCH	VPKAS, Almora	2007	Early	Hills of Uttarakhand	Kharif
51	Maize Hybrid AH-58 (PEHM-3)	SCH	IARI, Delhi	2006	Early	Delhi	Kharif
52	PMH-2 (JH-3851)	SCH	PAU, Ludhiana	2006	Early	Punjab	Kharif
53	COH(M) 4	TWC	TNAU, Coimbatore	2005	Medium	Tamil Nadu	Kharif & Rabi
54	HM-5	SCH	HAU, Hissar	2005	Medium	Haryana	Kharif & Rabi
55	Buland (JH-6805)	SCH	PAU, Ludhiana	2005	Late	Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu	Rabi
56	Vivek Miaize Hybrid-15 (FH-3176)	SCH	VPKAS, Almora	2005	Extra-early	Jammu & Kashmir, Uttaranchal , Himachal Pradesh	Kharif
57	Vivek Maize Hybrid-17 (FH-3186)	SCH	VPKAS, Almora	2005	Extra-early	Across the country except hill states	Kharif
58	Sheetal	SCH	PAU, Ludhiana	2004	Late	Punjab	Rabi

SN	Cultivar	Nature of Hybrids	Organization/ Center	Year Released/ Notifiied	Maturity	Area of adaptation	Cropping season
59	Pusa Extra Early Hybrid Makka-5 (AH-421)	SCH	IARI, Delhi	2004	Extra-early	Delhi, Haryana, Punjab, Western & Central Uttar Pradesh	Kharif
60	Pratap Hybrid Maize-1 (EH-50802)	SCH	MPUA & T, Udaipur	2004	Early	Maize growing areas of Rajasthan under rainfed conditions	Kharif
61	DMH-2	SCH	UAS, Dharwad	2002	Late	Karnataka	Kharif
62	JH-3459	SCH	PAU, Ludhiana	2001	Early	Delhi, Haryana, Punjab and Uttar pradesh	Kharif
63	Pusa Early Hybrid Makka-3 (AH-58)	SCH	IARI, Delhi	2001	Extra-early	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu	Kharif
64	Vivek Maize Hybrid-9 (FH 3077)	SCH	VPKAS, Almora	2001	Extra-early	Himalayan regions, Andhra Pradesh, Karnataka and Tamil Nadu	Kharif
65	Vivek Hybrid-5	SCH	VPKAS, Almora	2001	Extra-early	Uttar Pradesh	Kharif
66	HHM-1 (HKH-1082)	SCH	HAU, Hissar	2000	Medium	Haryana	Kharif & Rabi
67	HHM-2 (HKH-1071)	SCH	HAU, Hissar	2000	Early to late	Haryana under irrigated ecology	Kharif & Rabi

Source: Indian Institute of Maize Research, Punjab.

(ii) Promotion of climate-resilient maize cultivars: Presently, single-cross maize hybrids with a yield potential of 12-14 t/ha are available; however, such yield is obtainable only under stress-free and high-input conditions. On the other hand, maize fields in India are now increasingly experiencing rising temperatures, more frequent droughts, excess rainfall/flooding, as well as pathogens and insect-pests. Therefore, the future of maize production, and consequently, the livelihood of several million smallholder maize farmers, will depend to a great extent on affordable access to climate resilient cultivars. In order to develop climate-resilient maize germplasm and hybrids, the breeding programs will need re-orientation for simultaneous selection under combinations of stresses, that are expected to be more prevalent in near future. In addition, advances in plant genetic engineering, RNA interference and targeted mutagenesis techniques also offer new opportunities to engineer maize germplasm resistant to biotic and abiotic stresses.

Table 3.6 Climate resilient technologies of maize

Technology	Benefits
Adoption of conservation agriculture(CA)based	The highest system productivity as maize equivalent yield recorded in zero –tillage (ZT) i.e. 13.0 t/ha and the lowest (10.8 t/ha) was with conventional tillage (CT). In the initial two years, higher system productivity as maize equivalent yield recorded in

crop management in maize system	permanent beds (PB) (8.2–8.5 t/ha), while from third year onwards zero tillage (ZT) registered maximum productivity (11.3–12.9 t/ha) which was significantly higher then CT. ZT and PB practices reduced the irrigation water requirement by 40–65 ha-mm and 60–98 ha-mm, respectively compared to CT system, resulted enhanced system water productivity by 19.4% equally under both ZT and PB. Net profit from the maize-based systems under ZT was up to 31% higher with 72$ /ha lower production cost compared to CT. The soil organic carbon (SOC) increased by 34.6-35.3% at 0–15 cm, and 23.6-26.5% at 15–30 cm soil depths with conservation agriculture (ZT and PB) based crop establishment techniques over CT. Thus, adoption of CA based ZT practices could be a solution for depleting soil carbon and decreasing farm productivity and profitability with lowering water table.
Residue application and inter-cropping for rainfed maize.	Under rainfed conditions, residue retention @ 5 t/ha on the soil surface is recommended for enhancing maize productivity by 9-29 per cent. The inter-cropping of soybean/black gram in maize grown during *kharif* season is recommended for Northern Hill Zone, North Eastern Plain Zone and Central and western zone.

Source: Indian Institute of Maize Research, Punjab

(iii) Popularization of speciality corns: For diversification and value addition of maize as well as the growth of the food processing industry, development and cultivation of improved cultivars of speciality corns like baby corn, sweet corn, etc. in peri-urban pockets of the country will be helpful in enhancing employment and income of the farmers. The farmers can earn Rs.50,000-60,000 rupees per annum per acre with cultivation of 2-3 crops of baby corn and sweet corn, besides benefiting from an additional nutritious fodder crop/acre of 100 quintal to support livestock feed industries. These speciality corns can also be taken as catch crop in flood prone areas, as well as in the areas of cropping system having a small window period of 60-70 days. The establishment of processing industries can further strengthen production of baby corn and sweet corn in the hinterlands as well.

Table 3.7 Speciality corn hybrids

SN	Variety	Type	Institute / Centre	Year	Duration	States	Season
1	DMRHP1402 (Popcorn)	SCH (Popcorn)	ICAR-IIMR, Ludhiana	2017	Early	Punjab, Haryana, Delhi NCR & Western Uttar Pradesh, Rajasthan, Madhya Pradesh, Chattishgarh & Gujarat	Kharif

SN	Variety	Type	Institute / Centre	Year	Duration	States	Season
2	Vivek Hybrid 27 (Central Maize VL Baby Corn 2 (Babycorn)	SCH (Baby corn)	ICAR-VPKAS Almora	2017	Early	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Delhi, UP, Maharashtra, Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Gujarat, Rajasthan, Chhatisgarh and Madhya Pradesh	Kharif
3	BPCH-6 (Popcorn)	SCH (Popcorn)	PJTSAU, Telangana State	2016	Meidum	Across Country	Kharif
4	Central Maize VL Sweet corn 1 (FSCH18) (Sweet corn)	SCH (Sweet corn)	ICAR-VPKAS Almora	2016	Medium	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, NE Hills, Punjab, Haryana, Delhi, Western UP, Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Gujarat, Rajasthan, Chhatisgarh and Madhya Pradesh	Kharif
5	HSC 1 (Sweet Corn)	SCH (Sweet corn)	HAU, Hissar	2010	Medium	Himachal Pradesh and Uttarakhand	Kharif
6	HM-4 (Baby corn)	SCH (Baby corn)	HAU, Hissar	2005	Medium	Across the country	Kharif & Rabi

Source: Indian Institute of Maize Research, Punjab.

(iv) Promotion of bio-fortified maize hybrids: The ICAR Institutes and different State Agricultural Universities (SAUs) have developed various bio-fortified maize hybrids for cultivation in both kharif and rabi seasons. The list of such hybrids is as under:

Table 3.8 Bio-fortified maize hybrids

SN	Variety	Type	Institute / Centre	Year	Duration	States	Season
1	Pusa Vivek QPM-9 (APQH9)	SCH	ICAR-IARI, New Delhi	2017	Extra early	J&K, HP, Uttarakhand (Hills) & NEH states , Maharashtra, Karnataka, AP, Telengana &TN	Kharif
2	Pusa HM4 (AQH-4)	SCH	ICAR-IARI, New Delhi	2017	Medium	Punjab, Haryana, Delhi, Uttarakhand (Plain), UP (Western region)	Kharif
3	Pusa HM8 (AQH-8)	SCH	ICAR-IARI, New Delhi	2017	Medium	MH, Karnataka, AP, Telengana &TN	Kharif
4	Pusa HM9 (AQH-9)	SCH	ICAR-IARI, New Delhi	2017	Medium	Bihar, Jharkhand, Odisha, UP (Eastern region), West Bengal	Kharif
5	Pratap QPM Hybrid-1 (EHQ-16)	SCH	MPUA & T, Udaipur	2013	Medium	Rajasthan, Gujarat, Madhya Pradesh and Chhatisgarh	Kharif
6	HQPM-4	SCH	HAU, Hissar	2010	Late	Across the country except Himalayan belt	Kharif
7	Vivek QPM 9 (FQH 4567)	SCH	VPKAS, Almora	2008	Extra-early	Jammu & Kashmir, Uttarakhand, Himachal Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	Kharif
8	HQPM-7	SCH	HAU, Hissar	2008	Late	Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra	Kharif
9	HQPM-5	SCH	HAU, Hissar	2007	Late	Across the country	Kharif

SN	Variety	Type	Institute / Centre	Year	Duration	States	Season
10	HQPM-1	SCH	HAU, Hissar	2007	Late	Across the country	Kharif & Rabi
11	Shaktiman-3	SCH	RAU, Dholi	2006	Late	Bihar	Kharif & Rabi
12	Shaktiman-4	SCH	RAU, Dholi	2006	Late	Bihar	Kharif & Rabi
13	Sakthiman-2	SCH	RAU, Dholi	2004	Late	Bihar	Kharif
14	Shaktiman-1	TWC	RAU, Dholi	2001	Late	Bihar	Rabi

Abbreviations: SCH: single cross hybrid**;** DCH: double cross hybrid; TWC: three way cross

(v) Efficient hybrid seed production: One of the major constraints in promoting adoption of single-cross hybrid seeds in India is their higher costs. The development of better male as well as female lines can contribute towards efficient and affordable seed production. Further, hybrid maize is produced by manual or mechanical detasseling of the female line, followed by pollination from the male line. The process of detasseling is labour- and cost- intensive and adds significantly to the high cost of the hybrid seed production.

The mechanical stress of tassel removal can also reduce seed yield. Partial detasseling can result in self-pollination, thereby compromising seed quality. As an alternative to tassel removal, numerous genetic strategies have been attempted to achieve male sterility. Numerous genetic male sterile mutants affecting over 40 loci have been identified in maize. Some of these are located on the nuclear chromosomes, while others are located on the mitochondrial chromosomes. Development of an efficient genetic male sterility and restoration system can significantly reduce cost of single cross hybrid seed, facilitating its greater adoption and consequent increase in maize productivity & production.

(vi) Conservation agriculture technologies: The Conservation Agriculture (CA) technologies provide an opportunity for planting of full duration maize hybrid and harvesting higher yields, as 10-15 days' of time is saved in tillage operations. Besides, these practices lower the tillage cost by Rs.2,000-4,000 per hectare and hence improve farm profitability. The adoption of **zero-till maize in coastal** Andhra Pradesh, Cauvery Delta (Tamil Nadu) and Karnataka after harvest of rice has become a success story of CA in India, where farmers are harvesting more than 10 tonnes/ha. The adoption of CA helps in moisture conservation and improvement in soil health and has been found beneficial in other cropping systems of maize when it is grown in rotation with wheat and mustard. Thus, research and adoption of CA in maize can be expected to pay rich dividend in India in her effort to achieve higher yields and sustain soil health.

(vii) Crop diversification: Maize has wider adaptability and compatibility under diverse soil and agro-climatic conditions, and hence it is cultivated in sequence with different crops in various seasons and under different agro-ecologies of the country. It is, therefore, considered as one of the potential driver of crop diversification under different situations.

The selection of suitable crop holds the key to remunerative crop production. The selection should be made on the basis of available resources, and the profitability of crop production. For example, in recent years due to rising temperature during grain filling stage of wheat, the crop in the states of Bihar, Gujarat, Madhya Pradesh, Rajasthan, Jharkhand and Chhattisgarh has become vulnerable to heat stress. One option to check yield and income losses from wheat cultivation is to substitute it by maize cultivation in rabi season.

The less remunerative sorghum production area in Maharashtra is also shifting to maize. In Odisha, maize is coming up as a potential alternative crop to rice cultivation during *kharif* in low rainfall areas. Likewise, the *rabi* rice areas in the states of Odisha, West Bengal, Karnataka, Andhra Pradesh and Tamil Nadu facing problem of ground water shortage are seeing shift to maize as an alternate crop.

The cultivation of spring maize after harvest of potato and sugarcane has become a reality in some of the states (Punjab, Haryana, western UP and lower valley of Uttarakhand) emerging as a profitable crop replacing summer rice. Maize a purely row crop and with its initial slow growth facilitates inter-cropping of pulses, oilseeds and vegetables (Table 3.9) enabling additional income opportunity. Hence, maize as a substitution can be promoted for enhancement of income and nutritional security of the farmers.

Table 3.9 Inter-cropping with maize, vegetables, spices, flowers and pulses

SN	Inter-cropping systems	Suitable area
1	Foodgrains: Mungbean,cowpea, urdbean, rice Oilseed: Groundnut, soybean Cash crops: Potato, cotton, sugarcane	NEPZ, PZ, CWZ
2	Winter vegetables; gladiolus	Peri-urban interface
3	Turmeric, ginger, mungbean, frenchbean	Hilly areas

Source: DFI Committee

(viii). **Management of weeds and diseases**

Dominant weeds in maize fields in India during Kharif season are:

Grassy weeds: Echinochloa colonum, Echinochloa crusgalli, Acrachne racemosa, Digitaria sanguinalis Dactyloctenium aegyptium, Paspalum dialatum and Cynodon dactylon.

Broadleaved weeds: Trianthema portulacastrum, Trianthema monogyna, Digera arvensis, Commelina benghalensis, Phyllanthus niruti, Xanthium strumarium, Boerhaavia diffua, Oxalis corniculata and Parthenium hysterophorus.

Sedges: Cyperus rotundus, Cyperus esculentus and Cyperus iria.

The period of first 30 days after sowing is a critical period of weed competition in maize, and hence the crop should be kept weed-free for at least first 30 – 45 days after sowing to obtain full potential of hybrids grown in *kharif* season. However, the maize sown during *rabi* season should be kept weed-free for at least first 15 – 60 days.

Table 3.10 Herbicides for weed control in maize.

Name	Dose (g a.i. /ha)	Time of application	Remarks
Atrazine	1000	Apply with 500 litre/ha of water before emergence of crop as well as weeds	Control all weeds except *Dactyloctenium aegyptium* and *Cyperus rotundus*
Atrazine	1000-1500	Can be safely applied upto 15 days after sowing of maize crop	-do-
Pendimethalin	750-1000	Apply with 500 litre/ha of water before the emergence of crop as well as weeds	Control all weeds except *Commelina benghalensis* and *Cyprus rotundus*
Metribuzin	200-300	It can be safely applied both pre-emergence and post emergence (upto 15 days after sowing)	It is effective against both broad leaved and grassy weeds.
2,4-D	500	It can be applied as post emergence in heavily broadleaf weed infested fields.	It is not effective against sedges and grassy weeds.
Tembotrione	120	It can be applied as post emergence in all type of weed infested fields at 25-35 days after sowing.	It is a good post emergence herbicide for post emergence broad and narrow leaf weed.

Source: Indian Institute of Maize Research, Punjab

Diseases management: In India, the major diseases cause an average yield loss of 13.2 per cent of which the more damaging ones are foliar diseases (5 per cent); and stalk rots, root rots, ear rots (5 per cent). For reduction of incidence of diseases, resistant varieties/hybrids should be grown.

Quality inputs

- Production and delivery of high-quality improved seed, agro-chemicals and fertilizers in the target geographies.
- Genetically modified (GM) maize seed.

Weeds and insects are two serious impediments that impact maize production and productivity in India. Presently, available herbicides have only limited schedule of application in pre-emergence conditions and are not very effective during critical growth period. Fortunately, effective GM-based technologies for weed management and stem borer control are already available and are being used by maize farmers in various countries on a large scale for almost last 20 years. India needs to evaluate and take an early view on this.

Deploy bio-technology to achieve higher productivity: The farmers already have access to traits like multiple insect resistance, herbicide tolerance, drought tolerance, enhanced lysine, modified amylase and male-sterility. Further, some important traits like nitrogen use efficiency, low phytale, high oil, bio-fortification etc. are in advanced R&D stage in the private sector. It is advisable to support private players to conduct multi-location trials and related field trials; as also strengthen regulatory and IPR regime to create an enabling environment for researchers and breeders.

Other focus areas in maize R&D that warrant prioritization are advancement in genomics and molecular breeding, next generation mutation techniques, adoption of RNAi technology for insect resistance, cell wall engineering, virus resistance, aflatoxin resistance etc.

3.8.2 Institutional innovations

(i) Promote producer irrigation and market linkages: With the income tax exemption and emphasis on FPOs, there should be a drive to promote seed production hubs, seed production villages in the seed sector, besides promoting maize producer companies for efficient input and output management.

(ii) Contract farming for speciality maize and seed production needs attention. The Model Contract Farming and Services Act would be a great support and the states need to be persuaded to adopt the Model Act.

(iii) Promote innovative PPP based model across the value system. These include:

- PPP to ensure timely availability of seeds
- Maize based skill development centres
- Maize based farm machinery banks
- PPP in extension and marketing support

(iv) Deployment of ICT for real time sharing of advisory at production and marketing stages; as also risk management.

(v) Tap alternate sources of water and ensure availability of protective irrigation, which is the best insurance against drought/crop failure.

(vi) Promote dedicated infrastructure. These include:

- Dedicated seed cold storages
- Install maize dryers for better price realisation
- Promote maize silos at modern storage techniques
- Establish maize value added units

(vii) Transformation as a high value crop by tapping the global market demand for maize based products. The associated processing and manufacturing industry will also need a push up.

(viii) Skilling and promotion of women SHGs on speciality corn based products for improving the income at the household level.

(ix) Strengthening of market forces and promoting online trade, which is beneficial for all agri-commodities, including maize and this would help in transferring remunerative prices to the farmers.

3.8.3 Policy interventions

(i) The lowest hanging fruit that can be harvested to achieve higher productivity is by emphasising on bridging yield gaps. Existing technologies and farm management practices need to be reached out to farmers to target this as an immediate intervention during the targeted period of DFI.

(ii) Adoption of single-cross hybrids, authorization of genetically modified (GM) maize for traits highly relevant to farmers, popularization of scientific package of practices for cultivation including conservation agriculture, price stabilization mechanisms, incentives for maize-based processing industries, etc. are some of the measures that can help catalyse the country's maize production in both short-term and long-term.

(iii) Export promotion of maize needs support. The current exports stand at 3-4 million tonnes and it is a tough competition in the global market from countries with high productivity. Hence, maize exports will require an incentive in the short run, while in the long run the strategy will have to be built around higher productivity & reduced cost of cultivation.

(iv) Robust procurement linked to MSP will need to be put in place to negotiate situations of market dips, as maize production ramps up.

3.9 Annotation

Maize is next only to paddy and wheat in terms of its contribution to the total output of cereals in India. Globally India ranks fifth with respect to output. However, it compares very poorly in respect of both production and productivity vis-a-vis major maize/corn producing countries like USA, Brazil and China.

Maize deserves due emphasis on account of its universal adaptability across India's agro-climatic zones, high genetic potential (being a C4 plant) and multiple uses. Besides being a foodgrain, its major role lies in meeting the feed and fodder requirements of poultry & cattle respectively. With robust growth of the latter two sectors, the demand for maize can only grow further. In addition, maize is highly suited to industrial activities. Maize starch can be used to manufacture more than 3500 types of industrial products. Hence, maize production can be linked to industrial activities for additional off-farm jobs and incomes.

There are several reasons for low productivity of maize in India. A critical intervention to surmount this challenge is to increase the maize cultivation area under single cross hybrids (SCHs), which now stands at only 30 per cent. Further, many states have shown over the last 8 years, that if SCHs and improved agronomic practices are adopted, there will not only be substantive increase in yield, but also impressive gains in farm incomes. Besides productivity increases, there also exists scope to bring additional area under cultivation through crop diversification, inter-cropping and using post-kharif fallow lands, that contain adequate residual moisture.

In the strategy for doubling farmers' income, maize has a useful role to play.

Key Extracts

- Average productivity in maize is half of global average, primarily because of limited adoption of improved production and protection technologies, and lack of irrigation during critical reproductive growth stages.
- Maize is highly adaptive to a range of agro-climatic zones, including less endowed marginal lands, and is therefore an appropriate crop in rainfed areas, particularly in the emerging situations of climate change.
- Maize being a pure row crop, offers opportunity for inter-cropping of pulses, oilseeds and vegetables, and should be promoted for farmers' income enhancement.
- Only around one third of maize cultivation is under single cross hybrids. Promotion of single cross hybrid technology, will play a key role in productivity gains. Maize can be a good substitute for paddy and wheat in IGP (Indo-Gangetic Plains) where temperatures are rising and water table is going down.
- Agricultural research in development and cultivation of improved cultivars of speciality corns like baby corn, sweet corn, wax corn, etc. in peri-urban pockets of the country will be helpful in enhancing income of the farmers.
- Industrial use of maize has yet been not fully tapped. Maize can be processed into a variety of food and industrial products, including starch, sweeteners, oil, beverages, glue, industrial alcohol, and fuel ethanol. Maize is more of an industrial crop and offers vast potential for promoting industrial enterprises including feed industries. These will generate off-farm jobs in rural areas.
- QPM (Quality Protein Maize) is a rich and cheaper source of protein and can be promoted as a nutrition provider to counter under-nourishment & mal-nourishment of the populations.
- Enhancement strategy with respect to productivity and production will require deployment of science & technology, as also appropriate institutional & policy support.

Chapter 4
Nutri-cereals

The production performance of millets, both major as well as minor, is important in context of India. This chapter gives an overview of current level of returns from cultivation of millets, with critical factors like yield gap, total factor productivity and resource use efficiency of various millets, along with specific strategic interventions required on priority basis for doubling income of millets farmers. Considering the nutritional value of millets, they deserve to be called 'nutri-cereals'.

4.1 Introduction

The green revolution in India had some fall outs (Mukherjee *et al.*, 2016) despite positive gains it had at that point of time. The high yielding production technologies recommended during the period of green revolution created some serious problems like nutrient imbalances caused by huge application of nitrogenous fertilisers, depletion of soil micro-nutrients, over-exploitation of groundwater, degradation of land, more frequent emergence of pests and diseases, and diminishing returns to inputs (Chand et al., 2011). It was felt that the potential of green revolution technologies had reached its limits and it was not able to sustain the future growth in Indian agriculture (Chand et al., 2012). Disparities among different regions also have become a concern to policymakers in the country (Sripoorni and Manonmani, 2014).

The thrust of the green revolution was majorly on fine cereals namely, rice and wheat which primarily belonged to irrigated ecosystem, while the dryland crops of India, i.e., pulses, millets and others dryland horticultural crops were disfavoured both in terms of input subsidies and output incentivisation. This caused sustained decline in their crop acreage share in the country significantly. The dryland agriculture, which still accounts for more than half of total cropped area, is predominantly peopled, by the poorer lot, and they grow millets, pulses and horticultural crops. These were largely bypassed by the green revolution.

Further the policy then adopted has led to major imbalances in diversification of the food consumption basket of millions of consumers across the country leading to emergence of malnourishment (including hidden hunger problems) on the one hand, and over-nourishment problems. In addition, emergence of lifestyle diseases such as CVD, diabetes in not only urban areas but also in rural areas is a manifestation of skewed food plate. Fortunately, millets are one of the most important dryland crops which are a sustainable choice for dryland arid ecosystem, being cultivated in the country in various states since ancient times. However, their importance has been significantly reduced over the past five decades giving way to other commercial crops, and pulses and oilseeds due to their relatively lower remuneration and declining consumption demand. Despite the potential of millets to address nutritional and health problems the consumption demand met a decline. These crops are cultivated in wide ranges of climatic conditions and marginal conditions of soil and irrigation and are therefore climate resilient. They are hence highly suited to less endowed regions and are a good fit under climate implications.

4.2 Landscape and Uniqueness of Nutri-cereals

History

Millets constitute one of the oldest foods known to humanity, estimated to be under cultivation since 2500 B.C. Millets have been the stable diet and main source of income, dietary energy and protein for a billion people in arid and semi-arid tropics in the world. The array of millets offers the range of grains, flavours and textures suitable for a variety of cuisine and healthy consumption.

India with large tracts of semi-arid tropics and swathes of rainfed agriculture systems has for long been home to large number of millets, which have thereby been the staple diet on the food plates for many. However, with the onset of green revolution, riding on the shoulders of wheat and paddy, millets slipped into shadow in terms of production and consumption preference of the farmers and the consumers respectively. The farmers had to perforce push them into the penumbra of cropping system due to their relatively lower income potential when compared to other competing crops; and the consumers did so on account of hierarchal perception created around them as inferior commodities. With this, the share of millets in the foodgrain output, as also the diet of Indians has seen a decline over the last about four decades. It's a fortuitous coincidence that the current climate change reality and the increasing health consciousness among a large section of the society across India and globe are bringing back millets into focus of attention.

Cultivation and consumption of the millets and millet products in the country saw a significant decline in the recent decades due to lack of farm level processing facilities, and the associated drudgery involved in primary processing and dehulling required to obtain small millets rice from the harvested produce. Proper support and facilitation for "farmgate processing" and value addition measures are a pre-requisite to marketing of the millets and their cultivation. A combination of climate resilience and nutritional value of millets is a potential answer to raising the farm income in rainfed systems. To promote millet marketing a supply chain model is needed with emphasis on development of value added products from millets, to suit and create demand, including marketing to export destinations. Of late, there is a visible growth in the demand for millets, which have been placed as gluten free nutri-cereal smart foods. This demand is being driven by the health and wellness industry and the food processing sector is growing @ 13 per cent.

Nutritional profile and health benefits of millets

Millets contain substantially high amount of fat, fibre and minerals in comparison to other cereals like wheat and rice, which have been categorized as fine cereals. The protein content in millets, namely, jowar (10.4 per cent), bajra (11.6 per cent), proso millet (12.5 per cent), foxtail millet (12.3 per cent) and barnyard millet (11.6 per cent) is comparable with wheat (11.8 per cent) and is much higher than that of rice (6.8 per cent). In exception to this, though finger millet contains lesser protein (7.3 per cent), it is richer in mineral matter and calcium in comparison to wheat and rice. All the millets contain more fibre than fine cereals. Particularly, the small millets namely barnyard millet (14.7 per cent), kodo millet (9.0 per cent) little millet (8.6 per cent) and foxtail millet (8.0 per cent) are much richer in fibre in comparison to wheat (1.2 per cent) and rice (0.2 per cent).

In a way, India with one of the largest extent of arable land, a major part of which is under rainfed systems is capable of being the millet leader in the world. Millets are low in gluten and glycaemic index, apart from being richer in calcium and various other nutrients which are essential for good human health. Now, that various non-communicable diseases like diabetes etc. have begun to afflict a larger section of the society, millets with low gluten character are emerging as healthy food substitutes.

Productivity potential of millets

Interestingly, the decline in area and production of millets over the last three-four decades and consequential supply coincides with currently, increasing market demand. From the perspective of farmers, it is a propitious situation that can generate better prices on their produce, thanks to farmer-favouring demand-supply position. Unfortunately, millets as of now are confined to less endowed cultivation tracts of the country. The landholdings where millets are cultivated are largely marginal and the farmers are generally small & marginal with poor access to capital and other production resources. They are also raised under rainfed systems with no assured source of irrigation exposing a good crop at its critical stage of production to stress; cascading into lower yield.

Further, having remained outside the pale of green revolution centric science & technology, the R&D too has largely bypassed them causing outcomes that cannot compete with paddy, wheat & maize in terms of yield increases. The average yields of millets in India today is 1.1 tonnes per ha. in contrast to 2.5 tonnes per ha in case of rice, 3.2 tonnes per ha in case of wheat and 2.7 tonnes of maize. The policy framework, particularly the marketing support by way of procurement has also betrayed the millets as poor cousins of wheat & paddy. The substantial decline in the quantum of production of millets over the decades has also dried up the open market channels. In sum, millets, once the principle staple crops of India, have been relegated as relatively forgotten crops.

The vision of DFI which aims not only at enhancing the income of the farmers at macro-level, but also at ensuring equitability by bringing greater focus on regions and farmers with lower incomes has provided an opportunity to pay needed attention to rainfed systems and the forgotten millets. An appropriate strategy that would help increase the productivity by deploying technology and farm management practices; the production by enhancing cropping intensity; provide post-production support including marketing and procurement; and reduce cost of cultivation by adopting sustainable agriculture practices is now needed. This would impart greater sustainability & stability to cultivation and farm incomes in case of millet cultivators in particular and farmers in general.

4.3 Trend in Area, Production and Yields of Millets

Millets which are generally referred to as coarse cereals (while calling paddy, wheat etc. as fine cereals) are in essence nutri-cereals and deserve to be called as such, as they hold inherent potential of contributing substantially to the nutritional security of the people. They are also referred to as noble cereals, because they are highly eco-friendly and therefore are noble in their influence on cultivation environment.

In India the principle millets being cultivated are eight in number, categorised as major and minor. There are some lesser known, pseudo and extinct crops covered under millets and list of their botanical and common names is given below in Table 4.1.

Table 4.1 Millets by Category

SN	Common	Botanical name	-1 Local name (Hindi)
(A) Millets under cultivation			
Major millets			
1	Sorghum	*Sorghum bicolor* (L.)	*Jowar*
2	Pearl millet	*Pennisetum glaucum* (L.)	*Bajra*
3	Finger millet	*Eleusine coracana* (L.)	*Ragi/Mandu*
Minor millets			
4	Barnyard millet.	*Echinochloa frumentacea*	*Sanwa/Jhangora*
5	Proso millet	*Panicum miliaceum* (Is.)	*Cheena*
6	Foxtail millet	*Setaria italica•*	*Kakun/Kangni*
7	Kodo millet	*Paspalum scrobiculatum* (L.)	*Kodo*
8	Little millet	*Panicum sumatrense*	*Kutki*
(B) Lesser known millets			
9	Brown top	*Brachiaria ramosa* (L.)	
10	Crap grass	*Digitaria cruciata*	
(C) Extinct millet			
11	Jobs tear millet	*Coix lacryma* (L.)	
(D) Pseudo millet			
12	Purple	*Amaranthus cruentus*	*Chaulai*
13	Buck wheat	*Fagopyrum esculentum & F. tataricum* (L.)	*Kuttu*

Of the above, all three (3) major millets, five (5) minor millets and brown top millet are the nine (9) principle nutri-cereals cultivated in India. Over the last few decades, millets have witnessed significant decrease in area across the globe including India for reasons discussed earlier.

4.3.1 Global picture of millets

Table 4.2 Area, production and yield of millets in the world (2016)

SN	Millet crop	Area (000 ha)	Production (000 tons)	Yield (kg/ha)	Per cent contribution to total millets production	No. of major production countries
1	Barnyard millet	146.3	151.2	1034	0.16	2

SN	Millet crop	Area (000 ha)	Production (000 tons)	Yield (kg/ha)	Per cent contribution to total millets production	No. of major production countries
2	Finger millet	2106.3	3417.7	1623	3.62	9
3	Foxtail millet	1057	2290.0	2166	2.42	3
4	Kodo millet	200	84.2	419	0.09	1
5	Little millet	255.5	119.9	469	0.13	1
6	Pearl millet	27161	23092	850	24.43	40
7	Proso millet	944.1	1449.5	1535	1.53	36
8	Sorghum	44771	63931	1428	67.63	91
	Total millets	**76185.7**	**94331.4**	**1238**		**131**

Source: IIMR Estimates - based on FAO data

Table 4.3 Production of millets in major millet producing countries during 2016

SN	Country	Area (000 ha)	Production (000 tons)	Yield (kg/ha)	Per cent contribution to production
	Barnyard millet				
1	India	146.0	151.0	1034	99.9
2	Japan	0.3	0.2	837	0.1
	Total	**146.3**	**151.2**	**1034**	
	Finger millet				
1	India	1138.3	1822.0	1601	53.3
2	Ethiopia	456.2	1017.1	2230	29.8
3	Nepal	266.8	302.4	1133	8.8
4	Uganda	167.3	234.3	1401	6.9
5	Malawi	51.7	19.5	378	0.6
6	Burundi	9.5	10.6	1112	0.3
7	Sri Lanka	5.8	5.6	959	0.2
8	Rwanda	10.7	4.5	418	0.1
	Total	**2106.3**	**3417.7**	**1623**	
	Foxtail millet				
1	China	746	1995.9	2675	87.2
2	Myanmar	238	243.4	1023	10.6
3	India	72.6	50.2	691	2.2
	Total	**1057**	**2290.0**	**2166**	
	Kodo millet				
1	India	200	84.2	419	100
	Total	**200**	**84.2**	**419**	
	Little millet				
1	India	255.5	119.9	469	100
	Total	**255.5**	**119.9**	**469**	
	Pearl millet				
1	India	7129	10280.0	1442	44.5
2	Niger	7230	3886.1	537	16.8
3	Mali	2040	1806.6	886	7.8

SN	Country	Area (000 ha)	Production (000 tons)	Yield (kg/ha)	Per cent contribution to production
4	Nigeria	1736	1468.7	846	6.4
5	Sudan	3007	1449.0	482	6.3
6	Burkina Faso	1245	1056.9	849	4.6
7	Chad	1225	725.7	593	3.1
8	Senegal	858	612.6	714	2.7
9	Pakistan	492	318.3	647	1.4
10	Tanzania	341	312.4	917	1.4
11	Guinea	189	194.0	1028	0.8
12	Ghana	162	159.0	980	0.7
13	Gambia	117	101.9	871	0.4
14	Cameroon	72	100.0	1398	0.4
15	Yemen	125	86.7	691	0.4
16	CÃ´te d'Ivoire	67	54.5	815	0.2
17	Kenya	88	54.0	611	0.2
18	Namibia	228	44.6	195	0.2
19	Angola	187	42.0	224	0.2
20	Congo	61	41.0	669	0.2
	Total	**27161**	**23092**	**850**	
	Proso millet				
1	Russia	409.3	629.6	1538	43.4
2	USA	167.1	284.8	1704	19.6
3	Ukraine	107.7	189.7	1761	13.1
4	South Korea	69.2	73.5	1061	5.1
5	Kazakhstan	55.8	61.2	1096	4.2
6	France	12.3	41.9	3403	2.9
7	Poland	24.4	41.0	1682	2.8
8	Belarus	14.1	28.0	1982	1.9
9	India	31	20.0	645	1.4
10	Iran	8.5	18.8	2220	1.3
11	Afghanistan	2.9	10.0	3502	0.7
12	Hungary	5.5	7.5	1354	0.5
13	Argentina	4.4	6.9	1554	0.5
14	Uzbekistan	1	6.6	6812	0.5
15	Turkey	2.3	5.3	2309	0.4
16	Bangladesh	15.7	4.8	305	0.3
17	Bulgaria	2.4	3.7	1568	0.3
18	Viet Nam	1.4	3.7	2605	0.3
19	Syria	2	3.5	1778	0.2
20	Iraq	2	1.7	867	0.1
	Total	**944.1**	**1449.5**	**1535**	
	Sorghum				
1	USA	2494	12.2	4891	19.1
2	Nigeria	5816	6.9	1193	10.9
3	Sudan	9158	6.5	706	10.1
4	Mexico	1513	5.0	3309	7.8
5	Ethiopia	1882	4.8	2525	7.4
6	India	5650	4.4	781	6.9
7	Argentina	674	3.0	4498	4.7
8	China	533	2.4	4502	3.8
9	Niger	3605	1.8	502	2.8
10	Australia	521	1.8	3440	2.8

SN	Country	Area (000 ha)	Production (000 tons)	Yield (kg/ha)	Per cent contribution to production
11	Burkina Faso	1652	1.7	1055	2.7
12	Mali	1560	1.4	893	2.2
13	Cameroon	856	1.3	1565	2.1
14	Brazil	558	1.2	2068	1.8
15	Chad	1191	1.0	832	1.6
16	Bolivia	296	0.8	2822	1.3
17	Tanzania	782	0.8	967	1.2
18	South Sudan	447	0.7	1595	1.1
19	Egypt	154	0.7	4521	1.1
20	Yemen	463	0.4	851	0.6
	Total	**44771**	**63931**	**1428**	

Source: IIMR Estimates- based on FAO data

4.3.2 Status of millets in India

In India the principle millets cultivated are eight in numbers categorized as major and minor. The status area, productivity and production and change over the years are highlighted below. In India, millets contribute an extent of 10 per cent to the country's foodgrain basket. They are grown on about 15 million ha with an annual production of 17 million tonnes.

i. Among the states, maximum area under millets is in Rajasthan (5 m ha; 87 per cent of it under bajra) followed by Maharashtra (4 m ha; 75 per cent under jowar) and Karnataka (2 m ha; 54 per cent under jowar & 32 per cent under ragi)

ii. The total area under millets declined at a CAGR of 5.4 per cent per annum during the period 2010-11 to 2014-15 and their total production has also declined at an annual rate of 4 per cent during this period.

iii. On account of a marginal increase in the productivity at a CAGR of 1.2 per cent, the annual decline in production was less than the loss of area under millets.

iv. The total area, production and productivity of sorghum (jowar) declined at a compound annual growth rate (CAGR) of 4.4, 5.8 and 1.4 per cents respectively during the period of 2010-11 to 2014-15. The loss in sorghum area has been more visible since the mid-1980s, with a rate of decline over 3,60,000 acres per annum.

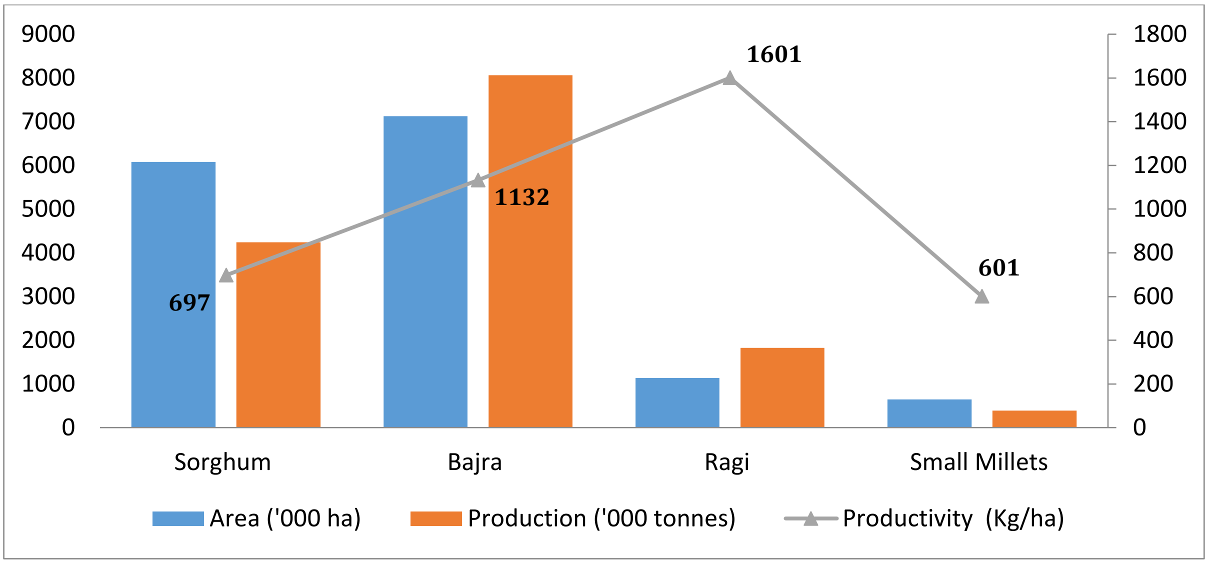
v. Finger millet (Ragi) forms a major part of the food basket in certain regions of the States of Karnataka, Telangana and Uttrakhand.

vi. Finger millet and other small millets have demonstrated similar declining trend in area and production and the respective CAGRs have been -1.1 & -1 per cents; and -7.7 & 3.2 per cents respectively. However, the productivity has shown a marginally positive growth of 0.1 and 1.2 per cents respectively.

vii. Pearl millet has also suffered a declining trend with respect to area and production at a CAGR of 6 and 3.5 per cents respectively. However, the productivity has shown a positive trend of CAGR of 3.1 per cent.

viii. Reduced demand has in way dis-incentivised millet cultivation, worsening the situation by poor investment in millet research. Yet the research efforts in crop improvement have enabled enhancement of millet productivity by 159 per cent and millet production by 32 per cent though area has reduced by 50 per cent since 1960.

Figure 4.1 Area, Production and Yield of Millets (2015-16)



Source: DFI Committee Estimates based on data compiled from DACNET

Notwithstanding impressive nutritional benefits of millets, there has been a drastic reduction in their consumption in the country. The main reasons for this are massive increase in output of paddy and wheat, which came to be procured and mainstreamed into PDS (Public Distribution System) across the country. This slowly but steadily substituted the local food habits, and squeezed the space for other cereals including millets. There has been in result a shift from production of millets (jowar in particular) to other competing crops such as soybean, maize, cotton, sugarcane and sunflower in the country as a whole. (An unfortunate social dimension of the cause of decline has been attributing millets as poor man's food, creating a hierarchical perception).

However, India being the largest producer of millets enjoys a key advantage of playing in global export and supply especially in case of sorghum, pearl millet and small millets.

4.4 Income Returns

Current levels of returns from millet cultivation have been computed and tabulated below (Table 4.4). The cost of cultivation (CoC) data of the millets for the year (2013-14) has been used for this purpose. Since the CoC data for small millets are not available, it was approximated from the primary survey conducted by IIMR (Indian Institute of Millets Research) in Madhya Pradesh and Uttarakhand during 2016-17 on kodo, little and barnyard millets. The gross returns earned by the jowar, bajra and ragi farmers during 2013-14 taken from CoC data is taken as current year income and the target is set to be 2.5 times the base year income to avoid the time lag from 2014-15 to 2016-17. It can be seen, that contribution of price growth has been targeted to be 25 per cent of the total income growth as compared to 20 per cent from yield growth. The growth of price is directly related to the growth in demand for millets products. The rest 45 per cent of the income growth has to be generated from value addition and reduced yield gaps.

Table 4.4 Millet's farmers' income and cost estimates

SN	Item		Jowar#	Bajra#	Ragi#	Small* Millets
1	Cost of Cultivation (Rs./hectare)	A1	16395.5	16659.61	18488.96	3470.13
2.i	Value of Main Product (Rs./hectare)		25692.79	27933.6	35376.95	20547.12
2.ii	Value of by-product (Rs./hectare)		7344.418	6439.684	5229.35	5150.613
3	Gross return		33037.21	34373.28	40606.3	25697.74
4	Net return over A1		16641.71	17713.67	22117.34	22227.61
5	Current (2014-15) yield level (qtl./ha)		8.84	12.55	17.05	6.5
6	Current price level (Rs./Qtl.)@ (2016-17)		1625	1330	1725	2220
7	Gross Income Projected in 2022 (2.5 times for jowar, bajra and ragi)		82593.02	85933.21	101515.8	51395.47
8	Contribution of yield growth @20%		16518.6	17186.64	20303.15	10279.09
9	Contribution of price growth @25%		20648.26	21483.3	25378.94	12848.87

*Source: DFI Committee Estimates based on data compiled from Directorate of Economics and Statistics, GoI. * Estimates of ICAR-IIMR based field survey of odo, little and barnyard millets from the states of Madhya Pradesh and Uttarakhand. @ Current price level is MSP during 2016-17 for major millets. For small millets it is the price realized by sample farmers. Cost A1 is used; imputed value of farmer family labour (FL) and land rent if leased is additional.*

Yield enhancement is an essential component of the strategy for increasing the production of millets in the country. The current level of growth rate of millets reveals (Table 4.5), that except for sorghum (-0.44 per cent), all other millets have shown positive trends in the last two decades. The table summarizes the target yield levels and annual growth during the period of 2017-18 to 2022-23. In case of sorghum, the yield increases have been targeted to realize positive growth, and in case of other millets, the target would be maintaining the pace of past trends.

Table 4.5 Annual productivity gains across millets for doubling farmers' income

SN	Crops	Current Level		Yield Growth Targets					
		Yield (kg/ha)	CAGR 1996-97 to 2014-15	2017-18 (%change over 2015-16)	2018-19 (Annual increase %)	2019-20 (Annual increase %)	2020-21 (Annual increase %)	2021-22 (Annual increase %)	2022-23 (Annual increase %)
1	Sorghum	884	-0.44%	900 (1.83)	950 (5.55)	1000 (5.25)	1050 (5.00)	1150 (9.5)	1200 (4.35)
2	Pearl Millet	1255	2.62%	1275 (1.59)	1300 (1.96)	1350 (3.84)	1400 (3.70)	1425 (1.78)	1450 (1.75)
3	Finger Millet	1706	1.47	1750 (2.58)	1775 (1.42)	1800 (1.40)	1850 (2.77)	1900 (2.70)	1925 (1.32)
4	Small millets	654	2.04	750 (14.59)	775 (3.33)	800 (3.22)	820 (2.5)	850 (3.65)	875 (2.94)

Source: DFI Committee Estimates

Increase in the yields of millets is expected to throw up its own challenges. With increased production a situation of market glut and consequential decrease in their prices is possible with a negative impact on farmers' income. There must be enough market demand for millets in order to absorb the additional output, which warrants simultaneous emphasis on creating a market.

4.5 Projected Millets Output over DFI Period

Table 4.6 Year-wise projected millet output

Area in '000 Ha Production in '000 tonnes		2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Target Yield level (Kg./ Ha)	Sorghum	900.0	950.0	1000.0	1050.0	1150.0	1200
	Pearl Millet	1275.0	1300.0	1350.0	1400.0	1425.0	1450
	Finger Millet	1750.0	1775.0	1800.0	1850.0	1900.0	1925
	Small Millets	750.0	775.0	800.0	820.0	850.0	875

Source: DFI Committee Estimates

Table 4.7 Dynamics of different regimes of area and productivity of millets (2018-19 to 2022-23)

Crop	Constant area with current productivity			Constant area with increased productivity			Increased area with increased productivity		
	Area m.ha (TE)	Productivity kg/ha	Production mill. tons	Area m.ha (TE)	Productivity kg/ha	Production mill. tons	Area m.ha (TE)	Productivity kg/ha	Production mill. tons
Sorghum	5.9	900	5.10	5.9	1200	7.08	7.08	1200	8.50
Pearl millet	7.37	1275	9.4	7.37	1450	10.69	8.48	1450	12.30
Finger millet	1.25	1750	2.19	1.25	1925	2.41	1.5	1925	2.89
Small millets	0.8	750	0.6	0.8	875	0.7	0.92	875	8.05
Total millets	15.32	1129	17.29	15.32	1362	20.88	17.98	1765	31.74

Note:

1. Area increase for five years considered in sorghum and finger millet upto 20 per cent; and pearl millet and other small millets upto 15 per cent
2. Productivity figures taken from table 4.6.
3. Constant/current area is the Triennium average (TE) of previous 3 years ending 2015-16

From the above table, it can be inferred that:

- During the ensuing five years (2017-18 to 2022-23) the increase in the estimated total production of all the millets taken together is 3.59 mill. tonnes over the base year 2016-17 when the productivity gains alone are taken into consideration and area remains constant.
- In alternate scenario, when both area and productivity levels increase, the estimated production of all millets taken together is 31.74 mill. tonnes over the base year. Obviously both area and productivity increases are important to register substantive production increases.

It means that the production due to increase in productivity and area (increase in area in coastal rice fallows, lands where water table has gone down, north eastern and eastern India areas, the area enhanced due to diversified uses in non-traditional belts, etc.) can make three times the contribution than the envisaged productivity enhancement can alone make (new improved cultivars, soil health improvement, shift from marginal lands to better lands under millet cultivation possible from better profits and crop management practices in adoption mode).

The emphasis and the investment should be with dual focus in order to attain the targeted output. In addition, post production value addition through interventions in primary processing and secondary processing with credible market linkages will go a long way in strengthening nutri-cereals supply chain. This will benefit both the farmers from the view point of their income and the nation from the perspective of food security.

This addition of production coming from millets, would release pressure to some extent on paddy and wheat tracts. The envisaged millet output could be realized through area expansion by incentivisation of millet cultivation, farm gate processing, support to farmer producer organizations, price support, crop insurance, efficiency of markets and procurement operations when markets fail. The announcement of Union Budget, 2018 committing the Government to a minimum MSP of 1.5 times the cost of production is expected to benefit millets as a class the most. Further push can be expected from the Government's assurance of honouring the notified MSPs by strengthening procurement operations.

The incentives as above can be reasonable held as sufficient to incentivize farmers to bring additional area under millets.

It is also expected that awareness about nutria-cereals as health food will trigger higher demand for them and engender area expansion. Enhanced production can enable stronger linkages of millet production systems with value adding activities and result in better price realisation for the farmer. In addition, the productivity augmentation can come from new high yielding varieties, better scientific package of practices and technologies that enhance production efficiencies. It is therefore possible to achieve the projected estimates in the given time frame.

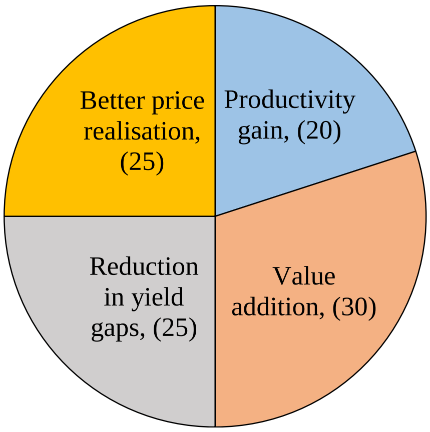
Chapter 5
Nutri-cereals: Productivity Gains

This chapter examines the reasons for low yields in millets and suggests that bridging yield gaps would be a quantifiable approach to enhancing average productivity and realizing higher total output thereby.

5.1 Interventions for Doubling Income of Millets Farmers

The dryland agriculture in the country is characterized by low productivity, low investment, poor technology, poor infrastructure, and low marketable surpluses. Besides poor infrastructure and over dependence on the agricultural lands is also seen. This situation challenges seriously the targeted income enhancement from farming. Before suggesting various interventions required for doubling farmers' income in the dryland situation, especially those cultivating nutri-cereals, it is important to examine the sources that can contribute to farmers' income, and segregate contributions of different components of income growth. Figure 5.1 summarises the contribution of major sources of millet income growth to achieve doubling of farmers' income.

Figure 5.1 Component-wise contribution towards doubling millet farmers' income



The highest contribution @ 30 per cent is expected from promotion of value addition, followed by yield gap reduction (25 per cent), remunerative prices (25 per cent) and productivity gain (20 per cent). Each component is a value added activity in hands of individual actors, and can benefit from optimisation efforts. Together, they integrate into the millet supply chain. In the subsequent sections, the strategies for tapping these potentials are discussed. It is important to note, that farm-gate processing and value addition hold the key to promoting millets.

5.2 Bridging the Yield Gaps as a strategy to upgrade Yield Levels

Increasing the productivity of agricultural crops per unit of area in general can increase the agricultural output. Expansion of area under nutri-cereal crops is a challenge, given the increased demand for land for non-agricultural purposes. At best, crop substitution is the possible major way of higher area coverage under nutria-cereals. Therefore, increase in productivity of millets remains the most viable option for enhancing their output, while simultaneously identifying other options available for increasing the total production.

Productivity enhancement is the single most important initiative that Indian dryland agriculture should embark upon in raising production. The yield levels of Indian millets still lag behind the global averages, just as is the case in other crops including the staple cereals. Some of the reasons for yield gaps between research claims/frontline demonstrations and farmer's field are:

- Cultivation in less endowed regions.
- Less than desired use of resources by the farmers; imbalanced use of resources.
- Inability of the farmers to adopt improved package of practices, as recommended.
- Lack of location specific-technologies, erratic weather conditions, and poor pest and disease.
- Lack of access to institutional credit.
- Lack of required information and knowledge among farmers.

The Front Line Demonstration (FLD) data for the purpose of estimating the impact of yield gap reduction in generating additional output of millets was compiled from the status report on coarse cereals, 2014 published by the Directorate of Millets Development, Government of India. The ratio of State Average Yield (SAY) to FLD yield was computed and the states were classified as under-performing or above-performing vis-a-vis the national average.

The states with lower ratio have to realize the national average, and those with the ratio equal to or more than the national average will have to aim to register an increase of at least 10 per cent over the next 3 years. In the following paragraphs millet-wise analysis has been carried out:

i. **Sorghum**: The all India average of SAY-to-FLD ratio for kharif sorghum was 0.46 (Table 5.1). Based on this the states of Andhra Pradesh and Rajasthan were classified as under-performing states with ratios 0.31 and 0.23, respectively. The ratios in case of all other major states cultivating sorghum were above SAY. Based on estimation procedure described earlier, an additional output of 2.47 million quintals of sorghum can be produced in the target period.

In case of *rabi* sorghum, the national average of SAY-to-FLD ratio was estimated to be 0.54, with Karnataka performing far above the national average at 0.85; and Andhra Pradesh and Maharashtra performing below average at 0.29 and 0.47 respectively.

Through yield gap reduction measures, an additional output of 3.12 million quintals of sorghum can be produced from these three states during the target period, 56.59 per cent of it coming from Maharashtra and 36 per cent from Karnataka.

Table 5.1 Gain in additional output of sorghum due to reduction in yield gap

State/ UT	SAY (Qt./ ha)	FLD (Qt./h a)	Area ('000 ha)	SAY-to-FLD ratio	Target SAY-to-FLD ratio	Target SAY (Qt./ha)	Additional yield (Qt./ha)	Additional output ('000 Qtl.)	Share of additional output (%)
1	**2**	**3**	**4**	**5 = 2 / 3**	**6**	**7**	**8 = 7-2**	**9 = 8 x 4**	**10**
KHARIF									
Andhra Pradesh	10.0	32.2	102.7	0.3	0.5	11.0	1.0	102.5	4.1
Gujarat	10.7	25.9	85.0	0.4	0.5	11.7	1.1	90.5	3.7
Madhya Pradesh	13.5	22.9	426.4	0.6	0.7	14.8	1.4	574.3	23.2
Maharashtra	12.0	23.4	978.5	0.5	0.6	13.2	1.2	1178.1	47.6
Rajasthan	4.2	18.1	646.9	0.2	0.5	4.7	0.4	273.6	11.1
Tamil Nadu	8.3	12.1	171.6	0.7	0.8	9.8	1.5	255.7	10.3
All India	9.8	22.4	2411.2	0.5				2474.8	100.0
RABI									
Andhra Pradesh	14.5	50.1	157.6	0.3	0.5	15.9	1.5	228.1	7.3
Karnataka	10.5	12.4	1070.0	0.9	0.9	11.6	1.1	1127.8	36.1
Maharashtra	6.2	13.2	2837.5	0.5	0.5	6.9	0.6	1767.8	56.6
All India	10.4	25.2	4065.1	0.5				3123.6	100.0
Karif + Rabi			6476.3					5598.4	

Source: DFI Committee Estimates

ii. **Finger millet (Ragi):** The SAY-to-FLD ratio for finger millet (ragi) was calculated to be 0.55 (Table 5.2) and the major ragi producing states were classified using this as a benchmark. Further, based on assessed reduction in yield gaps between SAY and FLD, it was estimated that an additional 2.21 million quintals of ragi can be produced from these states in the target period. Karnataka will alone contribute about 63 per cent of the total additional output followed by Maharashtra (11 per cent), if suitable measures are adopted.

Table 5.2 Gain in additional output of finger millet due to reduction in yield gap

State/ UT	SAY (Qt./ha)	FLD (Qt./ha)	Area ('000 ha)	SAY-to-FLD ratio	Target SAY-to-FLD ratio	Target SAY (Qt./ ha)	Additional yield (Qt./ha)	Additional output ('000 Qtl.)	Share of additional output (%)
1	**2**	**3**	**4**	**5 = 2 / 3**	**6**	**7**	**8 = 7-2**	**9 = 8 x 4**	**10**
Andhra Pradesh	11.24	18.07	46.8	0.62	0.68	12.36	1.12	52.60	2.38
Chhattisgarh	2.71	20.08	8.5	0.13	0.55	3.25	0.54	4.61	0.21
Gujarat	8.71	17.76	18.2	0.49	0.55	10.98	2.27	41.31	1.87
Jharkhand	5.92	25.17	11.3	0.24	0.55	7.10	1.18	13.38	0.61
Karnataka	17.88	22.94	781.4	0.78	0.86	19.67	1.79	1397.14	63.29
Maharashtra	10.07	17.4	124.8	0.58	0.64	12.08	2.01	251.35	11.39
Odisha	6.83	22.08	62.7	0.31	0.55	8.20	1.37	85.65	3.88
Tamil Nadu	21.98	22.05	84.9	1.00	1.10	24.18	2.20	186.61	8.45
Uttarakhand	13.48	16.29	129.6	0.83	0.91	14.83	1.35	174.70	7.91
All India	10.98	20.20	1268.2	0.55				2207.35	100.0

Source: DFI Committee Estimates

iii. **Pearl millet (Bajra):** In respect of bajra, the national average of SAY-to-FLD was 0.61 (Table 5.3). The performance of the States of Tamil Nadu and Haryana (0.75 and 0.70, respectively) was well above the national average, it was below the national average in case of Rajasthan and Maharashtra (0.49 and 0.40 respectively). If the States achieve the assigned target of SAY-to-FLD ratios during the target period, an estimated 1.44 million quintals of bajra can be produced.

Table 5.3 Gain in additionally output of pearl millet due to reduction in yield gap

State/ UT	SAY (Qt./ ha)	FLD (Qt./ha)	Area ('000 ha)	SAY-to-FLD ratio	Target SAY-to-FLD ratio	Target SAY (Qt./ ha)	Additional yield (Qt./ha)	Additional output ('000 Qtl.)	Share of additional output (%)
1	**2**	**3**	**4**	**5 = 2 / 3**	**6**	**7**	**8 = 7-2**	**9 = 8 x 4**	**10**
Rajasthan	7.79	15.86	496.80	0.49	0.61	8.569	0.78	387.01	26.95
Gujarat	13.87	21.31	74.30	0.65	0.72	15.257	1.39	103.05	7.18
Haryana	18.14	25.84	56.89	0.70	0.77	19.954	1.81	103.20	7.19
Tamil Nadu	16.09	21.54	50.00	0.75	0.82	17.699	1.61	80.45	5.60
Karnataka	8.58	13.81	28.82	0.62	0.68	13.36	4.78	137.76	9.59
Madhya Pradesh	16.49	24.96	17.44	0.66	0.73	18.139	1.65	28.76	2.00
Maharashtra	8.50	21.13	91.20	0.40	0.61	13.36	4.86	443.23	30.86
Uttar Pradesh	17.44	27.19	87.62	0.64	0.71	19.184	1.74	152.81	10.64
All India	13.36	21.45	1015.9	0.61				1436.27	100

Source: DFI Committee Estimates

iv. **Small millets:** As regards all the small millets put together, the SAY-to-FLD ration for the country stood at 0.54 (Table 5.4). The states of Maharashtra, Odisha and Uttarakhand were well above the national average with values of 0.69, 0.77 and 0.69 respectively. On the other hand, Andhra Pradesh and Chhattisgarh turned out to be under-performing states as per this criterion.

If the states adopt appropriate measures to reduce the yield gaps and achieve the assigned SAY-to-FLD ratios, the additional output during the DFI period would be 1.11 million quintals of small millets.

Table 5.4 Gain in additional output of small millets due to reduction in yield gap

State/ UT	SAY (Qt./ ha)	FLD (Qt./ ha)	Area ('000 ha)	SAY-to-FLD ratio	Target SAY-to-FLD ratio	Target SAY (Qt./ ha)	Additional yield (Qt./ha)	Additional output ('000 Qtl.)	Share of additional output (%)
1	**2**	**3**	**4**	**5 = 2 / 3**	**6**	**7**	**8 = 7-2**	**9 = 8 x 4**	**10**
Andhra Pradesh	6.3	19.19	30.80	0.33	0.54	6.93	0.63	19.40	1.74
Chhattisgarh	2.18	6.84	178.50	0.32	0.54	4.69	2.51	448.04	40.19
Karnataka	4.77	9.06	32.00	0.53	0.58	5.25	0.48	15.26	1.37
Madhya Pradesh	2.88	6.17	297.10	0.47	0.54	4.69	1.81	537.75	48.24

State/ UT	SAY (Qt./ ha)	FLD (Qt./ ha)	Area ('000 ha)	SAY-to-FLD ratio	Target SAY-to-FLD ratio	Target SAY (Qt./ ha)	Additional yield (Qt./ha)	Additional output ('000 Qtl.)	Share of additional output (%)
Maharashtra	4.83	7.00	71.40	0.69	0.76	5.31	0.48	34.49	3.09
Orissa	4.89	6.35	18.10	0.77	0.85	5.38	0.49	8.85	0.79
Uttarakhand	6.95	10.13	73.40	0.69	0.75	7.65	0.70	51.01	4.58
All India	4.69	9.25	100.19	0.54				1114.80	

Source: DFI Committee Estimates

The analysis above shows that an additional quantity of 0.78 million tonnes of all the millets put together can be produced in India only through reduction in yield gaps within the DFI target period. This signifies the importance of reduction in yield gaps and its positive impact on the farmers' income.

5.2.1 Measures to bridge the yield gaps of millet

- In order to enhance adoption of recommended location-specific technologies, it is important to create awareness and train the farmers suitably.
- Farmers should be made well aware about the extent of yield reduction due to weed infestation, and equipped with knowledge & technology for effective weed management. Weeds cause severe yield losses if not managed well.
- Millet farmers should be encouraged to adopt the recommendations of soil health cards (SHCs) so as to ensure balanced use of nutrients.
- The focus should be on improving the resource use efficiency and adoption of recommended farm management practices, so as to realise the full genetic potential of the variety or at the minimum FLD yield levels.
- Adoption of recommended agronomic practices will be able to enhance productivity. Use of quality seeds can be a major contributor yield upgrade in the short run.
- In the long run, release of new varieties, tolerant to vagaries of weather and with potential for high yield will be needed.

5.3 Increasing the Cropping Intensity in Dryland Agriculture

Most of the farmers in dryland parts of the country grow single crop in a year due to absence of dependable sources of water. With vast tracts of drylands in the country practising single season cultivation, the cropping intensity of the nation is pulled down. It currently stands at 145 per cent. Adoption of appropriate cropping systems and patterns will help increasing in cropping intensity.

This calls for proper crop planning to utilise more than one of the three seasons of *kharif, rabi and summer* in the dryland conditions. Millets offer most viable solution in promoting cropping intensity in dryland conditions, as they easily adapt to a range of climatic variations, including situations of water stress and high temperature.

For instance, sorghum can be successfully grown throughout the year. Many parts of the country cultivate sorghum both in *kharif and rabi* seasons.

Given the minimum requirements of water, small millets like *kodo, little and barnyard millets* can be successfully grown in the post-kharif fallows using residual moisture available in rainfed areas of the country. Most of the millets are short duration in nature (generally 65-80 days) and can be successfully grown in the post-*kharif* fallows. This will significantly increase the cropping intensity in dryland agriculture and contribute to higher output and farm incomes. This is one of the feasible options of bringing additional area under millets.

An estimated extent of 12 million hectares of post-kharif fallow is available in India, mostly in eastern India. This area with available residual moisture, can be used to cultivate short duration millets apart from pulses and oilseeds..

5.4 Improvement in Total Factor Productivity (TFP) of Millets

With the initiation of green revolution framework in the country, Indian agriculture registered impressive growth and saw increases in the production of food and non-food crops. This increase in production was driven by a package consisting of research, extension and price support. Government's support in the form of inputs (e.g., seeds, fertilizers) and investments in infrastructure also pump-primed agricultural growth. All this has helped the country in attaining self-sufficiency in foodgrains and many other agri-commodities, besides generating exportable surpluses.

Chand *et al.*, 2011 evaluated and reported that annual growth rates of TFP of jowar and bajra during the period from 1975-2005 in India were 0.63 and 1.04 respectively. The share of TFP growth in the output growth of jowar and bajra was estimated to be 24 per cent and 28 per cent respectively, despite negative growth of the real cost of cultivation. The study reported negative TFP for jowar in majority of jowar producing states, whereas in case of bajra the growth of TFP was moderately high.

ICAR-IIMR has estimated the Malmquist TFP mean of major producing states during the period from 2004-05 to 2013-14, and reported TFP growth rates to be positive which implies, that there exists good scope for increasing farmers' incomes.

Table 5.5 Malmquist TFP Index of State wise means of Millets from 2004-05 to 2013-14

State	Jowar	State	Bajra	State	Ragi
	TFPch		TFPch		TFPch
Andhra Pradesh	1.02	Gujarat	1.05	Karnataka	1.09
Karnataka	1.05	Haryana	1.12	Maharashtra	1.11
Madhya Pradesh	0.95	Karnataka	1.05	Tamil Nadu	1.33
Maharashtra	1.15	Maharashtra	1.02	Mean	1.17

State	Jowar	State	Bajra	State	Ragi
	TFPch		TFPch		TFPch
Tamil Nadu	1.23	Rajasthan	1.04		
Mean	1.08	Uttar Pradesh	1.13		
		Mean	1.07		

Source: DFI Committee Estimates

During the initial periods of green revolution public investments in the agricultural research and extension played the most important role in TFP growth, with shares of 21.5 and 67.0 percent, respectively (Evenson *et al.*, 1999). These public investments ensured development of high yielding production technologies and their rapid spread among the Indian farmers for adoption. These indicate the need for replication of the approach in respect of millets.

5.5 Productivity Enhancement of Millets through Seed & Soil Management

Seeds play a very critical role in increasing the productivity of the crop sector. For example, introduction of high yielding varieties of rice and wheat during the early sixties played a major role in unleashing green revolution in India. Similarly in improving the yield levels of different millets, use of quality seeds is important.

The yield performance varies between districts within the states and between different states as well due to various reasons. As of now yields of millets in the states, and national averages are below the potential. A quantifiable way to chase targets and improve upon the national averages is:

- The districts below state average to reach the same;
- The states below national average to reach the same;
- The states already above national average to realise a minimum additional of 10 per cent

The basic principle in all cases should be bridge the yield gaps between FLD and Farmer's Field.

It is important to focus on specific interventions that would help, improve the production potential of Indian millets through seed management. The following interventions are suggested:

- Identifying location-specific, short duration and high yielding millet varieties; building a robust seed production chain; and making them available to farmers.
- The identified varieties need to be resistant to drought and other biotic and abiotic stresses.
- Facilitating the farmers to adopt recommended package of practices access to credit, inputs, extension & education.

5.5.1 Soil management

This is one of the important measures to harness the productivity even in dryland crops such as millets. The Government of India's soil health card (SHC) scheme, that consists of collection of soil samples, comprehensive testing for 12 parameters and recommending nutrient management benchmarked to yield levels holds great promise of sustainable soil health and improved productivity.

5.5.2 High yielding varieties (HYV) and hybrids

Given the relatively short target period for doubling the farmers' income, it is not feasible to await release of new varieties of millets. Instead already available improved varieties of millets may be propagated for distribution among millet-farmers in India; however, ensuring their quality and timeliness are crucial factors for success. Seed village concept for multiplication and distribution of various millet varieties is an income generating avenue that can be propagated. Multiplication of identified product-specific cultivars in farmers' fields through contract farming with backward linkages can be replicated in millets through partnership with seed industry.

Spread of HYVs is more pronounced in sorghum and bajra but further efforts are needed for improvement in case of ragi and other small millets. Seed supply of small millets varieties is an area which needs focused attention for enhancement of farmers' income in tribal, hilly and other disadvantaged regions.

5.6 Bio-fortification of millets

Bio-fortification is the development of micronutrient-dense staple crop cultivars using the best traditional breeding practices and modern bio-technology. It provides a comparatively cost-effective, sustainable, and long-term means of delivering more micro-nutrients to people with poor access to markets or health care systems.

5.6.1 Incentives for cultivation of bio-fortified varieties

Consumption of bio-fortified commodities will reduce current malnutrition, improve resistance to health vulnerabilities and result in reduced family expenditure on health treatment. Increased work capacity will lead to more productive man-days and higher incomes. Hence, roll out policies encouraging cultivation of bio-fortified crop cultivators by means of incentivizing the choice of variety would be useful.

5.6.2 Branding of bio-fortified grains and food products

Apart from promotion of bio-fortified crop varieties, there has to be special emphasis on branding of produce of bio-fortified crops. This will help to differentiate the normal grains and micro-nutrient rich grains, and also in creating a niche market for such produce. The food products prepared using such grains will naturally attract a premium prices. They can also be included in mid-day meals and other government schemes aimed at easing of malnutrition among children.

5.6.3 Premium price for bio-fortified produce

The nutritional quality of the final produce has generally taken a back seat, as the prime aim was to produce more with a view to achieving food security. Higher productive capacity was never linked with higher grain quality, and in most of the instances negative relation is observed between yield and quality. Hence, bio-fortified varieties in general can be expected to suffer from relatively lower level of yield, which naturally dissuades the farmers from adopting them. This yield penalty has to be bridged by offering a premium for the bio-fortified produce which can compensate for the lower returns resulting from lower yield levels. A separate pricing policy is needed, whereby, margin of profit is linked to quality parameters of agri-commodities in notification of MSPs. May be it can come in the form of bonus on MSP for purpose of avoiding distortion in determining MSP. The differential pricing will naturally attract the farmers to adopt bio-fortified cultivars. Of course, if well branded and marketed, markets can themselves discover premium prices for these.

5.6.4 Development of seed villages

Seed village concept should be promoted in order to maintain steady supply of location specific quality millet seeds at minimum cost. This will ensure use of quantity seeds by the farmers. Since cost of seeds is one of the major contributors of the cost of cultivation, availability of seeds from seed villages will help in increased farm income due to cost reduction. This will also help the farmers to maintain their own seeds and save on input cost.

5.7 Cost Reduction and Resource Use Efficiency

The increased costs of inputs have made it difficult for dryland farmers to meet their crop production needs and when they cannot access institutional credit, tend to fall back upon money lenders. Thus improved technologies and farm practices that will reduce cost of cultivation millets will significantly add to the farmers' net income. Various cost reduction measures that could be emphasised are:

- Efficient use of farm inputs - seeds, nutrients and irrigation water.
- Technological upgradation.
- Adoption of water saving technologies.
- Farm mechanisations.

The approach that involves reduction in cost of cultivation for increasing farmers' income is highly effective for input intensive crops like rice, wheat and cotton. But millets are mostly cultivated by resource poor small and marginal farmers with marginal conditions of soil and irrigation. A survey in the States of Madhya Pradesh and Uttarakhand by IIMR has brought out that most of the small millet farmers use very less of purchased inputs like chemical fertilizers and irrigation water. They mostly use owned inputs including seeds and human labour.

Labour component constitutes a major cost of cultivation in millets. What is required is to promote rational use of farm machinery to reduce drudgery and enhance operational efficiency & productivity that emanates therefrom. Further, as focus brought on bridging yield gaps, there will be increase in use of external resources. In doing so, care will have to be taken to use resources efficiently and rationalise cost of cultivation.

5.7.1 Blending of indigenous and modern knowledge for resource conservation

Ironically, droughts and floods occur simultaneously in different parts of the country. Soil and water are the basic resources that need to be effectively conserved. Increasing pressure on land calls for blending of indigenous and modern knowledge for wider acceptability of resource conservation practices among the farmers.

Integrated watershed development programmes incorporate this approach, and it would be necessary to guide the farmers on various intervention, so as to generate optimal outcomes from the interventions made.

The interventions can be categorized into three broad sub-groups as in Table below. The various measures are mostly applicable to semi-arid and sub-humid areas with red and black soils receiving an annual rainfall from 500 mm to 1500 mm. Farmers themselves can practise low-input short-term measures. Implementation of medium-term measures requires technical guidance, while high input measures require both technical backstopping and financial support.

Table 5.6 List of options under different measures

Low-input and short-term measures	Medium-input and medium-term measures	High-input and long-term measures
Tillage: Summer ploughing, contour cultivation, sowing across the slope, frequent interculture, conservation furrow (dead furrow), Broadbed and furrow (BBF), ridge and furrow, set-row cultivation, etc.	**Tillage**: Deep ploughing	**Soil Conservation**: Land levelling, bunding, and terracing for arable land. Contour or graded border strip for black soils. Continuous contour trenching for non-arable land, etc.
Cropping system: Strip cropping, relay cropping, intercropping with millets, etc.	**Soil amendment**: Sand, silt pebble application, etc.	**Gully control structure**: Gabion, rock fill dam, loose boulder checks, etc.
Residue management: Cover cropping, green leaf mulching, residue incorporation, etc.	**Bio-engineering measures**: Vegetative (live) fence along with boundary bunds, live-beds, contour vegetative barriers, grassed waterways, sunken pits, gully control (sand bags with vegetative check, brush wood check), etc. **Alternate Land Use systems**: Alley cropping, agri-horticulture, agri-silviculture, silvipastoral systems, tree farming,etc.	**Water harvesting**: Percolation pond, check dam, stop dam, farm pond, recharge of defunct wells, lining of farm ponds, roof water harvesting, etc.

5.7.2 Resource Use Efficiency

The ill effects of poor management of natural resources are a serious threat to food security and livelihood of farmers, especially the poor and marginal among them. Soil and water are natural resources that are essential for sustainable crop production systems (field as well as horticultural crops). Apart from pressure on land, indiscreet use of agro-chemicals & water, non-adherence agro-climate based crop alignment & increasing mono-cropping have had adverse implication on natural resources. The negative impact of climate change is also beginning to be felt in the form of rising temperature and variation in rainfall spread. These do not augur well for the stability of agricultural production environment, and would therefore be needing priority attention by adopting sustainable practices.

5.7.3 Conservation Agriculture (CA)

Alternate & more sustainable practices are being gradually adopted in the tropics/ sub-tropics and temperate regions of the world under both rainfed and irrigated eco-systems. Globally, area under CA is now as high as 124 m ha (8 per cent of the world arable land area). Several studies conducted across the production systems under varied ecologies of South Asia have revealed potential benefits of crop cultivation, following three CA principles as follows:

- Minimum mechanical soil disturbance.
- Permanent organic soil cover with crop residues or cover crops.
- Diversified, efficient and economically viable crop rotations, leading to greater resource conservation, higher use efficiency of inputs, yield enhancement and soil health improvement.

Chapter 6
Nutri-cereals: Institutional & Policy Interventions

This chapter deals with creating a conducive environment for incentivising enhanced demand and the resultant higher production of millets in the country. It analyses the inadequacies in the current system and suggests ways of addressing the same

6.1.1 Generation of Demand for Millets through Value Addition

Generation of higher demand for millets will significantly incentivize the farmers to adopt better technology & management practices, leading to higher yields, production and income returns in dryland areas. Millets are climate resilient crops which can adapt to a range of varying conditions. They can be grown under marginal soil conditions with minimal requirement for irrigation water. But consumption of millets in the country has come down significantly over the decades due to several reasons. Creation of demand for millets is the key and a prerequisite to help farmers get better price in the market for their produce. In creating a millet-led paradigm shift in cereal production, the approach has to be market-centric. This is a learning from the production-led growth practised so far in India compromising the importance of monetization of farmers' produce as a critical incentive. In addition to sale in raw form, value addition measures will improve shelf life as also be available to the consumers in shape & form, that the latter desire. More importantly most millets need primary processing before they can be consumed.

As elaborated in chapter 4, the nutritional value of millets needs to be diffused through strong advocacy and promotional activities across the country. The millets have to be positioned appropriately as health foods. They deserve to be promoted as next generation smart and super foods. Millets are also ecology – benign, and therefore, good for the planet, particularly during times when climate change is posing serious challenges. In sum, millets are good for rainfed farmers who predominantly grow millets, good for the consumers who need low cost nutrition, and good for the planet whose ecological concerns are becoming critical.

A value system model is needed with emphasis on promoting the integration of disconnected value chains, who produce and market the value added products from millets. ICAR-IIMR has taken several steps in this direction by developing and commercialising a number of value added millet-products, namely, jowar atta, jowar rich multigrain atta, jowar pasta, instant pongal mix, jowar vermicelli and so on. IIMR has assessed the impact of model that integrates value chains in reviving the demand for sorghum /millets in the long term through interventions in supply chain management, on farm value addition, processing, product development, nutritional testing, marketing, policy and creation of awareness. The pilot model was scaled up where backward and forward linkages are well established and the impact was visible among various stakeholders in the supply chain, including the farmers. The farmers realized income increases by a ratio of 2-3 times by integrating with the secondary sector. The farmers in consequence were found to have shifted their sorghum cultivation from marginal lands to better endowed lands after realising profits based on four years of experimentation in their fields.

The bouquet of measures to induce the demand for the millets could be:

- Generation of awareness about the nutritional and health benefits of the millets and their products over other traditional foodgrains among the consumers – millets are gluten free & are low in glyacaemic index; are rich in calcium & other nutrients; and high in fibre.
- Consumers need to be educated about the nutri-rich status of millets; ironically biased perception of millets as poor man's food has affected demand for them adversely.
- Millets should be included under PDS, under the purview of National Food Security Act. This will warrant procurement, thereby incentivising farmers to bring both well-endowed and additional land under millets.
- Millets need to be pushed as nutri-cereals and mainstreamed as part of programmes such as Mid-day-meal (MDM), hostels, kitchens, feeding programme under ICDs etc.

6.2 Research and Development (R&D)

It was science that helped release of HYVs and hybrids in rice and wheat, thus laying the foundation for a pole vault in yield levels. Relative to these crops, millets have received much less investments, and attention from the national agricultural research system. It is now time to not just check area reduction (16 millon ha currently) under millets, as also production (currently at 17 million tonnes), but also give a vigorous push to scaling up millets output by adopting the strategy of i) area increase; and ii) productivity increase.

It is possible to do so by bringing focus on R&D activities that will help in increasing yield as also cropping intensity. Some suggestions in this context are as follows:

i. **Identification and development of product-specific cultivars of millets**: basic research for breeding end product specific cultivars is time consuming and not easy to find answers in short terms. Therefore, identification of millet cultivars specific to end products by screening already bred varieties, but either not released or popularized will be important. This will help to not only develop RTC/RTE food products from millets but also giving commercial color to millet cultivation. This was attempted by IIMR on pilot scale successfully, in case of sorghum. This approach will help in harvesting low hanging fruits.

ii. **Development of standards and grades**: is an important aspect in millet cultivation, and this will have a positive impact on demand for the produce. Lack of established standards and grades for millets often cause reluctance among traders to engage in commercial sale-purchase and export transaction. If this issue is address, trade transaction around millets in the open markets will increase, and create price buoyancy.

iii. **Fabrication of primary processing machinery:** for small millets to improve the efficiency of dehulling is important, as their outer seed coat is inedible making it unfit for human consumption. Associated drudgery in primary processing of small millets in particular has caused significant decrease in the consumption of millets in the country. The currently available machinery is of moderate efficiency at 65-80 per cent only. Further, there is no common dehuller suitable for primary processing of all small millets. Entrepreneurs in fabrication need hand-holding through research support, as this is the most critical constraining factor in utilization of small millets in the country. The market price in retail market is Rs 100-120/kg of processed grain, which is sold in supermarkets, while the procurement cost from farmers is around Rs 30-50/kg. Primary processing machinery, results in producing one kg of processed grain from two kg of unhulled grain. Efficiency of processing will reduce consumer cost and enhance producer's share in consumer's rupee.

Primary processing of millets also causes reduction in nutritional quality of grains. hence, it is important to develop and fabricate primary processing machinery to improve dehulling of millets, without causing loss of nutritional content. ICAR institutes such as CIPHET, CIAE, Bhopal and CFTRI in collaboration with IIMR can find a suitable answer to this problem. They can also partner with engineering institutes and organisations in both private and public sector.

iv. **Bio-availability and shelf life enhancement**: such studies would help in increasing the consumers' acceptability vis-à-vis value added products of millets. This will generate larger premium prices for the millets based products. Conducting these studies will also help in branding millets in the country as well as in the international market.

v. **Collaboration:** ICAR-IIMR should collaborate with CFTRI and NIN, Hyderabad for establishing data on bio-availability of nutrients from millets.

vi. **Referral laboratory:** setting up of a nutrition-cum-referral lab at ICAR- IIMR any other appropriate location for validation of all value added products from millets in order to curb misleading/wrong claims on nutrition value is important. This will help in sustaining the creditability of the claim relating to nutritional value of millets, so that demand is not affected in the long run.

6.3 Creation of Integrated Supply Chains: Farmers-Entrepreneurs Linkage

In many parts of the country millet-farmers fail to find steady market for their produce. On the other hand, the emerging entrepreneurs doing business in these crops find it difficult source quality grains on a continuous basis. When both farmers and entrepreneurs integrate their individual value creating activities into a larger collaborative supply chain, there is greater value creation in the integrated system. Thus linking the millets producers with entrepreneurs provides a win-win solution.

The main objective of this intervention should be to increase the producers' share in consumers' rupee paid. The maximum amount of the money paid in the whole millets supply chain must flow into farmers' pockets. This calls for disintermediation by creating robust agri-value systems - integration of value chain entities into supply chain modelled value system (Refer Vol. IV of this Report)

Creation of various innovative supply chain models like direct marketing models, online marketing platforms like e-NAM and direct linkage between producers with entrepreneurs will help in dis-intermediation where no additional service is being provided. Automatically, producer's share in the consumer's rupee will increase.

6.3.1 Markets to link producers with national & international markets

The small farms have proven to be more efficient than large ones in using land and resources, especially in labour-intensive crops or tending livestock, but are unable to generate enough surplus to market their produce their efficiently (Indian Rural Development Report, 2012-13).

Developing robust marketing infrastructure and efficient marketing system are important to enable discovery of competitive prices for millets in the markets. An integrated state and nation-wide market(s) will bring in efficiency and remunerative price discovery. Integration of physically dispersed markets is possible by deploying Information Technology (IT) platform is an important step for boosting the growth of integrated agricultural system in the country.

Further, development of Co-operatives/FPOs including FPCs/Farmer Interest Groups etc. for millet marketing system will significantly enhance the millet producers' bargaining power in the competitive market. Linking the Indian millet farmers with online marketing platforms like e-NAM, will be successful in creating a national network, and will therefore help them in realising better prices for their produce.

6.3.2 Development of millets sub-sector

The farmers' income in the dryland India can be significantly enhanced through development and promotion of millet sub-sectors. Sorghum and other millets have many alternate uses that can expand the horizon of business.

- **Development of Fodder Value Chain**: The availability of nutri-rich fodders is inadequate in India. Sorghum and other millets are good source of fodders and there is good business scope that can generate additional farmers' income. Sorghum varieties, CSV 32F and SSG 226 are major fodder yielding varieties released by IIMR. Nutri-rich millet fodder can be successfully integrated with existing millet supply chain models to contribute in enhancing farmers' income.
- **Industrial Uses of Sorghum and Millets**: There are several alternate uses that sorghum can be put to. These include starch, alcohol, malting, feed and bio-fuel etc. Development of by-product sub-sector from millets will help the blackened millet grains to be used gainfully. This is good for the farmers who will benefit from *kharif* sorghum grains that become unusable for food consumption due to mould formation. Upscaling the value addition protocols through pilot studies for use of *kharif* grain in non-food sector, particularly feed, starch production and potable or industrial alcohol; and sweet stalked sorghum in the production of syrup and ethanol will add to the farmers' income substantively. Exploring various industrial uses of sorghum and other millets especially

as bio-fuel production will enhance the potential of the crop, as a source of additional incomes.

6.4 Policy Interventions

6.4.1 Price and Procurement Policy

The price realised for millets can be a powerful signal in triggering higher area coverage and investments by farmers to realize higher yields per unit of land. Major millets like jowar, bajra and ragi are covered under the Minimum Support Scheme (MSP) of Government of India. MSP fixed for 2016-17 for jowar, bajra and ragi witnessed an increase of 65, 35 and 64 per cents respectively over the year 2011-12. State Governments and their agencies should step up to extend the benefit of MSP to the farmers by undertaking procurement, whenever prices in the market fall below MSP. As yet, there is no provision of MSP for the small millets, which if adopted will incentivize the farmers and benefit less endowed cultivation area. The Union Budget, 2018 commits the government to providing a minimum MSP of 1.5 times the cost of production. Millets will stand to benefit from adoption of this.

Procurement policy: The current procurement policy of the country has also contributed towards the reduction in consumption of millets. Millets are categorized along with maize in the group of coarse cereals under NFSM (National Food Security Mission). The procurement policy of the government of coarse cereals has mostly revolved around maize, ignoring the millets significantly. This needs to be corrected, and a promotional policy of MSP notification and procurement needs to be adopted for millets including small millets.

Contract farming: Contract farming so far largely explored in the field of vegetable cultivation has proven to be effective in addressing unpredictable market situation. Contract farming, when promoted with all necessary safeguards can ensure steady flow of income for the farmers because there is a pre-agreed price between the farmers and sponsoring company for the future delivery of produce by the farmers.

The scope of contract farming must be explored with regard to millets (with particular emphasis on small millets). Small millets are not covered under MSP and hence farmers suffer from price insecurity. Contract farming model can provide price security to the millet farmers including those growing small millets. Contract farming is more likely to be attractive, if the scope for value addition and processing is wider.

The Government's proposed Model Contract Farming Act will provide the much needed framework to adapt it to millets too.

6.4.2 Federating millets farmers as Farmer Producer Organizations (FPOs*)*

National Bank for Agriculture & Rural Development (NABARD), defines a Producer Organisation (PO) as a legal entity formed by primary producers, viz. farmers, milk producers, fishermen, weavers, rural artisans, craftsmen. A PO can be a company, a cooperative society or any other legal form which provides which provides for sharing of profits/benefits among the members.. PO is a generic name for an organisation of producers of any produce, e.g., agricultural, non-farm products, artisan products, etc.

Farmers Producer Organisation (FPO) is one type of PO where the members are farmers. These organisations will help the millet farmers to organise and enhance productivity through efficient, cost-effective and sustainable resource use and fetch higher returns. Formation of FPOs will also help to increase the bargaining power of the farmer-producers through collective farming and marketing.

The problem of middlemen in the agricultural supply chain can also be eliminated, and thereby, increasing the producers' share in consumers rupee. Supply of location-specific inputs, providing timely training programmes and direct procurement of the produce can be effectively managed through these organisations. Through aggregation, the primary producers can avail the benefit of economies of scale. The essential features of an FPO are:

- It is formed by a group of producers for either farm or non-farm activities.
- It is a registered body and a legal entity.
- Producers are shareholders in the organization.
- It deals with business activities related to the primary produce/product.
- It works for the benefit of the member producers.
- A part of the profit is shared amongst the producers.
- Rest of the surplus is added to its owned fund (corpus fund) for business expansion.

There is lot of value creation by mobilizing millet farmers into FPOs and expanding their economic activities so as to integrate with the larger value system. To harvest advantages of FPO federations at production and post-production stages, linkages between millet and pulse FPO can be brought about. ICAR-IIMR and NIN, Hyderabad can provide technical backstopping support to these FPOs for expanding their own value chain by taking up added activities, such as farm-gate level value addition through custom hiring of processing technologies, as well as in crop production technologies for higher productivity.

- Farm gate level value addition to the millets with technical backstopping from IIMR will significantly add to the nutritional profile of the locally produced value added products. FPOs can play an efficient role in establishing district level nutrition clusters around millets, incorporating other rainfed crops like pulses to the nutrition plate.

- The start-up entrepreneurs can be linked with the FPOs for creation of innovative supply chain models including development of value added products. This will create a steady market for the millets and other nutri-rich cereals. These entrepreneurs can be backstopped with value added products and process technologies developed at IIMR. These measures will enhance the farmers' capture a larger share in consumer rupee

Therefore, it is imperative that Governments policy should focus on:

- Support for creation of millet FPOs.

- Provision of small ware housing for storage for clusters after creating FPOs.
- A more rational GST for millet products.

The strategy is to not only for encouraging of FPO formation in nutri-cereals sector but also to incentivise them to play a larger role in value addition and and transfer higher returns on the produce to the millet farmers.

6.4.3 Facilitating assured institutional credit and farm insurance

Small lots of production from fragmented land holdings disable farmers from generating enough funds to reinvest in agricultural activities. Therefore, it is very essential to lend financial support to the millet-farmers to meet their credit needs. This will also prevent dependence of the farmers on private money lenders who charge exorbitant rate of interest.

Providing insurance coverage to the millet-farmers is also very much essential since they are dependent on weather conditions that impart vulnerability to production. Providing crop insurance will de-risk the millet- farmers against financial loss arising from weather truancy.

The states must emphasize on bringing millet areas under the coverage of crop insurance to provide financial security to the farmers. Both loanee and non-loanee millet cultivations should be covered.

Already existing government schemes like interest subvention scheme (ISS) for institutional credit and PMFBY (Pradhan Mantri Fasal Bima Yojana) for crop insurance should be taken advantage of by the field Extension functionaries to pay special attention to millet-farmers, who cultivate mostly on marginal lands. It would also be useful to examine the scale of finance for millets, so that it is realistic and promote higher investments.

Table 6.1: Crop-wise insurance coverage under all schemes in India during 2014-15

Crops	2014-15		
	Gross sown area	Area Insured	Insurance coverage (%)
Paddy	42.8	10.0	23.4
Wheat	30.5	7.7	25.4
Coarse grains	25.2	6.0	22.9
Sugarcane	5.4	0.2	2.7
Cotton	11.9	1.5	12.9
Jute and Mesta	0.9	0.1	8.2
Oilseeds	29.1	10.4	35.8
Pulses	22.0	5.8	26.3
Vegetables	5.5	2.1	38.0
Fruits	3.8	0.2	5.6
Total	194.4	45.3	23.3

Source: State of Indian Agriculture, 2015

6.4.4 Special Agribusiness Zones (SABZ) for millets

Development of millets sector needs special focus. Scattered and low volume nature of production of millets (small millets in particular) is one of the marketing challenges that needs to be addressed.

Development of Special Agribusiness Zones (SABZ) for millets can address this issue. These SABZs will focus on development of particular millets which is popularly cultivated in the local areas. Various SABZs can be developed across the country based on locational strengths. These include SABZ for sorghum in Telangana, SABZ for finger millet in Karnataka, SABZ for pearl millet in Gujarat, and SABZ for small millets in Madhya Pradesh. These SABZs can develop around FPOs, farm gate level primary processing facilities, ware housing units and value added food products.

The start-up entrepreneurs can be linked with the FPOs for creation of innovative models for development of value added products. This will create a steady market for the millets and other nutri-rich cereals. These entrepreneurs can be backstopped with the value addition and process technologies developed at IIMR which in turn will enhance the farmers' share in consumer's rupee. The SABZs will serve as promotional hubs for realizing export potential of value added products from millets.

6.4.5 Promoting Organic Millets

Organic cultivation which relies more on natural resources for management of soil nutrients and crop cultivation is aptly suited for rainfed areas. Millets are generally grown in such areas, implying that organic millets can be raised to the mutual benefit of each other. With increasing health consciousness amongst the consumers across the globe, demand for organic food produce is on the rise. The consumers would be very happy to purchase organically grown millets, which in a way would benefit them twice over.

As already discussed, millets are nutritionally rich and when grown organically they would be toxic free (these are the two basic attributes that health conscious consumers are constantly seeking). Since the average yields and income from millets are relatively lower than the other crops like wheat & paddy, it would be necessary to brand millets including the organically grown ones, as nutritionally rich super-foods, so as to fetch premium price in the market.

6.4.6 Exploring international trade opportunities

Agriculture sector at the macro-level produces exportable surpluses too. During 2014-15, agricultural exports were of the order of Rs.2,29,996 crore, as compared to Rs.1,22,188 crore of agricultural import bill realizing thereby a net trade surplus for the country. However, the exports are not as yet broad based. However the gap between imports and exports has been closing in the recent years, emphasizing the need for aggressive agri-exports.

The government now realizes the importance of expanding the horizon of marketing to global level. Therefore, there is consensus of adopting a favourable export policy for agri-products and raise the exports from the current US 30 Bn $ to 100 Bn $ by 2022. In this context, millets also need to be placed appropriately on the agri-export platform. The following need to be noted:

- The export of Indian millets has not been upto the mark as compared to other cereal grains. The small volume of millets that is being exported from India is in the form of millets grains.
- It is important to explore the potential of export market of millets. This will help the farmers in receiving global competitive prices for millets.

The export opportunities of millets can be enhanced by working on the following:

i. Most important factor that reduces the competitiveness of the millet grains in the international market is its quality. Release of pest and disease resistant varieties could effectively address this problem. Besides this, farmers need to be educated about quality concerns at all stages of production and harvesting.
ii. Co-operative or collective cultivation of the millets will help in reducing the cost of cultivation and improve the bargaining power of the farmers. FPOs can foot the bill.
iii. Value addition to the millet grains is the most effective way to improve export competitiveness.
iv. Providing incentives to millets growers, as also processing and value addition enterprises, facilitating exports.
v. Provide tax benefits to value added products to generate demand and area expansion.
vi. Integrate millets into agri-value systems, so that organized supply chains are possible and agri-logistic concerns are addressed.

6.5 Policy Recommendations

Dubbed as a poor man's food and with little investment in value added processing, currently millets growers face several challenges in realizing optimal returns for their investment. This perception is slowly changing with the growing recognition of health and environmental advantages of millets. Millets need to be promoted not only as eco-friendly and rainfed compliant crops, but also as nutri-rich commodities. As of now, rice and wheat are the principle components of the PDS under NFSA, and these two commodities are more easily available in the country due to high production & procurement.

It is now time to include millets under the PDS which will then warrant procurement, and thereby serve as an incentive to the farmers to produce more. A demand of this nature would automatically lead to bringing higher extent of cultivable area under millets.

A larger share of millets in the foodgrain basket of the country would result in releasing a certain percentage of land now under paddy & wheat (by reducing the pressure for higher production) making it available for high value crops like horticulture and high value activities like dairying and livestock. The need of the hour is to achieve re-arrangement of the cultivable land under crops and commodities, that will help generate higher farm incomes to the farmers without compromising the food and nutritional security of the country.

Millets and pulses, which are highly amenable to cultivation under rainfed conditions, particularly when protective irrigation can be provided are suitable candidates in diversifying the Indian food basket, and consequently support the desired aim of new crop geometry and product matrix.

Although, demand for millets has been declining throughout the years, this is more due to circumstantial factors than a cognizant choice. Major reason for this is the lack of interest suffered by the millets at policy formulation level, which never received the same developmental attention as other cereals like rice and wheat.

The first national all-inclusive scheme for millet development is the Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP), introduced in 2011 under the "Rashtriya Krishi Vikas Yojana" (RKVY). It has been planned as an integrated scheme by combining different policy components like demonstration, inputs, seed, post-harvest technology, awareness raising, capacity building and research. The scheme covers all states and union territories and targets all millets (sorghum, pearl millet, finger millet and five other small millets).

The primary aim of the INSIMP scheme is to catalyse the production of millets in the country and while doing so, it also aims to enhance India's nutritional security. The districts with large crop size under millets (more than 10,000 ha area under sorghum & pearl millet, or more than 5,000 ha under finger millet or more than 2,000 ha area under small millets, namely, barnyard, kodo, kutki, foxtail and proso) but with yield less than that of the National Average Yield (NAY) could be taken up for active promotion of production technologies through block demonstrations. But there is lot of variation across different states on how they utilize these opportunities for promoting millets.

Also, most of these states usually focus on sorghum, pearl millet and finger millet and leave out most of the small millets while executing these schemes. Obviously, there is intra-millet discrimination a la intra-cereal discrimination, to the disadvantage of millets as a class. It is time, this blunder is corrected in the larger interest of dryland agriculture and dryland farmer, as also the consumers of the country.

It emerges, that triggering and sustaining higher level of millet production demands creation of a supportive market for millets and millet products. Obviously, the strategy needed is 'fork to farm' approach. Market-facilitation linked to winning the consumers back to millet diet is best done by engaging multiple and varied stakeholder like the Doctors, Chefs, Nutritionists and the like for speaking on the advantage and possibility of using millets in one's diet.

The larger market creation will also need promoting the non-food scope of millets. Such broad advocacy will need multi-locational road shows for advocacy and education. Once the initial interest is generated, it has to be sustained by the system's ability to meet the demand through adequacy of supply. The implication is that the policy makers and implementing agencies need to adopt a fine balance of simultaneous promotion of demand generation and supply adequacy.

The Ministry's decision to celebrate the year 2018 as the 'Year of the Millets' will provide the much needed platform to position millets appropriately.

6.6 Annotation

Millets used to be the major staple food in several parts of India till the time of green revolution. With the advent of high-yielding varieties of rice and wheat, millets got sidestepped and came to be replaced on the food plates. The government's push for rice and wheat under the subsidized public distribution system left the consumers with a Hobson's choice and the farmers with no choice

Millets, preferably to be called nutri-cereals in cognizance of their higher nutrition value are as a group, most appropriate for cultivation in rainfed and other less endowed.

If 1960s responded to the crisis of food by adopting paddy and wheat as the saviours, the stimulus of climate change challenge of the current millennium can probably be negotiated by inviting climate-resilient millets into the production agenda.

Given the adverse impact of climate change, millets are crops that deserve to be adopted more vigorously. While R & D will help in the long run, there is scope to achieve higher yields in the short by adopting improved agronomic practices.

The approach to yield increases can be linked to bridging yield gaps between the levels realised under situations of FLDs and farmers' fields. One of the most important requirement would be promoting processing facility at the farm gate, as millets mostly cannot be consumed without it. It would help to adopt 'fork to farm' approach, that is, create a demand for millets & millet products.

It is possible to create demand by advocating the nutritive values of millets among the consumers. In addition to promoting them as food crops, their relevance in industrial sector (agro-processing) needs emphasis.

Major Extracts

- It is possible to realise a total nutri-cereals output of 31.74 M. tonnes by 2022-23, based on increases in productivity and area. The principle approach has to bridging yield gaps vis-a-vis FLDs.
- The cost of cultivation of millets can be reduced by adoption of recommended package of practices and increased resource use efficiency, technological upgradation and adoption of water saving technologies.
- Resource use efficiency on the other hand can be increased by adopting conservation agriculture and blending indigenous and modern technologies of millets cultivation. Adoption of integrated farming system models with inclusion of millets for cultivation in post-kharif rice fallows will increase cropping intensity in dryland agriculture.
- Value addition for demand creation can contribute upto 30 per cent of additional income required for doubling millets farmers' income by 2022. Demand for millets and value added products can be done through various policy advocacies including price support.
- Development of product-specific varieties, creation of farm level grading and standards, fabrication of primary processing machinery and conducting bio-availability and shelf-life studies will create demand for millets in the country. Setting up of nutrition-cum-referral labs on nutrition will significantly contribute towards "branding of millets" in the country.
- Addition of nutri-rich fodder in the millets value system and other millets subsector development will significantly help in doubling the farmers' income.
- Federating the millets farmers into FPOs will increase the bargaining capacity of millets farmers. These FPOS need to be supplemented with provision for farm gate level processing of millets with technological backstopping from institutes like IIMR. The start-up entrepreneurs can be linked with FPOs for creation of innovative supply chain model resulting in remunerative prices to the millets farmers.
- The policies should aim at creation of FPOs with regard to millets with provision of small warehousing and farm gate processing facilities for incentivising them to benefit from integrating with the supply chain.
- Contract farming can be promoted under millets sector in the dryland parts of the country to provide price security to the farmers. This will also ensure timely and systematic supply of quality millets grains in the market.
- Formulation of steady price policies, expanding the coverage of small millets under MSP, more procurement of millets through MSP and providing insurance coverage to all the nutri-cereal crop enterprises. Improvement in the terms of trade (ToT) of agriculture, extending credit and insurance support to the farmers and providing tax exemption to the millets farmers and entrepreneurs will boost the millet farmers' income in the coming years.

Chapter 7
Pulses

This Chapter presents an insight into national scenario of pulses and highlights the need for and approach to achieving self-sufficiency for the country. Further, in depth analysis of various constraints related to low productivity viz. technological, agronomical, infrastructural has been carried out and broad strategies for enhancing the production, primarily through productivity has been recommended. Besides, strategic interventions required on priority basis to meet the DFI objective within the stipulated time have been outlined

7.1 Current status

In the global context, India occupies the first and the foremost position in area and production. In respect of acreage, India is followed by Myanmar and Brazil (4 per cent each); and China and Canada (3 per cent each). In terms of production, next to India, it is Canada (8 per cent) followed by Myanmar and China (6 per cent each) and Brazil (4 per cent). However, in terms of productivity Canada (2030 kg/ha) ranks first followed by USA ((1943 kg/ha) and China (1550 kg/ha). Among different pulses, dry bean occupies the largest in terms of area (36 per cent) and production (34 per cent) globally followed by chickpea (16 & 18 per cent respectively) and dry peas and pigeonpea.

India is the world's largest producer of pulses with 22.95 million tonnes from an acreage of 29.46 million hectares with a productivity of 779 kg/ha (2016-17). The country accounts for 35 per cent global area and 27 per cent of global production (ICAR, 2016). Pulses are commonly grown under rainfed condition all over India (87 per cent rainfed) during two principal seasons of the year, namely, kharif rainy season: pigeonpea (*Cajanza cajan* L. Millsp), cowpea, mungbean (green gram) and urdbean (black gram); and rabi season (winter-spring): chickpea, lentil, fieldpea and rajmash. Pulses are also grown during spring or summer (mungbean and urdbean) in some of the regions.

In India, over a dozen of pulse crops are raised of which few are more prominent in terms of area coverage. These include chickpea (46 per cent), pigeonpea (16 per cent), mungbean (10 per cent), urdbean (10 per cent) and lentil (6 per cent). As these are generally grown in rainfed areas under poor management condition and face various kinds of biotic and abiotic stresses, both productivity and overall production are yet to reach desirable levels. Besides this, nutrient deficient soils, unfavourable weather unavailability of quality seeds, socio-economic limitations, improper and inadequate post-harvest handling & storage and insufficient market support are the major constraints in realizing the full potential of production/productivity gains in case of these pulses.

It is however not to say, that there has been no improvement. There have been impressive technological backups field surveys show that in recent years, a number of improved varieties of pulses have been released for cultivation altering the seed replacement rate by improved strains in India. In addition, improved water and other input management are helping some gain in production and productivity of pulses.

Pulses are important vegetable protein sources in India. As per ICMR recommendation, every person should consume 52 gm of pulses daily for meeting his protein requirement. The split grains of the seeds of pulses are called *dal* (soup*)* and are excellent source of high quality protein, essential amino and fatty acids, fibres, minerals and vitamins. India is the largest consumer of pulses.

These crops have an inherent potential in improving soil fertility through biological N fixation (BNF) by its root nodules, thereby enhancing soil N status, long-term soil fertility and sustainability of the cropping systems. Most of the nitrogen requirement of pulses is met from BNF from air and the rest is left behind in the form of residual N and soil organic matter (SOM) for use by subsequent crops in rotation. The input needs of these pulses are also meager. For example, in respect of water it is about one-fifth of the requirement of cereals. Thus pulses play a key role in nutritional security of the people, soil amelioration and sustainable crop production.

Within the group of pulses, chickpea and pigeonpea are the two major ones grown in India during r*abi* and k*harif season* respectively. India dominates in the global chickpea market as it has the distinction of being globally the largest producer, consumer and importer of chickpea and accounts for nearly two-third of global output.

Amongst the states, Madhya Pradesh (5.88 m ha) followed by Rajsthan (3.87m/ha) and Maharastra (3.54m.ha) accounts for the largest area and production of chickpea. The States of Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka and Gujarat together contribute around 90 per cent of the production from 85 per cent of area. This crop has contributed maximum to pulse production and productivity in recent years, because of several factors that include expansion of its area in dry regions of central and peninsular India, and development of short duration, wilt resistant and high yielding varieties (JG 11, Saki 9516, Jaki 9218 and Vijay etc.) besides matching production technologies.

Pulse requirement in the country is projected at 32 million tonnes by the year 2030 and 39 million tonnes by the year 2050 based on an annual growth rate of 2.2 per cent. This needs a holistic approach comprising area expansion and productivity enhcnement. Area increase can come from increasing cropping intensity like using post-karif rice fallows. Productivity appreciations in the short run can come from improved agronomic practices including use of quality seeds; and in the long run from R&D based better varieties. However, policy support inclufing good MSPs supported by robust procurement operations and favourable EXIM will be critical to incentivise the farmers.

Based on three yardstick of per capita availability of land, population growth rate and technological innovations, projections for productivity show that it has to be scaled up by an average of about 80 kg/ha at an interval of 5 years to achieve average pulse yield of 950 kg/ha by 2025 and 1335 kg/ha by 2050, along with expanding the cultivation area by about 3-4 million ha. Significant progress has been made at local level to supply seeds of improved pulse varieties through release/notification programmes in the country in the recent years. Marker assisted breeding and development and utilization of genomic tools have also been given due importance, to develop multiple disease-resistant cultivars. Amalgamated with these are matching package of practices which can enhance productivity and production.

Foodgrains cover almost 62 per cent of total gross cropped area comprising 51 per cent under cereals and11 per cent under pulses in India. Further, the area under pulses breaks into 4, 2 and 5 per cents respectively under gram, arhar and other pulses (Table 7.1) The net irrigated area in the country is 47 per cent while the remaining falls under rainfed ecology. The pulse cultivation under irrigation is about 13 per cent, and that under rainfed conditions counts at 87 per cent. Top six pulses grown in India are chickpeas (chana), pigeonpea (arhar/tur dal), urad beans (urad dal), mung beans (moong), lentils (masoor) and peas. The share of pulses as a good component of total area and production under foodgrains is about 20 & 7 per cents respectively.

Table 7.1 Percentage share of total pulses to total foodgrains ***(Area: lakh ha; Prod: lakh tonnes)***

Year	Total Food grains		Total Pulses		Pulses (% Share)	
	Area	Production	Area	Production	Area	Production
2011-12	1247.55	2592.86	244.62	170.89	19.61	6.59
2012-13	1207.71	2571.35	232.57	183.42	19.26	7.13
2013-14	1250.47	2650.45	252.18	192.55	20.17	7.26
2014-15	1242.99	2520.23	235.53	171.52	18.95	6.81
2015-16	1232.17	2515.66	249.11	163.48	20.22	6.50

Source: Annual Report2016-17, DPD, Bhopal/DES, DAC&FW, GOI.

The status of total area, production and productivity in 10 major states, contributing to approx. 90 per cent of area and production, namely Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, Andhra Pradesh, Gujarat, Chhattisgarh, Jharkhand and Tamil Nadu, is shown in table 7.2. The information about various pulses across different states in terms of area, production and yield during the seasons of rabi and kharif is in Annexure.

Table 7.2 National status of pulses (Area: lakh ha; Production: lakh tones; Yield: kg/ha)

State	Area	% cont.	Prod.	% cont.	Yield	YI
MP	54.56	22.47	48.20	27.33	883	122
Maharashtra	34.91	14.38	22.68	12.86	650	90
Rajasthan	38.26	15.76	21.64	12.27	566	78
UP	22.65	9.33	18.07	10.25	798	110
Karnataka	24.41	10.05	13.05	7.40	534	74
AP	12.50	5.15	10.61	6.02	849	117
Gujarat	7.21	2.97	6.40	3.63	887	122
CG	8.66	3.57	5.77	3.27	666	92
Jharkhand	5.62	2.31	5.45	3.09	970	134
TN	7.51	3.09	5.00	2.84	666	92
Other	26.51	10.92	19.50	11.06	736	101
All India	**242.80**		**176.37**		**726**	
Kharif Pulses ***(Area: lakh ha; Production: lakh tones; Yield: kg/ha)***						
State	**Area**	**% cont.**	**Prod.**	**% cont.**	**Yield**	**YI**
Maharashtra	19.73	18.75	11.94	20.47	605	109
Rajasthan	24.03	22.84	9.56	16.39	398	72
Madhya Pradesh	13.82	13.13	7.96	13.66	576	104

State	Area	% cont.	Prod.	% cont.	Yield	YI
Karnataka	12.80	12.16	6.10	10.47	477	86
Uttar Pradesh	8.60	8.17	5.68	9.74	660	119
Gujarat	4.67	4.44	3.73	6.40	799	144
Jharkhand	3.25	3.09	2.87	4.93	883	159
Odisha	4.53	4.30	2.36	4.04	521	94
Telangana	4.06	3.86	1.99	3.42	490	88
Tamil Nadu	2.22	2.11	1.49	2.56	671	121
Other	7.54	7.16	4.62	7.92	613	111
All India	**105.25**		**58.30**		**554**	
Rabi Pulses *(Area: lakh ha; Production: lakh tones; Yield: kg/ha)*						
Madhya Pradesh	51.02	22.38	43.39	25.78	850	115
Maharashtra	32.47	14.24	22.78	13.53	702	95
Rajasthan	35.09	15.39	21.66	12.87	617	84
Uttar Pradesh	21.46	9.41	17.84	10.60	831	113
Karnataka	22.84	10.02	13.20	7.84	578	78
Andhra Pradesh	12.10	5.31	10.11	6.01	836	113
Gujarat	6.82	2.99	5.96	3.54	874	118
Chhattisgarh	8.30	3.64	5.57	3.31	671	91
Bihar	5.29	2.32	4.96	2.94	938	127
Jharkhand	4.84	2.12	4.66	2.77	963	130
Other	27.75	12.17	18.22	10.82	657	89
All India	**227.98**		**168.35**		**738**	

Source: DFI Committee Estimates based on data compiled from DACNET. Avg- 2011-12 to 2015-16

Despite steady increase in India's pulse production, India has emerged as the world's largest importer of pulses since the onset of the 21st century. Earlier, the country was exporting, albeit, a small quantity, as the country was hungrier for calories than proteins, with a large population below the poverty line. In the new millennium, the share of India's import of pulses as a share of world pulse trade increased phenomenally from a mere 4.82 per cent in 2000 to 26.41 per cent in 2011. India's aggregate imports increased from just 0.25 million tonnes in 2000-01 to 5.79 million tonnes in 2012-2013 reflecting an annual average growth rate of about 25 per cent over the last 15 years. With the rising incomes, and fall in the poverty ratio combined with greater health consciousness, the demand for pulses has run ahead of production. The pattern of imports is largely determined by the domestic production of different pulses, and the availability of specific pulses in the export markets.

India mainly imports peas, chickpeas (channa), urad and lentils (masur), which together presently account for almost 95 per cent of the total value of imports of pulses (Table 7.3). Among these, peas and lentil alone account for as much as 60 per cent of the total imports. Pigeon pea has, of late, emerged as another important pulse import.

Table 7.3: Percentage value share of major pulses in total import values of pulses

Commodity	2001	TE 2010	TE 2016
Pea (Pisum Sativum)	38.12	33.71	30.33
Lentil (masur)	25.45	32.15	31.02
Chickpea (channa)	27.53	16.30	15.85
Moong/urad	8.91	17.83	16.31
Pigeon peas (tur)	0	0	6.49

Source: DFI Committee Estimates

Considering the expected population and income growths in the coming years, India's domestic demand for pulses may reach around 25 million tonnes by 2022. This warrants total focus on productivity gains, besides bringing additional area under pulses.

Imports of pulses were being permitted at zero duty since 2006 to meet domestic demand. Following the DFI vision, the country has shifted its approach from import-led consumer satisfaction to achieving domestic self-sufficiency of production. The interventions of the Ministry led to a leap frog in output from 16.62 million tonnes in 2015-16 (base year of DFI) to 22.95 million tonnes by led of 2016-17. This currently combined with normal imports resulted in market crash. Responding to muted market environment, union government, has begun to revisit the import-export duty structure to protect the interests of farmers. It began intervention with a 10 per cent import duty on pigeon pea (tur) in March, 2017 as prices of pulses fell below the minimum support price (MSP) across key producing states. Following up on a string of pro-farmer trade policy decisions, the Government recently imposed a 30 per cent import duty on *chana* (gram) and *masur* (red lentil) to support domestic growers in expectation of high production in forthcoming rabi season (2017-18).

Table 7.4 Current import duties of major pulses

Commodity	Tariff Schedule		
	Bound Duty	Statutory Duty	Applied Duty
Peas (*Pisum Sativum*)	50%	50%	Nil
Chickpeas (channa)	100%	30%	30%
Moong/urad	100%	30%	Nil
Lentil (masur)	100%	30%	30%
Pigeon peas (tur)	100%	30%	10%*

Source: DFI Committee Estimates based on data compiled from DACNET

* Department of Revenue vide Notification No. 10/2017-Customs dated 28th March, 2017 has imposed 10% import duty on Tur (Arhar). The import duty on remaining pulses is still 'Nil' i.e. 0%.

7.2 Reasons for low productivity[2]

7.2.1 Technological constraints

The production of pulses in India is distinguished by a high degree of diversity as indicated both by the number of crops, and their spatial distribution across varied agro-climatic conditions (soil types, rainfall and thermal regime). In most of the cases, a single state or few states account(s) for the bulk of the area and production of a given pulse crop. Hence, there cannot be a single national policy for scaling up pulse production in the country, and what is needed is regional and crop-specific strategies. The region-specific production technology will need to include crop varieties with traits relevant to prevailing biotic and abiotic stresses. Also, region and agro-climate specificity for them to be effective. R&D, policy and farm machinery have to be attuned accordingly. For example, non- availability of a dependable ridge planter

[2] Drawn from Report of Expert Group on Pulses, Department of Agriculture & Co-operation Government of India, Ministry of Agriculture, 2009

for kharif pulses in black soil region is impacting farming operations to a large extent resulting in low productivity.

7.2.2 Climatic factors

The pulses are mainly grown under rainfed conditions except for in few districts of Karnataka, Uttar Pradesh, Madhya Pradesh, Rajasthan and Bihar. Below normal monsoon and lack of protective irrigation affect adversely the output of pulses. Thus both area under pulses and productivity in any given year are largely dependent upon the amount and distribution of rainfall in that specific year. Both kharif and rabi pulse crops are vulnerable to the quantum & distribution of rainfall. While excess rainfall causing water logging render kharif pulses vulnerable, in case of rabi pulses the vulnerability is caused by water stress. Cold waves or on the contrary unexpected rise in temperature during winter season also lower crop productivity of rabi pulses.

7.2.3 Soil related constraints

Major soil related problem is salinity and alkalinity. Pulse crops usually are very sensitive to saline, acidic and alkaline soil conditions. Salinity and alkalinity are high in both semi-arid tropics and irrigated areas of Indo-Gangetic plains (IGP). The north-west region consists of areas with high soil pH and eastern and north eastern states suffer from chronically acidic soils. Deficiency of secondary nutrient (sulphur) and micro-nutrients, especially boron, molybdenum and zinc is widespread among pulse growing regions further building a challenge. The region characterized by deep black cotton soils in the States of Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, and Tamil Nadu get inundated during kharif season, serious by damaging pigeonpea, urdbean and mungbean. On the other hand, shallow and coarse textured soils in northern and western states have low water retention capacity, requiring protective irrigation for a good rabi pulse crop.

7.2.4 Input quality and availability related constraints

The availability of nitrogenous fertilizers iin the country has improved after introduction of hundred per cent neem coated area since 2015-16. However, at farm level, pulses are not paid due attention vis-à-vis the principle cereals. This is easily correctible, if farmers become more aware and appreciate that pulses as leguminons crops are nitrogen-fixers and need only small supplementation, mostly relating to phosphate & potassium. It is now important to educate the farmers about the importance of adhering to the nutrient management recommendations of soil sample test based soil health cards, with reference to major, secondary & micro-nutrients, besides soil amendments. The latter are very critical in the context of salinity & alkalinity of soils. Since pulses are consistently subjected to abiotic stresses which results in sub-optimal nutrient uptake, farmers tend to use low doses of fertilizer nutrients.

The universal soil health card once at an interval of 2 years, now operational across the country is expected to provide the farmer access to soil nutrient status, and if used well, the soil health even in pulse growing areas will stand to benefit.

7.2.5 Pests and diseases

Pulses are highly vulnerable to pests & diseases. There are more than 250 insect species which affect pulse prodcution in India. Around one dozen of them cause heavy crop losses. An estimate suggests that 2-2.4 million tonnes of pulses valued at nearly Rs 6,000 crore are lost annually due to ravages of insect pest (R. R. Reddy, 2009). Moreover, pests during storage also cause heavy damage to pulses. Pod-borer in chickpea and pigeon-pea has been a major cause of concern.The infestation if not controlled in time can destroy the crop completely.Pulses are prone to many other insect pests and seed borne diseases. Mungbean and urd crops are often damaged by yellow mosaic virus and powdery mildew. Fusarium wilt is wide spread in chickpea, pigeon-pea and lentil growing regions, whereas occurence of podfly and maruca results in serious damage to pigeonpea.

7.2.6 Infrastructural constraints

The rainfall received during the maturity stage of kharif pulses, causes losses in yields and grain quality, particularly when farmers do not have permanent and covered threshing floor. Farmers also lack awareness and means for safe storage of grain/seed of pulses. Post-harvest losses account for 9.5 per cent of total pulse production. Among post-harvest operations, storage is responsible for maximum loss (7.5 per cent) (R. R. Reddy, 2009). Improved road connectively and existence of warehouses in close proximity will help in reducing losses and benefitting from better prices. This will serve to incentivise farmers practising pulse cultivation.

7.2.7 Loss from blue bull damages

Blue bull causes substantial damage to standing crops in the Indo-Gangetic Plains. Farmers primarily in the states of Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan and Chhattisgarh leave fallow the potential area suitable for taking pulses crops because of this. Lack of viable strategy in controlling this challenge is only compounding the problem.

7.3 Broad Strategy for Increasing Production and Productivity of pulses

The average yield for all the pulses as a group has risen from 578 kg/ha in 1990-91 to 652 kg/ha in 2015-16 and 2016-17 was the year that saw a pole vault in total pulse production. However, Indian yield averages do not compare favourably with France, Canada, USA, Russia and China, other pulse producing countries while productivity is a concern, but highlights simultaneously the scope that exists for scaling up the productivity and record high level of production. The interventions to scaling up and consolidating the production are discussed in the following sections.

7.3.1 Utilization of potential area of rice-fallow lands

Rice fallows are widely distributed in rainfed ecosystems of eastern, central and peninsular India, besides north-eastern hill region. The estimated extent of post-harvest rice fallows is about 12 mha, mostly in the eastern states of the country. The potential horizontal expansion under post-kharif rice fallow area to be cultivated during rabi has been delineated by National Crop Forecast Centre (NCFC), now also a part of Targeted Rice fallow Area (TRFA-RKVY programme). About 30-40 per cent of the area currently left fallow after paddy harvest can be converted into productive farm lands. These exists scope to bring about 3.0 million ha of additional land under pulses and 1.0 million ha under oilseeds with appropriate policy interventions. The distribution of rice fallows, potential districts and area are presented in Table 7.5 (a to c). A new sub-scheme '***Targeting Rice Fallow Area***' under Bringing Green Revolution to Eastern India (BGREI) has been rolled out by the Ministry in six (6) states with effect from 2016-17. It is aimed to promote pulses and oilseeds and the annual allocation is Rs. 200 crore under RKVY. Of this, the central share is Rs. 130 crore. This is to supplement the budgetary allocations under NFSI and NMOOP.

Table 7.5 Targeting post-kharif rice fallows for pulses

(a) Distribution of Rice Fallows

States	Major Districts
Andhra Pradesh	Krishna, Guntur, East Godavari, West Godavari, Srikakulum, Nellore and Prakasam
Assam	Lakhimpur, Jorhat, Sibsagar, Dibrugarh, Golaghat, Karbi, Nagaon and Maringon
Bihar	Kisanganj, Sahibganj, Gaya, Aurangabad, Katihar and Bhagalpur
Chhattisgarh	Surguja, Jashpur, Raigarh, Durg, Bilaspur and Bastar
Jharkhand	Ranchi, Purbi Singhbhum, Paschim Singbhum, Hazaribagh, Gumala Sahibganj, Deogarh, Palamau, Dumka and Dhanbad
Maharashtra	Dhule, Amravati, Nagpur, Wardah, Bhandara, Chandrapur and Nanded
Madhya Pradesh	Shahdol, Seoni, Balaghat, Damoh, Mandla, Rewa, Betul and Sidhi
Odisha	Koraput, Kalahandi, Sambalpur, Sundergarh, Bhadrak, Cuttack, Puri, Dhenkanal and Mayurbhanj.
West Bengal	Purulia, Bankura, Birbhum, Bardhaman, Medinapur, Murshidabad, South 24-Parganas, Maldah, West Dinajpur, Jalpaiguri and Coochbihar
Uttar Pradesh	Gonda, Siddarthnagar, Lakhimpur, Kheri, Pilibhit, Etawah, Mirzapur, and Sonbhadra
Karnataka	Shivamogga and Belagavi
Tamil Nadu	Salem, Namakkal, Tiruchirappalli, Cuddalore, Ramnathpuram, Madurai, and Villupuram

(b) Rice Fallow Area

SN	States	Rice fallow area (Mha)
1.	Odisha	2.961
2.	CG	2.856
3.	WB	1.159
4.	Assam	1.042
5.	Jharkhand	0.475
6.	Bihar	0.049
7.	Other States	3.458
	Total	**12.000**

Source: (National Crop Forecast Centre, DAC & FW, New Delhi)

(a) Distribution of Rice Fallows		
(c) Potential pulses area under rice fallows		
State	**Potential area (M ha)**	**Rice-fallow Districts**
Chhattisgarh	0.88	Bilaspur, Dhamtari, Kanker, Jashpur, Raipur, Durg, Rajgarh, Kabirdham, Korba, Mahasamund and Rananadgaon
MP	0.53	Anuppur, Chhattarpur, Damoh, Dindori, Raisen, Jabalpur, Katni, Jhabua, Rewa, Satna, Shahdol, Seoni, Mandla, Narsingpur and Umaria
Odisha	0.37	Baleshwar, Dhenkanal, Sundergarh, Mayurbhanj, Kalahandi, Bolangir, Kheonjar, Puri and Cuttack
WB	0.52	Bankura, Purulia, Medinapur, West Dinajpur, Malda, Jalpaiguri, Bardhaman and Birbhum
Assam	0.16	Marigaon, Naogaon, Lakhimpur, Kokrajhar, Bongaigaon, Nalbari, Kamrup, Barpeta, Darrang, Cachar, Goalaghat, Jorhat, Dibrugarh, Tinsukia and Sonitpur
Total	**2.46**	

Source: The Expert Group on Pulses, DAC & FW, MoA & FW, GoI, (2009)

i. **Changing cropping pattern**

- **Diversification: Replacement of less remunerative crops with pulses**

More than 5 Lha (lakh hectares) of upland paddy areas, and 3 Lha area under barley, mustard and wheat may preferably be diverted to pulses in kharif/rabi. More than 20 Lha vacated by wheat, peas, potato, sugarcane and lentil may be brought under spring/ summer pulses by providing critical irrigation support in the States of Bihar (3 Lha), Tamilnadu (2.31 Lha), Odisha (2.14 Lha), Madhya Pradesh (1.51 Lha), Uttar Pradesh (1.36 Lha), Andhra Pradesh (0.74 Lha), West Bengal (0.61 Lha), Gujarat (0.40 Lha), Chhattisgarh (0.20 Lha) and Punjab (0.20 Lha).

- **Promotion of inter-cropping and utera cultivation**

Inter-cropping of pulses is the best approach for increasing production of pulses through horizontal area expansion. The farmers in rainfed States of Karnataka, Gujarat, Madhya Pradesh, Chhattisgarh, Maharashtra and Andhra Pradesh have been traditionally cultivating pulses. Besides increasing the overall productivity of the production system, pulses as a legume fix atmospheric nitrogen and help farmer economise on 'N' fertilizer. Wheareas, mungbean and urdbean are an ideal inter-crop with spring planted sugarcane under irrigated/rainfed conditions, cotton and spring summer sunflower, lentil, fieldpea, chickpea and rajmash are ideal intercrops in autumn planted sugarcane under irrigated conditions.In Andhra Pradesh, out of 9 Lha groundnut area, 4 Lha alone goes under inter-cropping (groundnut+ tur- 7:1, 11:1); (cotton+ tur-1:11,1:12,1:7); (maize/jowar+ tur- 2:1); (mung/urd+ redgram- 7:1). An additional are of area of 0.3 Lha can be brought under pigeonpea in Chhattisgarh, Madhya Pradesh, Odisha, West Bengal and Jharkhand by cultivation of pigeonpea on rice bunds/transplanting.

Table 7.6 Prominent inter-cropping systems

States	Intercropping Systems
Andhra Pradesh	Pigeonpea+Groundnut/castor, Chickpea+Sunflower, Rice + Mungbean / Urdbean, Tapioca+Mungbean/Urdbean
Bihar	Pigeonpea+Maize/Small millets/Turmeric, Chickpea+ Mustard/Linseed, Lentil+Mustard, Fieldpea+Mustard,Potato+Common bean, Rice+Pigeonpea
Gujrat	Pigeonpea+Groundnut, Cotton+ Pigeonpea, Pearl millet +Mothbean, Castor+Urdbean/Munhgbean/Cowpea/Horse gram
HP	Maize+Urdbean/Soybean/Cowpea/Common bean
Karnataka	Pigeonpea+Horse gram/Small millets/Cowpea/Groundnut, Finger millet+Horse Gram, Chickpea+Sunflower, Tapoca+Mungbean/Urdbean
Madhya Pradesh	Pigeonpea +Pearlmillet/Sorghum/Urdbean/Mungbean/Castor/Soybean, Pearl millet+Mungbean/Urdbean, Chickpea+ Mustard/ Wheat/ Barley/ Linseed, Field pea + Mustard,Lentil +Linseed/Mustard/Barley, Cotton+Pigeonpea
Maharashtra	Pigeonpea+Sorghum/Maize, Cotton+Pigeonpea/Mungbean/Urdbean, Grd.nut+Pigeonpea
Orissa	Pigeonpea+Ground nut, Tapioca+Mungbean/Urdbean
Punjab & Haryana	Chickpea+Wheat/Barley/Mustard/Linseed, Sugarcane+Summer Mungbean /Urdbean /Chickpea, Pigeonpea+Mungbean/Urdbean, Urdbean+Maize, Maize + Soybean
Rajasthan	Pearl millet+Urdbean/Mungbean/Cowpea/Mothbean, Sorghum+Mothbean, Cluste rbean+Mothbean, Chickpea+Barley/Mustard/Wheat
Tamil Nadu	Pigeonpea+Sorghum, Tapioca+Mungbean/Urdbean, Sugarcane+Urdbean
Uttar Pradesh	Pigeonpea+Pearl millet/Sorghum/Castor/Maize/Urdbean/Mungbean, Pearl millet +Urdbean/Mungbean, Sugarcane+ Urdbean/Mungbean/Field pea/Chickpea, Chickpea+Wheat/Barley/Linseed/Mustard.
West Bengal	Sunflower+Mungbean, Chickpea+Mustard/Lentil, Jute+Urdbean

Source: Adopted from Sekhon and Singh (2005)

Table 7.7 Scope of area expansion through intercropping system manipulation

Crop	Intercropping with	Specific Area
Mungbean/ Urdbean	• Spring planted sugarcane (irrigated) • Cotton and Millets (Rainfed upland) • Spring/Summer Sunflower (Rainfed upland)	• Western U.P., Central U.P. and North Bihar, Maharashtra, A.P. and T.N.Western U.P., Haryana and Punjab
Lentil, Field pea, Chickpea, Rajmash	• Autumn planted sugarcane (irrigated)	• Western U.P., Central U.P. and North Bihar
Rajmash	• Potato	• Western U.P., Central U.P. and

Crop	Intercropping with	Specific Area
		North Bihar
Pigeonpea	• Soybean, Sorghum, Cotton, Millets and Groundnut (Rainfed upland)	• A.P. Malwa Plateu of M.P., Vidarbha of M.H., North Karnataka, North T.N. South East Rajasthan, Punjab, Haryana, U.P. and Bihar
Chickpea	• Barley, Mustard and sunflower (Rainfed upland)	• South East Rajasthan, Punjab, Haryana, U.P., Bihar, Vidarbha of Maharashtra

Source: DPD Bhopal

ii. Increasing Productivity: various approaches are discussed below

- **Bringing yield gaps for vertical expansion of area**

The potential of vertical expansion begins with yield gap analysis of pulses in terms of inter-state, intra-state; and between FLD and state's average yield (SAY) under different pulses in the major pulse growing states. Here, the strategy would be to bridge the yield gaps by adopting improved recommended technologies under NFSM in all the 29 states of the country, with major emphasis on the 10 major states that account for more than 90 per cent of the country's pulse production. By bridging the yield gaps, farmers benefit from additional returns. The yield gaps at national and inter-state levels are given in the table 7.8:

Table 7.8 Yield gap: National and Inter-state (Avg. Yield - kg/ha)

Crop/Season	National	Highest/Lowest Yield	States > National Avg.	States < National Avg.
Total Pulses	726	Jharkhand (970)/ Karnataka (534)	Jharkhand, MP, Gujarat, UP, AP	Karnataka, Maharashtra, Rajasthan, CG, TN
Total Kharif	554	Jharkhand (883)/ Rajasthan (398)	Mha., MP, UP,Guj. Jha, TN	Rajasthan, Karnataka, Odisha, Telangana
Total Rabi	738	Jharkhand (963)/ Karnataka (578)	MP, UP, AP, Guj., Bihar, Jha.	Mha., Raj., Kar., CG,
Tur	727	Gujarat(1076)/ Telangana(456)	MP, UP, Guj., Jha., Odisha, TN	Maharashtra, Karnataka, Telangana, AP
Mungbean (K)	415	AP(783)/ Karnataka(53)	Raj., Mha., Guj., Telangana, MP,AP, TN, Jha.	Karnataka,Odisha,
Urdbean (K)	523	Jharkhand (830)/ Odisha (362)	UP, Jha., Guj., TN, WB,	MP, Mha, Raj., Odisha, Karnataka
Kulthi(K)	470	Bihar (889)/ CG (298)	Karnataka, Jha., Uttarakhand, TN, Bihar, Mha., AP,	Odisha, CG,MP,
Moth(K)	378	HP(2000)/ Mha(318)	Guj., HP, J&K, Haryana	Raj.,Mha.,
Gram	936	Telangana(1386)/ Karnataka(672)	MP,AP,UP,Guj.,Jha., Telangana	Raj.,Mha., Karnataka,CG,
Urd (Rabi)	732	WB(917)/ Karnataka(429)	AP,WB,	TN, Assam, UP, Odisha, Telangana, MP, Karnataka, Gujarat
Mungbean (Rabi)	579	Punjab(865)/ Odisha(356)	TN, AP, Bihar, Punjab,UP, WB	Odisha,MP, Haryana, Gujarat
Lentil	702	Bihar (1049)/ CG (400)	UP,Bihar,WB,Jha., Raj., Uttarakhand, Haryana	MP, Assam,CG,
Kulthi (Rabi)	514	TN(589)/ Maharashtra(308)	Karnataka, TN	AP, Mha., WB, Telangana
Lathyrus (Khesari)	745	WB(1103)/ Maharashtra(286)	Bihar, WB	CG, MP, Maharashtra

Crop/Season	National	Highest/Lowest Yield	States > National Avg.	States < National Avg.
Peas	944	Rajasthan(1667)/ Odisha(593)	UP,Jha.,HP, Bihar, Manipur, Rajasthan, WB,	MP, Odisha, Assam

Source: Annual Report 2016-17, DPD, Bhopal

- **Aiming to achieve FLD yield levels**

By adopting improved practices, the yield gaps that exist between FLDs and farmers' practice, can be bridged, and the additional average returns to the farmers will be Rs. 15,554 per ha. Likewise, if yield gaps are bridged vis-à-vis state average yield (SAY), the average additional return is estimated to be Rs. 22,119 per ha. The additional returns have been worked out by multiplying the yield gap quantities by notified MSP for all crops, excluding field pea, which has no provision of MSP, and ruling market price (@ Rs3,500/qtl) has been used. The details of crop-wise yield gaps and additional return by bridging the yield gaps are given in table 7.9.

Table 7.9 Crop-wise yield gap and additional return ***(Yield: Kg/ha; Return: Rs./ha.)***

Crop	**Yield (kg/ha)**			**Gap over FP**		**Gap over SAY**		**Yield 2016-17 ***	**Additional return by bridging yield gap (Rs/ha)**	
	IP	**FP**	**SAY**	**Actual**	**%**	**Actual**	**%**		**FP**	**SAY**
Pigeonpea	1394	1078	863	316	29	530	61	787	17373	29177
Chickpea	1502	1244	907	257	21	594	66	860	10296	23776
Rice fallow Chickpea	1275	960	976	315	33	299	31	772	13871	13145
Mungbean(Kh)	781	608	435	173	28	345	79	455	9682	19339
Mungbean(R)	1398	1228	704	170	14	694	99	508	9520	38864
Mungbean(RF)	960	723	532	237	33	428	80	434	13272	23968
MungbeanSummer/Spring	931	559	674	372	66	257	38	717	20832	14414
Urdbean (Kh)	813	622	368	191	31	445	121	614	10287	24019
Urdbean (R)	1203	986	774	217	22	429	55	788	12152	24024
Urdbean (RF)	1185	1002	774	183	18	411	53	788	10220	22988
Lentil	1289	966	777	323	33	512	66	756	12920	20480
Field pea	1225	933	904	292	31	321	36	827	10220	11235
Average	**1163**	**909**	**724**	**254**	**30**	**439**	**65**	**692**	**12554**	**22119**

Source-Annual Report- 2016-17, GoI, DPD, Bhopal (Ave. 2013-14 to 2015-16)
*State Average Yield - E&S (Ave. 2011-12 to 2015-16) *Third Advance Estimates2016-17*
IP: Improved Practise FP: Farmers Practise SAY: State Avergae Yield

iii. Emphasis on improvement in total factor productivity

Total factor productivity (TFP) is an important source of output growth which directly contributes to cost saving and increase in income. Some recent development initiatives include PMKSY, SHCs, PKVY, PMFBY, NFSM for various crops including pulses. These aim at achieving resource use efficiency for reducing cost of cultivation and sustainability, besides higher per unit yields. In order to improve the net returns from pulses vis-à-vis other high yielding crops, like paddy and wheat, emphasis on reducing cost of cultivation is critical.

Under NFSM (Pulses), DAC&FW has expanded the coverage to as many as 627 districts. This expansion has mostly happened over the last four years and now covers even those districts where per hectare yields may be more than the state / national average. While this has helped in upgrading the technologies, over larger pulse production area, it is felt necessary to bring sharper focus on the districts where average yields are lower than the state / national average. This would help in bridging yield gaps where most needed. It is therefore suggested that there be two categories of districts for coverage under NFSM for pulses as follows:

a. NFSM Pulses for general districts
b. NFSM Pulses+ for districts where yield levels are lower than state/national averages and there exists critical yield gaps.

Under NFSM Pulses+, additional support may be offered to farmers by identifying factors that would contribute to higher yields.

Of the various input costs, pest & disease management is of utmost importance in case of pulses. Integrated pest management practices are useful in this regard. Another high cost is on account of labour and demands farm mechanisation. Water use efficiency can be promoted by adopting micro-irrigation systems. Water harvesting ponds served by micro-irrigation systems (sprinklers) have proved highly effective in protecting pulse crops raised in dryland areas, by enabling a lifesaving water in Karnataka.

iv. Strengthening storage and processing to reduce post-harvest losses

Pulses are vulnerable to post harvest loss which has been estimated to be the order of 20 to 30 per cent. Some of the important reasons for high losses in pulses are:

- Lack of efficient and good quality harvesting and threshing equipments
- Traditional dal mills resulting in low dal recovery
- High infestation of stored grain pests (bruchids)

v. Precision Agriculture

Precision agriculture involves site-specific management (SSM). It is guided by the ability to collect and control information to address parts of field accurately & approximately in preference to treating the whole field based on averages. Some of the important features are:

- It is an integrated agricultural management system, involving right amount of input at the right location and right time to enhance productivity; decrease input cost; improve quality of the product; and/or protect the environment.
- The technological tools often include the Global Positioning System (GPS), Geographical Information System (GIS), yield monitor, variable rate technology, and remote sensing.

- The major philosophy of precision farming is to find ways to reduce cost of cultivation/energy input; use inputs appropriate to the productive capacity of the soil; optimise outputs for safe and stable supply of food; ability to handle variations in productivity within a field and to maximize financial returns; reduce wastages; minimize negative impacts on the environment.

Precision agriculture has utility in all cropping systems including pulses, when the aim to reduce cost of cultivation, with a view to realise higher net farm incomes and enable doubling of farm incomes.

Importance of Precision Farm Machinery

The estimated benefits are:

- Increased production/productivity - 10-15 per cent
- Higher cropping intensity - 5-20 per cent
- Savings in seeds -15-20 per cent
- Saving in fertilizer/chemicals - 15-20 per cent,
- Reduction in time/labour - 20-30 per cent

Table 7.10 Effect of protective irrigation on yield of various crops

Crop and Irrigation	No. of protective irrigations	Yield (q/ha)		Increase Over rainfed (%)	WUE (Kg/ha	
		Rainfed	Irrigated		Rainfed	Irrigated
Pigeonpea	01	8.00	12.00	50.00	1.25	1.73
Greengram	01	5.00	11.25	125.00	0.78	1.63
Chickpea	01	5.00	9.50	90.00	0.78	1.48

Source: Annual report -2016-17, DPD, Bhopal

vi. Technological interventions

- **Increasing the availability of improved/recommended varieties**

Seed is the most important input for increasing the productivity of pulses**.** Increased productivity by 20-30 per cent has been reported with improved /quality seeds. Non-availability of quality seeds in adequate quantity is one of the major constraints in pulse production. The existing SRRs (seed replacement rate) under pulses now at a low of 15-20 per cent, may be enhanced to 42 per cent. Crop-wise requirement of certified seed, foundation seed and breeder seed uptill 2022, as worked out are given below (table 7.11).

Table 7.11 Requirement of seed under different categories (2018-19 to 2021-22)*(Quantity in Qtl.)*

Crop	Normal Area	Certified seed				Foundation seed				Breeder seed			
		2018-19 (36%)	2019-20 (38%)	2020-21 (40%)	2021-22 (42%)	2018-19	2019-20	2020-21	2021-22	2018-19	2019-20	2020-21	2021-22
Arhar	39.25	282.6	298.3	314.0	329.7	7.1	7.5	7.9	8.2	5.7	6.0	6.3	6.6
Urdbean	24.80	178.6	188.5	198.4	208.3	6.0	6.3	6.6	6.9	8.9	9.4	9.9	10.4
Mungbean	23.60	169.9	179.4	188.8	198.3	5.7	6.0	6.3	6.6	8.5	9.0	9.4	9.9
Other Kharif	18.14	130.6	137.9	145.1	152.4	4.4	4.6	4.8	5.1	6.5	6.9	7.3	7.6
Total Kharif	105.79	761.7	804.1	846.3	888.7	23.2	24.4	25.6	26.8	29.6	31.3	32.9	34.5

Crop	Normal Area	Certified seed				Foundation seed				Breeder seed			
		2018-19 (36%)	2019-20 (38%)	2020-21 (40%)	2021-22 (42%)	2018-19	2019-20	2020-21	2021-22	2018-19	2019-20	2020-21	2021-22
Gram	86.80	875.8	924.5	973.1	1021.8	58.4	61.6	64.9	68.1	87.6	92.5	97.3	102.2
Lentil	14.14	127.3	134.3	141.4	148.5	4.2	4.5	4.7	5.0	6.4	6.7	7.1	7.4
Fieldpea	9.93	357.5	377.3	397.2	417.1	23.8	25.2	26.5	27.8	35.8	37.7	39.7	41.7
Urdbean	7.85	56.5	59.7	62.8	65.9	1.9	2.0	2.1	2.2	2.8	3.0	3.1	3.3
Mungbean	9.26	66.7	70.4	74.1	77.8	2.2	2.4	2.5	2.6	3.3	3.5	3.7	3.9
Other Rabi	11.11	160.0	168.9	177.8	186.7	8.0	8.4	8.9	9.3	8.0	8.4	8.9	9.3
Total Rabi	139.09	1643.8	1735.1	1826.4	1917.8	98.5	104.1	109.6	115	143.9	151.8	159.8	167.8
Total Pulses	244.88	2405.5	2539.2	2672.7	2806.5	121.7	128.5	135.2	141.8	173.5	183.1	192.7	202.3

Source: Annual Report-2016-17, DPD, Bhopal

- **Improved Farm Management Practices**

Farming is an economic venture, where farmers work the land to gain an income, in order to maximise economic returns while simultaneously addressing environmental concerns, a number of management practices that will help to maximize the production and reduce loss on account various biotic and abiotic factors.

Different standard nutrient management practices across various states for different crops as suggested, if well adopted will help in achieving optimal nutrient use efficiency and also result in higher crop yields, better crop quality, and higher economic returns. About 63 per cent area under pulse is rainfed and consequently it faces severe moisture stress and shows low productivity. Quantum jump in productivity can be achieved by applying lifesaving irrigation, especially in rabi pulses grown on residual moisture. Micro- irrigation can be used for most efficient use of scared irrigation water. On light textured soils, 1-2 irrigations at branching and or pod development prove highly beneficial in most of the rabi season pulses.

Irrigation should be avoided during active flowering period, as it may trigger shedding and reversion to vegetative growth. Weed management is another important practice as about 17-20 per cent of losses in pulses are caused due to weeds. In respect of pests, an average 20-40 per cent of crop is annually lost due to damage caused by pod borers in pigeonpea and chickpea. Pod fly also causes 10-15 per cent loss especially in North India. Wilt and root rots cause heavy loss to pigeonpea and chickpea crops. Effective IPM module is suggested for management of targeted pests and diseases.

Despite the fact that efforts have been made to acclimatize a number of high yielding varieties of pulses with matching agro-technologies, and tolerance to biotic and abiotic stresses (associated with existing agro-ecologies and new niches), enhancing productivity remains a challenge. Renewed emphasis should be on sustainable intensification of pulse-based cropping systems, and technologically backed input management strategies including water for a given farm level impact.

For example, water, a critical input for sustained crop production, is becoming limiting both under rainfed and irrigated condition depending on its availability, competing factors, allocation to priority crop(s) and season of the year. Water source creation, conservation and efficient use (by a blend of systems like micro-irrigation and technology like crop alignment) can promote more crop per drop. PMKSY is based on this principle. There could be a life-saving or supplementary irrigation during post rainy or *fall* months which would possibly sustain productive potential of crop through alleviation of moisture stress under conservation agriculture (CA). Local water harvesting by constructing small ponds and using the water via a sprinkler has demonstrated the useful in protecting pulse, crops, during periods of monsoon withdrawal or delay in Karnataka.

Few agro-technologies can offer a sound back up for better water delivery and its usage. Such examples are precision land levelling, no-till systems, FIRB planting systems, crop diversification and its residue management etc. which lower water use and/or increased crop/water productivity (WP) and its use efficiency (WUE). In a typical FIRB system, the crop is sown on ridges or beds of suitable sizes depending on the crops to enhance the total crop and water productivity over a time. In the era of deficit rainfall/dry or dryland farming further amalgamated with rapid and visible climate change, there is a greater need to apply need based critical inputs at the point of interception to improve resource use efficiency (RUE) along with higher productivity of pulse crops. Therefore, adaptive strategies for grain legumes or pulses will be highly site-specific and offers an alternative for a higher productivity and production. To sum up, improved tactical water management in pulses could play a strategic role in sustainable intensification of a given food production system.

vii. Cropping system approach: addressing biotic and abiotic constraints.

- **Biotic stress management**

Several biotic stresses involving pests (during life cycle and storage), diseases (fungus, bacteria, nematode and virus) and weeds cause considerable damages to the pulses. Pulses on account of their initial low vigour often suffer heavily due to weed infestation.

The yield losses due to weeds have been estimated at 30–50 per cent in chickpea and up to 90 per cent in pigeonpea. Among the diseases, fusarium wilt coupled with root rot complex (probably it is the most widespread disease causing substantial economic loss in chickpea), sterility mosaic and phytophthora blight in pigeonpea; yellow mosaic, cercospora leaf spot and powdery mildew in both mungbean and uradbean; and rust and wilt in lentil cause considerable losses, if uncontrolled. Similarly among pests, gram pod borer in chickpea and pigeonpea; podfly in pigeonpea; whitefly, jassids and thrips in dry beans among pests cause severe damage to crops. Besides these, some of the areas are infested with nematodes.

- **Abiotic Stresses**

Abiotic stresses are primarily unavoidable and are most detrimental to the growth and productivity of pulses, especially under un-irrigated conditions. The ability to effectively tolerate by challenging these stresses is a complicated phenomenon stemming from various plant interactions occurring in the specific environments. Abiotic stresses occur naturally and can only be resolved with mitigation strategies under varied climatic conditions. In addition, abiotic stresses like drought and high temperature at terminal stages, cold as well as sudden drop in temperature coupled with fog during the reproductive phase, and soil salinity/alkalinity severely retard potential expression of crops and yield formation.

Various non-monetary inputs/techniques, viz. selection of crops, selection of drought-resistant/tolerant/early-maturing/short-duration varieties, healthy and disease-free seeds, seed treatment can mitigate abiotic and biotic stresses and enhance productivity and profitability of pigeonpea in dryland areas. Better crop-management practices like nutrient, water and weed management, insect-pest and disease management are essential to withstand these stresses. Climate-resilient crop varieties along with other suitable adaption and mitigation strategies will help overcome the adverse impact of climate change by lowering the yield losses under stress condition.

For example, varieties suitable to rice fallows can be determined based on *fall* temperature, soil texture and soil moisture availaibility. In eastern plains, small seeded lentil varieties such as WBL 77, KLS 218, NM1, and DPL 15 with resistance to rust perform well. While chickpea varieties like, Pusa 372, PG 186, and Udai are recommended for this region. The newly developed lathyrus varieties Ratan, Parteek, Mahateora have low ODAP content and suitable for rice fallows. Here also, small seeded varieties perform better than large seeded due to better contact with soil, less rotting and thus, better plant stand.

These interventions are now found prominence in Chhattisgarh, Jharkhand, Bihar, West Bengal and Assam. This in fact, can be reinforced with short duration and HYVs of rice that could vacate the field early, latest by the end of October. In low land situation, lentil is more suitable over chickpea because of its short duration, crop hardiness and low water requirement; and is preferred (with stable yields) in the lowland of Eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal. However, in coastal region due to higher relative humidity and warm condition, powdery mildew could also be severe. It had been a deadly disease in uradbean and mungbean until the development of powdery mildew resistant varieties like, LBG 17, LBG 602 and LBG 623 of urdbean; and those of mungbean *viz*., Pusa 9072, NARM-1, NARM-2 and NARM-18. LBG 17, the first powdery mildew resistant variety with an yield potential of 1.5 t/ha. This has revolutionized *rabi* urdbean cultivation in rice fallows of coastal peninsula.

In a recently carried out screening cum varietal selection programme on *promotion of pulses in NEH region (2014-17)*, the study showed that chickpea-IPC 97-67 and PUSA 372; lentil - DPL 62; fieldpea - AMAN in most of the locations, and fieldpea-TRCP 9 in Assam and Tripura locations; and mungbean - HUM 12 and IPM 2-14 were promising and suitable under north eastern and himalayan region conditions.

- **Drought stress**

Impact of moisture stress depends on its intensity/ severity and duration; and prevents the crops from reaching the maximum yield. Nitrogen fixation, uptake and assimilation by leguminous plants are reduced due to reduction in leg haemoglobin in nodules and number of nodule under moisture stress conditions. Depending on the level of stress, legumes may suffer from grain yield losses to a larger extent compared to shoot biomass reduction.

- **Water logging stress**

Water logging affects a number of biological and chemical processes in plants and soils that can impact crop growth in both short and long terms. Germinating seeds/ emerging seedling are very sensitive to water logging, as their level of metabolism is high. Pigeonpea is sensitive to water logging compared to other crops.

- **High temperature**

Kharif pulses require an optimum temperature of 15-30°C for better growth and development. Soil moisture stress coupled with high temperature affects the growth and development of crop plants to larger extent in dryland areas.

- **Low temperature stress**

Temperature lower than that required for optimal growth causes chilling stress. Stress due to temperature less than 15°C is known as chilling stress and this occurs in plants which grow at 25-35°C. In majority of the crops, chilling stress occurs at temperature less than 10°C but above 0°C, and is most common in tropical and sub-tropical species, such as pigeonpea. Cool/ winter season pigeonpea is highly sensitive to low temperature stress during flowering and early pod-formation stages.

- **Nutrients stress**

The two conditions of nutrient deficiency and excess occur when an essential nutrient is either not available to plant in required quantity or is available in excess of plant needs. Unlike deficiency symptoms, toxicity symptoms are more common. In some cases, the presence of one element in excess concentrations may induce the deficiency of another element.

Table 7.12 Biotic and Abiotic Resistant Varieties of Pulses

A. Biotic Stresses		
Name of Disease	**Crop**	**Varieties**
Wilt	Chickpea	GNG 1581, CSJ 515, RVG 202, JGK 5, JG 6, JG 16, Digvijay, Gujarat Gram 3, BG 391, Ujjawal, GLK 26155, HK 05-169, BDNG 797, RSG 991
	Pigeonpea	Maruthi, Asha, BDN 2, BSMR 736, MA 6 , Vipula
	Lentil	JL 3 , RVL 31, VL Masoor 133, Pant P-8, VL-514, Pant lentil 5, VL Masoor 125, VL 507, IPL 406, Moitree(WBL 77), Pant L 6, Pant L 7

***Ascochyta* blight tolerant**	Chickpea	GNG 469, Himachal Chana 1 , PBG 5, RSG 807, GJG 0809
	Lentil	LL 699, Shalimar Masoor-1
***Botrytis* Grey Mold tolerant**	Chickpea	Pant kabuli chana 1
Dry root rot tolerant	Chickpea	RSG 974, RVG 202, CSJ 515, CSJ 140, JGK 5, JG 6, RSG 959
	Lentil	VL Masoor 133, VL Masoor 125, Shalimar Masoor-1, VL-514
Resistance & moderately resistance to rust	Lentil	HPL-5, Lens 4076, PusaVaibhav(L 4147), Azad Masoor 1(KLS 218), HUL 57, HM-1, LL 931, DPL 62 (Sheri), VL Masoor 133, Pant lentil 5, Pant P8, LL 699
	Fieldpea	HUDP 15 , Pant Pea 14, Prakash (IPFD 1-10), Pant Pea 25, Pant P 42, IPF 5-19(Aman), IPF 4-9, HFP 529
Resistant to leaf spot	Lentil	Shalimar Masoor-1
Resistant to powdery mildew	Fieldpea	Adarsh (IPF 99-25), KPMR 400, KPMR 522, Subhra(IM9101), Rachna, JM 6, JP 885 , HUDP 15, Pant Pea 14, Vikas (IPFD 99-13), Prakash (IPFD 1-10), Paras, Pant Pea 25, Pant P 42, IPF 5-19(Aman), TRCP 8(Gomati), Pant P-13, DantiwadaFieldpea 1 (SKNP 04-09), IPF 4-9, HFP 529, IPFD 10-12
	Mungbean (rabi)	TARM 18, TM 96-2, Vamban 2, Vamban 4, TARM 2, TARM 1, TM 2000-2
	Urdbean	VBG 04-008, NUL7, IPU 02-43, Mash 114
Resistance to MYMV	Mungbean	HUM 1(Malviya Jyoti), Pusa 9531, Pusa Vishal Pant Mung 5, Meha (IPM 99-125), HUM 16(Malaviya Jankalyani), Sweta (KM 2241) IPM 02-3, PKV AKM 4, Pusa 0672, KM 2195 Basanti (MH -125), MH 421, MH 2-15 (Sattaya), WBM-4-34-1-1, Pant Mung-6, COGG 912, IPM 02-14, OBGG-52, ML 818, LGG 460 (Lam 460), PAU-911, TJM-3,PDM 139
	Urdbean	Mash 338, Pant U-19, TU 94-2, KU 301, KU 91-2 (Azad urd 1), IPU 94-1 (Uttara), KU 300, KU 309 , (Shekhar 3), Mash1008, Pant U 31 Pant U 40,WBU 109 (Sulata),KUG 479, UH-1, VBG 04-008, NUL7, IPU 02-43, Azad U-3(KU 96-3), Mash 114, LBG 752, Pant U-35
Resistant to MYMV and PM	Urdbean	IPU 02-43, LBG 625, LBG 685
Resistance to CLS	Mungbean	MH 2-15 (Sattaya), WBM-4-34-1-1, COGG 912, OBGG-52, Pant Mung-6, TJM-3
	Urdbean	GU-1
Sterility Mosaic Disease	Pigeonpea	Bahar, BSMR 736, Asha, Sharad, Pusa 9 , IPA 203

Wilt and SMD	Pigeonpea	Asha, BSMR 736, BSMR 853, Rajeev Lochan, BDN 711
B. Abiotic Stresses		
Type of stresses	**Crop**	**Varieties**
Heat and drought tolerant	Chickpea	JG 14, RSG 888, Vijay
Drought tolerant	Pigeonpea	JKM 189

Varieties for special features

Special features	Crop	Varieties
Early maturing	Chickpea	JAKI 9218, Rajas, Pusa 547, RVG 202, RVG 203, JGK 1, KAK 2, Shubhra
Short duration varieties for spring/summer	Mungbean	IPM 02-3, Samrat, TMB 37, HUM 16, HUM 1, Pusa Vishal, OUM 11-5, Pant M 6, SML 668, Pusa 9531, SGC 16
	Urdbean	WBU 109, Azad Urd 1, KU 300, Pant Urd 31, PDU 1, KU 92-1, KUG 479, LU 391
Large seeded	Chickpea (Kabuli)	MNK 1, PKV Kabuli 4-1, Phule G 0517
	Lentil	Sheri (DPL62), DPL 15, L 4076, Sapna, Priya, Pant L 5, Malika, WBL 58 (Subrata), Jawahar Lentil 3 (JL 3), Noori (IPL 81) , Shalimar masoor -2, RVL 31, Shekar -4, Krati (KLB 2008-4), IPL 316
	Mungbean	Pant M 5, Pusa Vishal, SML 668, HUM 16, TMB 37, IPM 02-3,
Mechanical Harvestable	Chickpea	NBeG 47, GBM 2
Rice –fallow condition	Lentil	Pusa Vaibhav, KLS 218, Pant L 639, DPL 62, Pant L 5
	Mungbean	CO 7,Vamban 3, ADT 3
	Urdbean	CO 6, ADT 5, Vamban 6
Hybrid	Pigeonpea	GTH-1
Green seeded	Fieldpea	HFP 9907 B, HFP 9426, IPFD 10-12
Bio-fortified	Lentil	IPL 220 (High Zn and Fe)

7.4 Improving Terms of Trade for Farmers

Doubling of farmers' income should not be viewed as the same as doubling of farm output. The policy framework has to be comprehensive enough based on efficiency of open markets, robust procurement operations, favourable import-export structure, so as to enable the farmers to get fair and remunerative returns on farmers' produce. Pulses which are prove to pests attack and other perishables certainly need good market support. Increased outputs do not automatically translate into higher farm incomes. In fact, there can be a paradoxical situation of food loss and income loss, when suitable agri-logistics and market support are absent.

Comparative statement of MSP & cost of production

An analysis of average gap between Minimum Support Price and cost of production of pulse crops during 2012-13 to 2014-15 reveals, that the MSPs are above the cost of production in arhar, urdbean and gram, but lower in mungbean and lentil (Table 7.13). It is pertinent to mention here that the cost of production varies from state to state, depending on cost of cultivation and productivity level of particular states.

Table 7.13 Comparative statement of MSP & cost of production (Rs./quintal)

Crops	2012-13			2013-14			2014-15			Average		
	CP	MSP	+ -	CP	MSP	+ -	CP	MSP	+ -	CP	MSP	+ -
Arhar	3428	3850	422	3529	4300	771	5237	4350	-887	3847	4167	320
Mungbean	4832	4400	258	5257	4500	-6	6864	4600	-1283	4844	4500	-344
Urdbean	3614	4300	686	4310	4300	-10	4485	4350	426	3949	4317	367
Gram	2971	3000	326	3058	3100	348	3183	3175	-8	2870	3092	222
Lentil	2555	2900	345	3289	2900	-389	3839	3075	-764	3228	2958	-269

Source: DFI Committee Estimates

Enhancements in MSP for pulses can incentivise the farmers to adopt recommended package of practices and realise higher productivity. Inter-crop comparisons will get more favourable in case of pulses, if (i) yields improve; and / or (ii) price returns increase. Price returns certainly need to improve in the context of pulse: rice / wheat comparison, as the latter two have already achieved relatively much higher per ha yields vis-à-vis pulses, leaving higher prices as the only option in the immediate run. It is this realisation that has influenced government decision to offer not only higher MSP, but also an attractive bonus on pulses over the last 3 years. In addition, the procurement of pulses has got more robust as reflected in a buffer stock of 2 million tonnes during the year 2016-17. Procurements become important, when market fluctuations occur and increasing production mute the market prices.

What is however important from the perspective of sustainability is to achieve higher yield per unit of land in case of all the pulses. The current average pulse yield of about 7 quintal / ha is much lower than the potential of 16 quintal / ha. It is easily possible to register an average of 12-14 quintals / ha, if the recommended farm management practices are adopted. This in the short run will help the country to meet the domestic demand, besides leaving surpluses for exports. The farmers have demonstrated the ability to respond, as seen from the substantive jump in pulse production from 16.3 million tonnes in 2015-16 to 23.2 million in 2016-17.

The five year road map (2016-17 to 2020-21) for increasing pulse production, adopted by the Department of Agriculture, Cooperation and Farmers' Welfare has succeeded in achieving this production. The area coverage under pulses as per first advance estimates for the year 2017-18 is indicative of an encore production. There is now confidence of consolidation and registering still higher production to meet the domestic demand of about 25 million tonnes by 2022-23.
In the long run however, R & D should help in offering the farmers varieties with higher yield potential and resistance to pests & diseases. This is critical considering, that India is a high consumer of pulses, and the demand can only be expected to shoot up northwards, with increasing purchasing power. It is a welcome demand, since pulses are not only rich resources of proteins, but are also the cheapest relatively, and are thus a right candidate to improve the nutritional intake of Indian population.

Further, it is no gain saying that pulses are eco-friendly and soil enriching in particular, besides aiding farmers realise higher farm incomes.

7.5 Summing up Strategies for Production Enhancements

Table 7.14: Approach-wise production targets of different pulses by 2020 & 2025

Approach	Target	Production target (MT)	
		Year 2020	Year 2025
Productivity Enhancement	Improving productivity from 786 to 1000 kg/ha	Production:23.5 Mmt Productivity:900kg/ha	Production:27.5 Mmt Productivity:1000kg/ha
Area of cultivation	Bringing 3-4 mha additional area under pulses over existing 24 mha	26 million ha	27.5 million ha
Bringing down duration of crop	Diversification of cropping system and bringing crop into new cropping system and niches	Reduction in maturity duration of mungbean by 10-12 days to bring down crop duration to 50-55 days for spring/summer season & rabi rice fallow and in cowpea by 10-12 days to bring down crop duration to 55-65 days	Reduction in maturity duration of urdbean by 10-12 days for spring / summer season and rabi rice fallow: chickpea/lentil by 15-20 days; and early duration Pigeonpea by 20-30 days to bring crop duration to <120 days

7.6 Productivity enhancement approach

Table 7.15 Activities and action plan

Activities	Action plan
Improving Seed Replacement Rate	• Advance planning for each state rolling seed plan; production of sufficient quantity of breeder seed and their conversion into foundation & certified seed; maintenance of seed buffer; public-private partnership and farmers' participatory seed production.

Providing life saving irrigation in pulse districts	• Micro-irrigation through sprinklers or drip and rainwater harvesting.
Ensuring availability of critical inputs	• Timely availability of critical inputs like bio-fertilizers, sulphur, boron, bio-pesticides etc. at field level.
Mechanisation for pulse production	• Farm machinery for essential agricultural operations like tillage, planting, harvesting, inter-cultivation, threshing, processing etc. through cooperatives or custo hiring.
Policy support	• Credit, insurance, MSP with procurement, incentives (subsidies). • Processing and value addition & innovative institutional marketing models like Amul, Parag, Dhara etc.

Table 7.16 Research for genetic enhancement

- Introgression of QLTs for improving yield, harvestability, quality & marketability.
- Pyramiding resistant gene(s) for various races of wilt disease in chickpea & pigeonpea.
- Developing intragenics/Cisgenics and transgenics against pod borer in chickpea & pigeonpea and MYMV in mungbean & urdbean.
- Allele mining & proteomics for MAS under biotic & abiotic stress.
- Developing climate resilience in pulses - tolerance to high temp. & drought in winter.
- Harnessing heterosis in pigeonpea to increase its yield by 30-40 per cent.
- Restructuring photo-synthetically efficient plant types for new niches.

Table 7.17 Research for crop management

- Development of micro-irrigation techniques for enhancing water use efficiency.
- Intensifying conservation agriculture for increased yield.
- Use of PGPR to have a direct impact on increasing productivity.
- Use of nano-technology for better water & nutrient use efficiency.
- Increase in nutritional quality through bio-fortification.
- Forecasting & forewarning systems for optimizing results to ensure higher returns.
- Capitalization on IT for market intelligence & technology transfer.

7.6.1 Area enhancement approach

Table 7.18 Increasing area under cultivation

Potential crop / cropping systems	Specific area / niche	Potential area (mha)
1. INTERCROPPING		
Mungbean with Sugarcane (Irrigated); & with Cotton & millets (Rainfed Upland)	UP (C, E & W), Bihar; MS, AP & TN	0.70

Pigeonpea with soybean, cotton, sorghum, millets & groundnut (Rainfed upland)	AP, Malwa (MP), Vidarbha (MS), Karn (N), TN	0.50
Chickpea with barley, mustard, linseed & safflower (Rainfed)	Raj (SE), Punjab, Haryana, UP, Bihar, Vidarbha (MS)	0.50
Chickpea/lentil with autumn planted / ratoon sugarcane	MS, UP, Bihar	1.0
2. CATCH CROP		
Mungbean spring / summer	UP (C&W) Haryana, Punjab, Bihar, WB	1.0
3. RICE FALLOWS		
Chickpea	UP (E), CG, WB, Bihar, Jharkhand, Odisha	0.4
Urdbean / mungbean	AP, TN, Odisha, Karnataka	0.5
Lentil	UP (E), Bihar, WB, Assam, Jharkhand	0.3
Lentil / fieldpea	North-East	0.1
4. KHARIF FALLOW		
Urd / mung	UP (Bundel), MP	1.2
	Total	6.2

7.6.2 Bringing down duration of pulse crops

Table 7.19 Reducing crop duration approach

Crop	Present status	Research strategy	Target	Time frame
Mungbean	65-70 days	Hybridization using cultivated germplasm and wild accessions for combining different components of maturity duration for reducing the crop duration and increasing per day productivity	50-55 days	2025
Cowpea	65-75 days		55-60 days	2025
Urdbean	75-85 days		65-70 days	2025
Lentil	110-130 days		100-110 days	2025
Chickpea	110-130 days		100-110 days	2025
Pigeonpea	120-150 days		<120 days	2025

7.7 Anticipated Area, Production and Productivity by 2025

Table 7.20 Anticipated area, production & productivity of different Pulses

Crop	Average TE ending 2012-13			Year 2025		
	A	P	Y	A	P	Y

Chickenpea	8.70	8.83	1014	9.50	12.63	1330
Pigeonpea	3.81	3.02	792	4.20	4.32	1028
Mungbean	2.75	1.19	432	4.25	2.46	580
Urdbean	3.19	1.90	596	3.50	2.55	730
Lentil	1.42	1.13	797	2.07	2.02	980
Fieldpea	0.76	0.84	1105	0.86	1.20	1400
Lathyrus	0.58	0.43	742	0.75	0.68	910
Cowpea	0.15	0.12	814	0.28	0.26	940
Horsegram	0.46	0.19	415	0.71	0.34	475
Mothbean	0.90	0.25	280	1.15	0.45	390
Other minor pulses	-	0.44	-	-	0.59	-
Total	**-**	**18.34**	**-**	**-**	**27.5**	**-**

A: Area (million ha)

P: Production (million tonnes)

Y: Yield (tonnes/ha)

Key Extracts

- Conduct mapping of major pulse growing areas and integration with water conservation and water use efficiency. NFSM pulses may be categorised into general areas and low yield areas.
- Soil test based nutrient applications including quality micro-nutrients should become the norms. Use of quality bio-fertilizer and bio-agents should be ensured.
- Adoption of short duration paddy varieties should be encouraged to accommodate pulses. Utilise rice fallows and promote of spring/summer pulse cultivation.
- Moisture conservation, contingent drainage in the event of high rainfall through promotion of ridge planter, raised bed planter and sprinklers recommended. Promote Zero-tillage practice to reduce cost of cultivation and adhere to timely sowing.
- PHM/Value Addition Promotion (spiral graders, clearer, mini dal-mill) as adopted in Assam should be encouraged. Screening and identification of potential local cultivars for NEH region should be promoted.
- Fencing/solar fencing project to keep off wild animal/stray cattle as adopted in Gujarat and Madhya Pradesh should be replicated.
- In additions to higher MSP, robust procurement operations are necessary. MSP for Moth bean may be considered. Short duration summer Mung seeds of 55 days should be procured by States in advance. Short duration seeds of pigeon pea available in Punjab and Haryana should be indented on priority.
- Quality seeds are critical to achieve high output. A robust integrated seed production system should be promoted. Adopt the approach of: productivity enhancement, increasing cultivation area and bringing down crop duration.

Chapter 8
Oilseeds

The production of oilseeds in India is impressive, but is not enough to yield the required quantum of edible oil for the growing demand. In consequence, spend on the import of vegetable oil is abnormally high. There exist wide yield gap variations, which need to be and can be bridged to move towards relatively higher self-dependence at the macro level.

8.1 Introduction

A wide range of agro-ecological zones prevailing in the country support diverse crops in general, and an array of oilseed crops in particular. This coupled with demographic and dietary diversity, has encouraged and sustained the identity and growth of each oilseed crop. The country is not only bestowed with a number of oil yielding species of plant origin which include the annuals (groundnut, rapeseed-mustard, soybean, sunflower, sesame, niger, safflower, castor and linseed), perennials (oil palm and coconut), minor oil bearing species of forest and tree origin and by-products of some non-traditional sources such as rice bran, cotton seed and corn, but also a diverse agro-ecological niches for their cultivation. Oilseed crops are the second most important determinant of agricultural economy, next only to cereals within the segment of field crops. The self-sufficiency in oilseeds attained through "Yellow Revolution" during early 1990's, could not be sustained beyond a short period. Despite being the fifth largest oilseed crop producing country in the world, India is also one of the largest importers of vegetable oils today. There is a spurt in the vegetable oil consumption in recent years in respect of both edible as well as industrial usages.

The demand-supply gap in the edible oils has necessitated huge imports accounting for 60 per cent of the country's requirement (2016-17: import 14.01 million tonnes; cost Rs. 73,048 crore**)**. Despite commendable performance of domestic oilseeds production of the nine annual crops (Compound Annual Growth Rate of 3.89%), it could not match with the galloping rate of per capita demand (~6%) due to enhanced per capita consumption (18 kg oil per annum) driven by increase in population and enhanced per capita income.

8.2 Sources of Vegetable Oils

Primary sources of vegetable oil: Nine oilseeds are the primary source of vegetable oils in the country, which are largely grown under rainfed condition over an area of about 26 million ha. Among these, soybean (34%), groundnut (27%), rapeseed & mustard (27%) contribute to more than 88 per cent of the total oilseeds production and >80 per cent of vegetable oil output. The major contribution to domestic vegetable oil production comes from mustard (35%), soybean (23%) and groundnut (25%).

The major oilseed producing states are Andhra Pradesh (groundnut) & Gujarat (groundnut), Haryana (mustard), Karnataka (groundnut), M.P. (soybean), Maharashtra (soybean), Rajasthan (mustard & soybean), Tamil Nadu (groundnut), U.P. (mustard) and West Bengal (mustard) accounting for more than 95 per cent of the total oilseed production in the country. India is producing about 7-8 million tonnes of vegetable oils from primary sources.

Secondary sources of vegetable oil: In addition to nine oilseeds, 03 million tonnes of vegetable oil is being harnessed from secondary sources like cottonseed, rice bran, coconut, Tree Borne Oilseeds (TBOs) and oil palm. Oil palm which is categorized as a secondary source of oils should in fact be included as primary source as it gives the highest per ha oil yield (4-5 tons per ha).

8.3 Import and Export of Oilseeds & Vegetable Oil

Import

India is heavily dependent on imports to meet its edible oil requirements and is counted as the largest importer of vegetable oils in the world (15 per cent share) followed by China & USA. Of the imported edible oils, share of palm oil is about 60 per cent followed by soybean oil with a share of 25 per cent and sunflower 12 per cent. Import growth in respect of edible oils during the last decade is about 174 per cent. The import figure of edible oils during 2015-16, reveals that India imported a total of 15.88 million tonnes of oilseed and vegetable oil products worth Rs. 69,331.96 crore.

Table 8.1 India's imports of oilseed and vegetable oil products

(Quantity: '000 tonnes), (Value Rs. Crore)

Commodity	2015-16 (P)	
	Quantity	Value
Sesame seeds	23.60	179.66
Niger seeds	5.78	44.14
Groundnut	0.11	0.31
Other oil seeds	62.51	218.62
Vegetable oils	15642.33	68676.62
Oil meals	148.30	210.38
Castor oil	0.14	2.23
Total	**15882.77**	**69331.96**

Source: DES, DAC&FW

Export

As per foreign trade policy export of edible oils was prohibited over the years. Currently the following exemptions are in place.

i) Edible oils permitted for export in bulk as well consumer packs of upto 5 kgs with Minimum Export Price (MEP).
   a) Groundnut oil , sesame oil, soybean oil, rice bran oil, coconut oil
   b) Minor forest product oils

ii) Edible oils permitted for export in only consumer packs upto 5 kgs with MEP of UDS 900 per metric tonne (MT)
   a) Olive oil, palm oil, sunflower oil, safflower oil, cotton seed oil. linseed oil, mustard oil.

Table 8.2 India's exports of oilseed and vegetable oil products

(Quantity: '000 tonnes), (Value Rs. Crore)

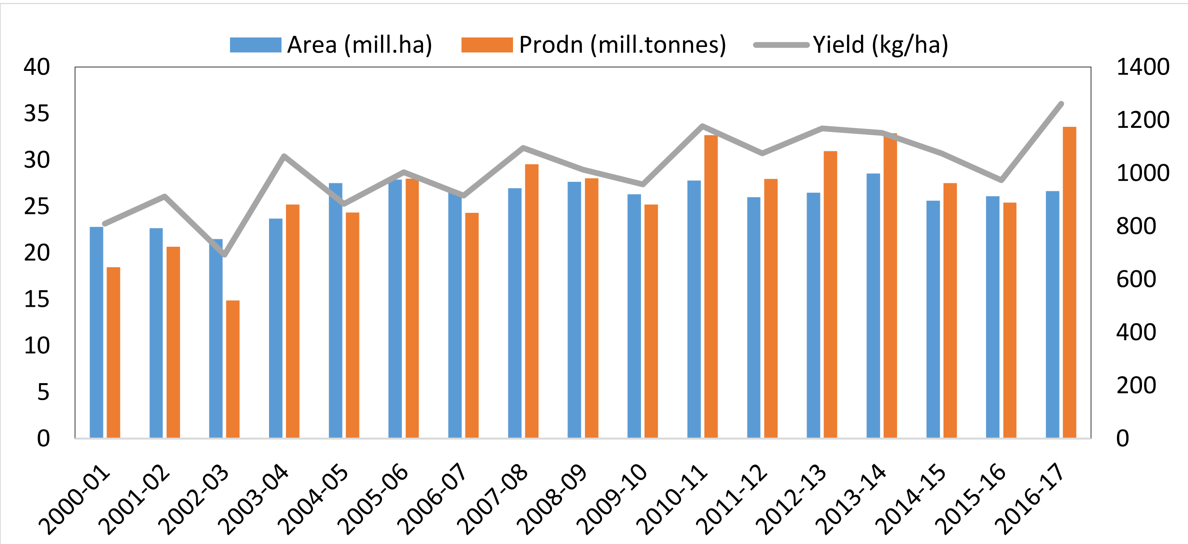
Commodity	2015-16 (P) Quantity	2015-16 (P) Value
Sesame seeds	328.46	3012.31
Niger seeds	14.12	123.27
Groundnut	542.73	4075.63
Other oil seeds	204.62	964.47
Vegetable oils	30.60	522.94
Oil meals	6578.17	16519.53
Castor oil	565.99	4309.82
Total	8264.69	29527.97

India was never a large exporter of edible oils. India's oil export basket comprised premium oils with higher value realization (refined coconut, groundnut and sesame oils) and recently de-oiled cake (DOC) oil meals, castor oil, groundnut oil and sesame oil which contribute the largest share. In the year 2015-16, India exported a total of 8.20 million tonnes of oilseeds and vegetable oil products worth Rs. 29,527.97 crore. This neutralises proportionately the country's heavy spend on imports.

8.4 Area, Production and Yield of Oilseed Crops in India

As brought out in the preceding section, annual oilseeds are cultivated over 26.67 million hectares of area producing 30.06 million tonnes annually (quinquennium ending 2016-17) (Fig 8.1. and Table 8.2). Majority of the oilseeds are cultivated under rainfed ecosystem (70%). The area under oilseeds has experienced a deceleration in general, and this is due to their relative lower profitability against competing crops like maize, cotton, chickpea etc., under the prevailing crop cultivation and marketing environments.

Figure 8.1 Trends in area, production and yield of annual oilseeds (2000-2017)



Source: DFI Committee Estimates based on data compiled from DACNET

8.5 Growth Rate of Oilseed Crops

The growth rates of all annual oilseed crops during the past decade (2001-02 to 2011-12) has been poor - negative for area and production, especially in case of sunflower, safflower, linseed & niger; and negative for area of groundnut. Soybean and castor crops have registered positive and high growth rates and rapeseed-mustard registered higher rate of production. The higher productivity driving the production (and profitability) and area expansion of castor is the best situation for oilseeds. The annual production of castor has continuously increased in the country and showed a positive growth during the period 2001 to 2013 compared to the decade of 1990-2000. The increased production has come from both increase in area and productivity implying a technology led growth.

Since the initiation of oilseed schemes in 1996-1997, area has increased by 1.8 times and productivity by 2.86 times resulting in total increase in production by 4.99 times.

However, a comparison of growth trends between XI and XII Plan periods brings out, that soybean alone among all the 9 seasonal oilseeds experienced a negative growth in yield, and positive growth in production came from a big jump of 18 per cent in area. In case of castor, both area and yield saw a positive growth. As regards other oilseed crops, area dipped, but yield growth was positive. Unfortunately, yield increase could not neutralize the area decline in case of linseed, niger and groundnut resulting in decline of total output (Table 8.3).

Table 8.3 Growth in XII Plan over XI Plan

Crops	Per cent increase/decrease		
	Area	Yield	Production
Castor	+11.10	+16.00	+27.00
Linseed	-24.60	+20.80	-7.72
Niger	-29.58	+15.10	-18.80
Groundnut	-14.00	+13.40	-2.44
Sesame	-7.70	+13.50	+5.00
Rapeseed & Mustard	+0.23	+7.20	+7.40
Soybean	+18.00	-10.00	+6.24

As per trends, vegetable oil production is around 7.0 million tonnes from about 30.0 million tonnes of oilseeds necessitating import to the tune of 10-14 million tonnes, accounting for about 60 per cent of the total (Table 8.4).

Table 8.4 Estimated domestic production, import and total availability of edible oils (Oils-Wise) during the years 2013-14, 2014-15 2016-17 (November to October) (Quantity in lakh tonnes)

Vegetable oils	2014-15		2015-16		2016-17	
	Oils	Oilseeds	Oils	Oilseeds	Oils	Oilseeds
Primary source (A)						
R-M	19.47	62.82	21.08	67.97	24.74	79.77
Soybean	16.6	103.74	13.73	85.70	22.10	137.94
Ground nut	17.02	74.02	15.27	67.33	17.16	75.65
Sunflower	1.43	4.34	0.98	2.96	0.80	2.41

Vegetable oils	2014-15		2015-16		2016-17	
	Oils	Oilseeds	Oils	Oilseeds	Oils	Oilseeds
Sesame	2.57	8.68	2.65	8.50	2.45	7.84
Niger seed	0.23	0.76	0.21	0.74	0.24	0.83
Safflower	0.27	0.90	0.15	0.53	0.22	0.78
Castor	7.48	18.70	6.16	17.52	4.99	14.21
Linseed	0.47	1.55	0.32	1.25	0.39	1.54
Sub-total (A)	**65.54**	**275.51**	**60.55**	**252.50**	**73.09**	**320.97**
Secondary source (B)						
Coconut	4.80		4.32		5.32	
Palm oil	1.71		1.98		2.30	
Cotton seed	12.15		10.05		12.24	
Rice bran	9.20		9.90		10.31	
SEO	3.00		3.50		2.85	
Tree & Forest origin	1.60		1.50		1.50	
Sub Total (B)	**32.46**		**31.25**		**34.40**	
Total (A+B)	**98.00**		**91.80**		**1047.90**	
Less exports & Industrial use	5.94		5.50		6.50	
NDA of edible oils	92.06		86.30		100.99	
Import of edible oils	138.53		148.50		153.17	
Total consumption of edible oils	**230.59**		**234.80**		**254.16**	

Source: DGCIS, Department of commerce

Considering the growing domestic demand for edible oils, the staggering deficiency and the cost to the exchequer on account of imports, the urgency of scaling up the oilseeds production does not need to be over-stated. The strategy, therefore, is to achieve a production of 45.64 million tonnes (mMTs) from nine (9) annual oilseed crops by 2022-23, expecting an additional production of about 15.58 mt over and above the 30.06 mt production (QE 2016-17) (Table 8.5). Thus, the availability of total vegetable oil from domestic production of nine annual oilseed crops would be about 13.69 mill tonnes by 2022-23 (at 30 per cent recovery) as against the current annual output of 7.0 mill tonnes.

Table 8.5 Status and anticipated area, production and yield of annual oilseed crops

Crop	Quinquennium ending 2016-17			Year 2022		
	Area (million hectares)	Production (million tonnes)	Yield (tonnes/ hectare)	Area (million hectares)	Production (million tonnes)	Yield (tonnes/ hectare)
Soybean	11.38	11.94	1.05	12.50	18.75	1.50
Groundnut	4.99	7.39	1.47	5.72	9.72	1.70
Rapeseed & mustard	6.19	7.39	1.19	7.47	11.95	1.60
Sunflower	0.59	0.44	0.75	0.97	0.87	0.90
Safflower	0.16	0.08	0.53	0.27	0.22	0.80
Sesame	1.75	0.77	0.41	1.97	1.18	0.60
Niger	0.26	0.08	0.32	0.32	0.16	0.50
Castor	1.06	1.80	1.70	1.40	2.45	1.75
Linseed	0.28	0.14	0.49	0.57	0.34	0.60
Total Oilseeds	**26.67**	**30.06**	**1.13**	**31.20**	**45.64**	**1.46**

Source: DFI Committee Estimates based on data compiled from DACNET

8.6 Vegetable Oil and Oilseeds: National Scenario

The total vegetable oil requirement in the country in 2022 has been estimated to be 33.20 million tonnes, assuming a per capita consumption of more than 22 kg per person per annum. The anticipated vegetable oil production in the year 2022 is in the range of 11-14 million tonnes (approx.), from 45.64 million tonnes of oilseeds.

The vegetable oil availability from secondary sources such as coconut, cotton seed, rice bran, solvent extracted oil (SEO) and tree & forest origin has been estimated at 5.22 million tonnes by 2022 (Table 8.7). As a sequel, the anticipated vegetable oil availability (primary + secondary + oil palm) would be around 17.03 million tonnes indicating the possible reduction in imports to the tune of about 15 per cent from the present 67 per cent by 2022. This would be an impressive achievement of reduction in import burden to an extent of about Rs. 15,000 crore vis-à-vis present status of import.

The anticipated area, production and yield of oilseed crops by 2022 is given in Table 8.4

Table 8.6 Year-wise projected area, production and yield of oilseed crops till 2022

Year	Area million ha	Production million tonnes	Yield kg/ha
2015-16 (base year)	26.09	25.25	968
2016-17	26.22	32.10	1225
2017-18	27.57	35.50	1288
2018-19	28.50	38.00	1335
2019-20	29.41	40.50	1379
2020-21	30.30	43.10	1423
2021-22	31.20	45.65	1500

Table 8.7 Assessment of vegetable oil requirement for 2022

Item/Year	2022
Expected population (billion)	1.34
Per capita consumption (kg/annum)	21.70
Vegetable oil requirement for direct consumption (mill tons)	29.08
Vegetable oil requirement for industrial use (mill tons)	4.12
Total vegetable oil requirement (mill tons)	**33.20**
Vegetable oil production from annual oilseeds (mill tons)	11.41
Vegetable oil production from oil palm (mill tons)	0.40
Vegetable oil availability from secondary sources (mill tons)	5.22
Total vegetable oilseeds requirement from 9 annual oilseed crops (mill tons)	45.64
Total vegetable oil availability (primary & secondary sources including oil palm)	**17.03**
Dependence on imports (mill tons)	**16.13**

Source:DFI Committee Estimates

It is known that excessive consumption of oil is not good for health. Unfortunately, those with affordable purchasing power and lack of knowledge relating to regulated consumption of vegetable oils, tend to increase their consumption. It is hence essential and also possible to reduce the consumption of vegetable oils by creating awareness among the consumers about optimum & healthy oil consumption habits. As per nutritional requirement, 12-13 kg per person per annum is sufficient, while an Indian is consuming more than 18 kg per person per annum. The excessive consumption habits can be normalized by educating the consumers through electronic & print media, mobile apps, advertisements, nutritional camps, general education etc. If this can be achieved, then the targeted oilseed and vegetable oils production would help in further bridging the total requirement and helps in reducing imports proportionately.

It is against this backdrop, that, the strategies for enhancing the productivity and profitability of oilseed based production system are prepared for the annual oilseeds and oil palm in the country. These are discussed in the sections that follow.

8.7 Reasons for Low Productivity of Oilseed and Oil Palm

8.7.1 Oilseeds

It would be useful to identify the generic reasons for low productivity before examining appropriate strategies needed to increase production through productivity gains. There are as follows:

- Largely rainfed cultivation (70% area), low/non-adoption of recommended soil and moisture conservation practices (like land configuration – contour cultivation – BBF); late sowing, mid-season and end-season drought/stress.
- Cultivated in areas with poor soil fertility; marginal lands.
- Low SRR (seed replacement rate) – non availability of quality seed of improved genotype at proper time.
- High seed rate required for some crops like groundnut and soybean.
- Inadequate and imbalanced nutrition (low NPK, S and Micro-nutrients) – no basal nutrition leading to low oil content.
- Low or improper plant population – broadcast sowing of sesame & niger; no thinning in sunflower, safflower, soybean, mustard, linseed; low plant stand establishment – crust, deep placement, etc.
- Less than satisfactory management and clean cultivation practices – competition and pest incidence as a result.
- No irrigation support at critical stages of crop life – water harvesting system not adopted (both *in situ* and farm pond based).
- Endemic and persistent pest and disease attack.
- Climate change impacts – rains at harvesting time, high winds and rain – loss due to lodging, flooding.

- Untimely harvesting practices– beyond physiological and harvest maturity – loss due to lodging, shattering, rodent and bird damage, etc.
- Low farm mechanization.

8.7.2 Oil Palm

The major constraints in Oil Palm cultivation are

- Oil palm has a long gestation period and restricts income flow to farmers for at least 4-5 years.
- Small holdings of farmers with limited resources.
- Fluctuation in prices of CPO (crude pamolein oil) in the international market.
- Erratic monsoon causing shortage of water.
- Competition from other economically viable crops such as rubber, arecanut, sugarcane, banana, coconut etc.
- Variation in import duty on edible oils; suggesting a need for stable trade regime.

8.8 Yield Gap Analysis

8.8.1 Primary sources (oilseeds) at different levels - farmers, national & global

The yield data under situations of FLD (Front Line Demonstration) and farmers' yield and comparison at national & global level provides an overview. As seen from Table 8.8. India's national average yields are much lower than global average. Further, within the country, there exist wide intra-state and inter-state variations. Also a substantial gap that exists between the yields under FLD and farmer's field situations is a manifestation of poor adoption of recommended cultivation practices. It simultaneously indicates the scope that is available to realise higher production through productivity gains, by improved agronomic practices in the near term.

Table 8.8 Seed yield of oilseeds (at frontline demonstrations in farmers' fields - 2007-2011)

Crop	Yield (kg/ha)		Yield (kg/ha)		IT Yield as a percentage	
	Improved technology (IT)	Farmers' practice (FP)	NAY	WAY	NAY	WAY
Groundnut	2234	1794	1418	1648	70.7	86
Soybean	1985	1495	1163	2620	37.1	44
R-M	1328	992	1170	1958	43.2	60
Sunflower	1554	1205	706	1669	160	42
Sesame	599	343	431	518	21.8	83
Safflower	1114	834	590	859	80.8	69
Niger	417	203	305	327	39.9	93
Castor	2430	1829	1604	1345	45	119
Linseed	965	565	478	986	89.4	48
Mean	**1403**	**1029**	**874**	**1376**	**65**	**66**

Source: DFI Committee Estimates based on information from NFSM

*SAY: State Average Yield of quinquennium (2010-11 to 2014-15); NAY (National Average Yield (2010-11 to 2014-15); *World Average Yield =Data pertains to 2014*

The yield performance of oilseeds is 66 per cent of the global average, with castor as an exception. India leads the world acreage, production and productivity with 119 per cent in respect of castor. For the oilseeds as a group, there is a yield gap of 65 per cent, and can be bridged by adopting the available improved technologies, that can easily double the yield of oilseeds. Highest scope exists in case of sunflower (160 per cent), while for other crops the yield gaps range from 22 per cent (sesame) to 89 per cent (linseed). The yield gaps in major oilseeds, namely, groundnut, soybean and rapeseed range from 37 to 71 per cent. If yield gaps are bridged, the increase in total output will be substantial, even if there is no change in the area under oilseeds.

8.8.2 Primary sources (oilseeds): crop- and state-wise analysis

i. Groundnut

Groundnut is primarily cultivated over an area of 5.00 million ha and the production stands at 7.00 million tonnes. The average yield levels are 14.29 q/ha (QE 2015-16) in the states of Gujarat, Andhra Pradesh, Karnataka, Rajasthan and Tamil Nadu. Kharif is the predominant cultivation season for oilseeds accounting for 84 per cent of the gross cropped area under oilseeds. The productivity levels under *kharif* season range from a meager 5.28 q/ha in Andhra Pradesh to 20 q/ha in Tamil Nadu. Low SRR, high seed requirement, bud necrosis, leaf spot disease, root grub and leaf miner are important reasons for low productivity.

Groundnut productivity ranges from 1.8 to 2.8t/ha with a yield gap between IT (improved technology) and SAY (state average yield) ranging from about 3 per cent (Tamil Nadu) to about 176 per cent (Andhra Pradesh), average an yield gap of 71 per cent nationally. Karnataka, Andhra Pradesh and Maharashtra are the important states. Yield gaps can be bridged by focusing on technology transfer.

Table 8.9 Productivity potential of whole package technologies in Groundnut (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Andhra Pradesh	65	1836	666	175.7	1418	1648
Gujarat	60	2158	1842	17.2		
Karnataka	70	1765	786	124.5		
Maharashtra	225	2402	1188	102.2		
Rajasthan	54	2857	1889	51.2		
Tamil Nadu	185	2152	2095	2.7		
West Bengal	28	2397	2233	7.3		
Total/Mean	**627**	**2420**	**1418**	**70.7**		

Source: DFI Committee Estimates

[3]SAY, NAY and WAY.

ii. Soybean

Soybean is cultivated over an area of 11.00 million ha and the production is 11.53 million tonnes registering a productivity of 10.45 q/ha (QE 2015-16) under Vertitsol in the rainfed ecosystem in Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Chhattisgarh and Telangana. There exist wide variations in the productivity ranging from around 9.5 q/ha in Karnataka and Chhattisgarh to 14.8 q/ha in Telangana, primarily due to farm level inefficiencies.

Table 8.10 Productivity potential of whole package technologies in Soybean (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Chhattisgarh	40	1657	954	73.7	1163	2620
Gujarat	45	1665	810	105.6		
Jharkhand	80	1262	931	35.6		
Karnataka	380	1899	952	99.4		
Madhya Pradesh	1596	1462	1110	31.7		
Maharashtra	384	1972	1247	58.2		
Manipur	45	1506	705	113.7		
Punjab	60	1620	NA	NA		
Rajasthan	329	1550	1230	26.0		
Tamil Nadu	40	1283	NA	NA		
Telangana	40	1995	1482	34.6		
Total/Mean	**3039**	**1595**	**1163**	**37.1**		

Source: DFI Committee Estimates

Dual problems of moisture stress (drought and excess moisture in Vertisols), non-availability of Broad Bed Furrow (BBF) equipment in adequate number, besides biotic stresses (stem fly, rust, yellow mosaic virus and spodoptera), high seed rate, low SRR, improper plant population maintenance are the major factors that limit productivity realization as per potential.

Soybean productivity ranges from 1.6 to 1.9 t/ha in general except for Jharkand, where productivity is as low as of 1.26t/ha. The yield gap ranges from 32 per cent (Madhya Pradesh) to 114 per cent (Manipur) with an average yield gap of 37 per cent. Gujarat, Karnataka and Chhattisgarh are important states for technology outreach to harvest greater productivity gains.

iii. Rapeseed - Mustard

The Rapeseed-Mustard (R&M) group is confined to *rabi* season and is largely grown in Rajasthan, MP, UP, Haryana, Gujarat and West Bengal. The R&M group of crops is cultivated over 6.1 million ha producing 7.1 million tons with average yield levels of 11.70 q/ha for the QE 2015-16.

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[3]SAY: State Average Yield of quinquennium (2010-11 to 2014-15); NAY: National Average Yield of quinquennium (2010-11 to 2014-15); World Average Yield: Data pertains to 2014.

Table 8.11 Productivity potential of whole package technologies in Rapeseed – Mustard (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Assam	30	1203	607	98.2	1170	1958
Bihar	47	2391	1105	116.4		
Himachal Pradesh	61	1193	541	120.5		
Jammu & Kashmir	87	1273	833	52.8		
Jharkhand	30	1021	672	51.9		
Madhya Pradesh	20	2245	1110	102.3		
Maharashtra	20	665	300	121.7		
Punjab	125	1866	1287	45.0		
Rajasthan	209	1878	1225	53.3		
Uttar Pradesh	100	1826	1127	62.0		
Uttarakhand	34	1597	816	95.7		
West Bengal	21	1400	1027	36.3		
Total/Mean	**784**	**1675**	**1170**	**43.2**		

Source: DFI Committee Estimates

The productivity varies from 3.0 q/ha in Maharashtra to 10.0 q/ha in West Bengal to 12.87 q/ha in Punjab. Around 50 per cent of the area receives minimal irrigation during the crop growth stage, while the remaining 50 per cent depends upon residual moisture conditions, and hence there are variations in the productivity across regions. Mustard saw fly, aphids, thrips, powdery mildew and rust are major biotic stresses. By adopting improved technology, the productivity of Rapeseed – Mustard can be raised to 1.0 to 2.4t/ha in general. Maharashtra with lowest productivity of 665kg/ha may defy this hope. However, the yield gap ranges from 45 per cent (Punjab) to 122 per cent (Maharashtra) with an average yield gap of 43 per cent. Bihar, Assam, Himachal Pradesh, MP and Uttarakhand are important states for technological intervention to improve mustard yield significantly.

iv. Sunflower

Sunflower cultivation is concentrated in the States of Karnataka, Andhra Pradesh, Maharashtra, Telangana and Odisha. It is cultivated over an area of 0.66 million ha and the production is 0.46 million tonnes with corresponding yield levels of 7.00 q/ha during *kharif* (34% area) and *rabi* (66% area) for the QE 2015-16.

Table 8.12 Productivity potential of whole package technologies in Sunflower (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Andhra Pradesh	138	2215	708	213	706	1669
Bihar	18	1483	1433	3		
Haryana	40	2489	2056	21		
Karnataka	178	2400	577	316		
Maharashtra	186	1134	546	108		

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Punjab	153	2009	1781	13		
Tamil Nadu	85	1987	1486	34		
West Bengal	245	1540	1324	16		
Uttarkhand	40	1564	NA	NA		
Total/Mean	**1083**	**1834**	**706**	**160**		

Source: DFI Committee Estimates

Spring sunflower in Indo Gangetic Plains (IGP) of Punjab, Haryana, Western Uttar Pradesh and Bihar record highest productivity of 1.8t/ha. In *kharif*, droughts of various degrees at all stages of crop especially at seed filling stage in Alfisols, and additionally water logging in Vertisols are the main reason(s) for low productivity. Further, inadequate and imbalanced nutrition, not practising thinning to create optimal population spread, severe bird damage when grown in isolated pockets; SND, Alternaria and powdery mildew diseases; and whitefly, jassids & head borer are major biotic stresses.

Productivity of sunflower ranges from 1.1 to 2.5t/ha under conditions of improved technologies of frontline demonstrations. Karnataka, Maharashtra and Andhra Pradesh record lowest productivity and account for highest yield gap of 160 per cent.

v. Safflower

Safflower is confined to residual moisture conditions during *rabi* season under Vertisols over an area of 0.18 million ha with production of 0.10 million tonnes and yield levels of 5.58 q/ha (QE 2015-16) in the States of Maharashtra, Karnataka and Telangana. It is also cultivated to a limited extent in Gujarat, Chhattisgarh and Madhya Pradesh. Uncertain *kharif* rainfall and inadequate profile soil moisture limit its productivity, affected by poor seed filling. Inadequate crop nutrition, Aphid and Alternaria are major abiotic and biotic stresses.

Table 8.13 Productivity potential of whole package technologies in Safflower (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Karnataka	361	1061	735	44.3	590	859
Maharashtra	516	1074	515	108.5		
Telangana	120	1183	732	61.7		
Uttar Pradesh	137	1139	NA	NA		
Total/Mean	**1223**	**1067**	**590**	**80.8**		

Source: DFI Committee Estimates

Productivity of safflower ranges around 1.0 t/ha in general under improved technology demonstrations with an average yield gap of 81 per cent. Maharashtra, Telangana and Karnataka are important states for technology transfer to gain higher yields.

vi. Sesame

Sesame is cultivated chiefly during *kharif* in Rajasthan, Uttar Pradesh, Madhya Pradesh and Gujarat during *rabi*/summer in West Bengal. The crop spans across an area of 1.8 million ha with production of 0.78 million tonnes, and yield level of 4.33 q/ha (QE 2015-16). This crop is confined to marginal environment under the small holders-agriculture condition. The inter-state productivity levels range from 1.9 q/ha in Uttar Pradesh to 5.12 q/ha in Madhya Pradesh during *kharif* season. The crop productivity is affected by drought, broadcast system of sowing, improper plant population, phyllody, powdery mildew and Antigastra (major insect pest).

Table 8.14 Productivity potential of whole package technologies in Sesame (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Karnataka	72	483	538	-10.3	431	518
Kerala	20	553	381	45.1		
Madhya Pradesh	80	574	512	12.2		
Maharashtra	111	458	305	50.0		
Punjab	65	592	358	65.4		
Rajasthan	28	446	321	38.9		
Uttar Pradesh	112	559	190	194.2		
Total/Mean	**488**	**525**	**431**	**21.8**		

Source: DFI Committee Estimates

Sesame productivity averages around 500kg/ha with the average yield gap ranging from 12 to 65 per cent and an average yield gap of around 22 per cent. Punjab, Maharashtra, Kerala, Rajasthan, Gujarat, West Bengal, UP & MP are important for increasing sesame productivity through technological interventions.

vii. Niger

Niger is cultivated during *kharif* season over an area of 0.29 million ha with production of 0.09 million tonnes and productivity level of 3.0 q/ha. It is cultivated in the States of Madhya Pradesh, Odisha, Chhattisgarh, Maharashtra and Karnataka. There are wide productivity variations across the states due to socio-economic and agro-ecological situations different production zones of Eastern Highland Zone of Odisha, Chhattisgarh and Madhya Pradesh), and predominantly under marginal conditions of small-holder agriculture. Drought, broadcast sowing, improper plant population, low input management, cuscuta, lodging due to high wind and rain are the causes of low productivity.

Table 8.15 Productivity potential of whole package technologies in Niger (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Bihar	60	441	NA	NA	305	327
Jharkhand	69	419	394	6.4		

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Karnataka	38	450	296	52.2		
Madhya Pradesh	95	505	273	84.8		
Maharashtra	95	372	286	30.0		
Total/Mean	**410**	**427**	**305**	**39.9**		

Source: DFI Committee Estimates

Niger productivity averages around 400kg/ha with yield gap ranging from 30 to 85 per cent and average at 40 per cent. Madhya Pradesh, Karnataka and Maharashtra are important for increasing niger productivity through technological interventions.

viii. Castor

Castor is cultivated under irrigated eco-systems of Gujarat and Rajasthan; and under harsh rainfed conditions in Telangana, Andhra Pradesh and Karnataka. The crop is cultivated over an area of 1.18 million ha with production of 1.92 million tonnes and productivity of 16.0 q/ha (QE 2015-16). The average productivity under rainfed conditions is around 5.42 q/ha, while under irrigated eco-system, it is 17.45 q/ha. in the States of Telangana, Karnataka and Tamil Nadu, where it is cultivated in kharif season. The reasons for low productivity are: pests (spodopteras, semiloper & whitefly) and diseases (botrytis, wilt); drought; inadequate and imbalanced nutrition, improper plant population, etc. Castor productivity averages around 1.6t/ha with a yield gap ranging from 20 to 500 per cent and an average yield gap of 45 per cent. Tamil Nadu, Madhya Pradesh, Telangana, Karnataka and Maharashtra are important for increasing castor productivity and production through technological interventions.

Pilot projects in Gujarat have shown, that ideal conditions of production the yields can be very high. Castor oil has certain advantages, in terms of its suitability for industrial output, providing a scope for targeted promotion. In this context, the following suggestions are made:

(i) The Department of Agriculture, Cooperation & Farmers Welfare may asses domestic demand and export potential of castor seeds and the by-products with necessary inputs from D/O Bio-Technology, D/o Commerce, D/o Chemicals & Petro-Chemicals and M/o Petroleum &Natural Gas.

(ii) Policy framework for promotion of domestic production of second and third generation derivatives, which have higher economic value may be put in place. Customs duties may need to be aligned to promote domestic value addition in this sector.

(iii) Research may be intensified by DARE/ICAR for development of high yielding varieties with a view to expand coverage and enhance productivity.

(iv) The Department of Chemicals and Petro-chemicals may initiate research on conversion processes for producing 2nd and 3rd level derivatives from castor oil. Necessary proposals in this regard may be processed for approval of competent authority.

(v) Oil Marketing Companies (OMCs) may consider setting up facilities for processing of castor seed for manufacturing lubricants and other higher order derivatives.

It may be examined whether the subject of Castor development may be allocated to the D/o Chemicals &Petro-Chemicals.

Table 8.16 Productivity potential of whole package technologies in Castor (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Andhra Pradesh	40	1109	429	159	1604	1345
Gujarat	171	2999	2029	48		
Haryana	117	3425	1133	202		
Madhya Pradesh	20	2609	459	468		
Karnataka	90	766	786	-3		
Orissa	55	767	633	21		
Rajasthan	215	3927	1460	169		
Tamil Nadu	157	1897	311	510		
Telangana	430	1740	538	223		
Uttar Pradesh	45	2014	NA	NA		
Total/Mean	**1371**	**2320**	**1604**	**45**		

Source: DFI Committee Estimates

ix. Linseed

Linseed confined to rabi season in the states of Madhya Pradesh, Uttar Pradesh, Chhattisgarh, Maharashtra and Jharkhand is considered a poor man's crop. The crop is cultivated over an area of 0.29 million ha with production of 0.15 million tonnes and average yield level of 4.95 q/ha (QE 2015-16). Utera cropping, high seed rate, inadequate plant population maintenance, inadequate nutrition, linseed bud fly are the major limitation affecting a good yield.

Table 8.17 Productivity potential of whole package technologies in Linseed (2012-13 to 2015-16)

State	No. of FLDs	Seed Yield in IT (kg/ha)	SAY (kg/ha)	% increase over SAY	NAY (kg/ha)	WAY* (kg/ha)
Assam	100	667	584	14.2	478	986
Bihar	101	1019	868	17.4		
Chhattisgarh	130	610	343	77.8		
Himachal Pradesh	60	744	279	166.7		
Madhya Pradesh	106	1238	471	162.9		
Maharashtra	120	804	257	212.7		
Nagaland	123	825	806	2.4		
Odisha	73	679	474	43.2		
Rajasthan	111	1326	1221	8.6		
Uttar Pradesh	393	987	460	114.5		
West Bengal	15	381	298	27.9		
Total/Mean	**1352**	**905**	**478**	**89.4**		

Source: DFI Committee Estimates

Linseed productivity ranges from 381kg/ha (West Bengal) to 1,326kg/ha (Rajasthan) with yield gap ranging from 2.4 per cent (Nagaland) to 166 per cent (HP & MP) and a mean yield gap of 89 per cent. The national average yield was 478kg/ha. The states of MP, HP, UP, Chhattisgarh and Maharashtra are important for technological interventions to realise higher productivity and production.

8.8.3 Oil palm - yield gap analysis of FFBs

There is wide gap in yield realization of FFBs (Fresh Fruit Bunches) in various states mainly due to improper agronomic and nutrient management of oil palm plantation. The average yield of FFBs is around 10-12 tons per hectare in most of the states, but the variation between the highest and lowest yields even within the states, is more than 25 tons/ha/year as presented in the table below.

Table 8.18 State-wise yield gaps of FFBs

State	Highest FFB yield (t/ha/Y)	Lowest FFB Yield (t/ha/Y)
Andhra Pradesh	30.00	5.00
Karnataka	50.00	0.50
Tamil Nadu	34.18	< 1.00
Mizoram	15.97	3.19
Goa	18.00	2.00

8.9 Government Schemes and Missions

8.9.1 National Mission on Oilseeds and Oil Palm (NMOOP)

This mission built upon the achievements of the erstwhile schemes of ISOPOM, TBOs and OPAE implemented during the 11th Plan period. These have had a positive impact on production and productivity of oilseeds and area expansion under oil palm, with increased production of FFBs. NMOOP comprises 3 Mini Missions (MM), one each for Oilseeds (MM-I), Oil Palm (MM-II) and Tree Borne Oilseeds -TBOs (MM-III).

NMOOP is a centrally sponsored scheme being implemented jointly by the central and state governments, sharing the expenditure in the ratio of 60:40 for general category states; and 90:10 for north eastern and himalayan states. However, there are a few interventions that receive hundred per cent central assistance. These include purchase of breeder seeds by both state and central seed producing agencies, supply of seed mini kits to the farmers through central seed producing agencies, development of seed infrastructure on the farms of SAUs/KVKs, conduct of Front Line / Cluster Demonstrations through ICAR/KVKs, R&D activities and kisan mela etc.

8.9.2 Operational area of NMOOP

The Mini Mission-I on oilseeds was implemented in 24 States *viz.*, Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Jammu and Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand, West Bengal, Arunachal Pradesh, Assam, Manipur, Nagaland, Tripura and Sikkim. The programme will continue in all these states during the next three years (2017-18 to 2019-20). The remaining states can also be included subject to potential and prospects of oilseeds in the concerned state.

Mini Mission-II of NMOOP for Oil Palm Development was implemented in 12 States, viz., Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Kerala, Chhattisgarh, Gujarat, Odisha, Mizoram, Nagaland, Arunachal Pradesh and Assam. The programme will continue in all these states during the next three years (2017-18 to 2019-20). There exists scope to include the remaining states too subject to potential and prospects of oil palm in the concern states.

Mini Mission-III was implemented in 12 States, namely, Arunachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Meghalaya, Maharashtra, Mizoram, Nagaland, Odisha, Rajasthan, Tamil Nadu, Tripura and Uttar Pradesh. The programme will continue in all these states during the next three years (2017-18 to 2019-20). The remaining states can also be included subject to potential and prospects of TBOs in the concerned states.

8.9.3 Major interventions

In addition to the above mentioned states, Central Agencies like NSC, IFFCO, KRIBHCO, NAFED, HIL, SFAC and institutions of ICAR, SAUs and ICRISAT are also involved in production and distribution of seeds including seed mini kits, and undertaking FLDs and R&D activities.

In order to encourage oilseed growers, various incentives like production and distribution of seeds, supply of minikits, plant protection equipments/ chemicals, micronutrients, supply of improved farm implements, irrigation devices, block/ IPM demonstrations, training of farmers, etc. are provided under MM-I(Oilseeds).

In order to promote oil palm cultivation assistance is provided under MM-II (Oil palm) in the form of planting materials, maintenance cost, irrigation devices, establishment of seed gardens, inputs for inter-cropping, support for oil palm processing unit in north east /hilly states and disturbed areas, farmers training, etc. Support is provided for planning materials , maintenance cost, incentives for inter-cropping , distribution of pre-processing and oil extraction equipments, farmers training etc. under MM-III (TBOs).

A new scheme under NMOOP, "Targeting Rice Fallow Area" (TRFA) is under implementation. Under this, an annual coverage of 1.50 lakh ha of area has been targeted under pulses & oilseeds for the period of 2017-18 to 2019-20 in 6 (six) eastern states including Assam, Bihar, Chhattisgarh, Jharkhand, Odisha and West Bengal.

It is apparent, that there exists an appropriate policy support under NMOOP to promote different oilseeds in the country. If the approaches suggested in chapter 9 are adopted, it is possible to realize the targeted area, productivity and production by the years 2022 and 2025.

8.10 Policy Recommendations

The strategy suggested is to work towards domestic self-sufficiency and import substitution over the next decade. The humungous export spend of nearly Rs.73,000 crore as of now can only be reduced in phases.

i) By 2022-23, the target should be to raise the current production from 30.06 million tonnes to 45 million tonnes of oilseeds (edible oilseeds – soybean, groundnut, rapeseed & mustard, sunflower, safflower, seasame & niger; non-edible oilseeds – castor & liaseed).

ii) Increase production of oil from 10.52 million tonnes (2017-18) to 16.34 million tonnes (primary and secondary sources) by 2022-23. The three (3) major oilseeds that can help achieve this are rapeseed – mustard, soybean & groundnut on account of their relative advantage in terms of area, productivity and oil conversion factor.

iii) Increase production of palm and coconut oil from 0.80 million tonnes (2016-17) to 1.00 million tonne (2022-23).

iv) Maintain a balance between market price and import duty during the phase of transition from current deficiency to domestic sufficiency over the next decade.

v) Enhance export incentives on oil, cake and oilseed commodities.

8.10.1 Towards self-sufficiency: Some critical factors:

There are three following related issues, that must be addressed to create a positive environment for enhancing domestic oil production. These are:

- Import duty structure
- Domestic processing
- Blending of oils

i) Import duty structure

On account of huge domestic deficit, India has been depending upon imports of both crude and refined oil. Consequently, import duties on different oilseeds & oils including palm oil were generally kept low. It is only over the last about a year (2017-18), that import duties have been hiked substantively to favour domestic prices, and incentivise local production. The existing duty structure is presented in Table 8.19.

Table 8.19 Existing import duty structure

Items	Applied Duty	
	Crude	Refined
Oilseeds	30% (except soybean-45%)	
Soybean Oil	35%	45%
Groundnut Oil	35%	45%
Palm Oil	44%	54%

Items	Applied Duty	
	Crude	Refined
Sunflower Oil	35%	45%
Mustard/rapeseed Oil	35%	45%
Coconut Oil	35%	45%
Olive oil	35%	40%
Cotton seed oil, safflower seed oil, saffola oil, coconut oil, palm kernel, Babassu oil, linseed oil, maize corn oil, castor oil, sesame oil, other fixed veg fats and oils	35%	45%

As seen from the table, the difference between crude & refined oils stands at 10 per cent. In fact, the difference was for long retained at a low of 7.5 per cent, making import of refined easier. When the import price between crude & refined oil was not very high, more of refined oil came to be imported, affecting domestic refineries in respect of their capacity utilisation. It is necessary to raise the duty differential such that more of crude oil gets to be imported, and feed local refineries. This differential can be a minimum of 20 per cent.

ii) ii. Vegetable oil industries

The country's vegetable oil industry is described by the following:

- Small scale expellers/Ghanis – outputs are oil and de-oiled cake (DoC)
- Solvent extraction plants – use DoC and also oilseeds directly to extract oil
- Oil refineries – use crude oil to refine, breach and de-odorise
- Vanaspati manufacturers – crude oil is hydrogenated to solidify.

The edible oil industry of the country is highly fragmented. Of the about 600 players, 12-15 are big ones accounting for a turnover of around 25 per cent. Most of the vegetable oil refineries are small scale with a 5 to 100 tpd capacity, and there are 13 major vegetable oil refineries with a capacity of 300 to 1000 tpd. Overall, the capacity utilisation is low at 35-50 per cent for different segments.

The table 8.20 below offers the current status of oil industry and capacity utilisation in the country.

Table 8.20 Capacity utilization of oil industry

Category	No of units	Processing capacity (million tonne/ year)	Capacity utilization (percentage)
Oil mills	15000	36.00	20-30
Solvent extraction plants	600	31.00	40
Vegetable oil refineries	465	20.00	50
Vanaspati units	250	3.00	40

It would be useful as a long term strategy to strengthen capacity utilisation of domestic oil industry, and some suggestions as follows are made in this regard:

- Increase supply of raw material through enhanced production of primary sources of vegetable oil (oilseeds)
- Greater exploitation of secondary sources of vegetable oils
- Enhance import duty difference between crude and refined oils with higher duty on refined oils (20% differential) to import more of crude oil
- Promote contract farming by oil industry and exporters – linking production with processors
- Safeguard mechanism against misuse of zero duty import from SAFTA countries

iii) Policy of blending of edible oils

Currently, policy regime permits blending of any two oils in the ratio of 80:20. It is seen as a result, that low priced edible oil like imported palm oil is blended with high priced quality oils like rapeseed – mustard, groundnut, sunflower, sesamum and discouraging expansion of area and production of these oilseeds, as a consequence.

As per FSSAI data, not more than two per cent of blended oil is sold in the market. However, this is only an accounted for quantum, and in reality the market share of blended oil is much higher. It is, therefore, suggested that blending regulation is strictly enforced in respect of labelling, mandatoriness of AGMARK and sale in sealed cover packs.

The labelling should clearly exhibit the oils and respective ratio of blending, which is not the practice now.

8.10.2 Price support for palm oil

Palm species has a certain gestation period before it begins to fruit. And it is a perennial species with an yielding life span of 35-40 years. Hence, growers need price support. In this context, it is suggested that whenever international prices for crude palm oil (CPO) fall below a certain level, the growers be compensated with the differential. A threshold of US $ 800 per tonne of CPO is suggested for the now.

In order to support such a price mechanism, Government may consider to create an 'Edible Oil Development Fund (EDOF)' by imposing a cess of 0.5 per cent on import of both CPO, and RBDPL.

It must however be noted, that major push towards domestic self-sufficiency will come from focus on primary sources, namely, 7 edible oilseeds and 2 non-edible oilseeds. The share of palm oil by 2022-23 and 2030 will still remain small. The production strategy should be designed accordingly.

8.10.3 National Mission on Vegetable Oils

Given the huge deficit of edible oils that India faces, as also the necessity of meeting the increasing demand for industrial oil, a National Mission with the following mandate is suggested.

- Adopt an accelerated pace of production of indigenous oilseeds
- Increase vegetable oil production mainly from primary Source (annual oilseed crops both edible & non-edible)
- Increase vegetable oil production from Secondary Source (rice bran, coconut, cotton seed, oil palm and TBOs)
- Enhance capacity utilization of domestic processing industries
- Reduce per capita consumption of edible oil and minimize import. Campaign for a healthy oil consumption.
- Promote consumption of coconut as edible oil.

Chapter 9
Oilseeds - Broad Strategies for Increasing Production

The strategies encompass both production and post-production aspects. And there exists adequate space and scope to increase the production through productivity gains in the near term by stressing on adoption of good quality seeds and other agronomic practices. However, the incentive for this has to come from remunerative price returns.

9.1 High Area-Low Productivity Districts

Addressing the issues of technology in low productivity districts, but with high area under cultivation is a potential opportunity in increasing the productivity of oilseeds. The strategy will involve demonstrating improved technologies in "High Area-Low Productivity" districts; and crop expansion/diversification programme in "Low Area-High Productivity" districts / regions.

Table 9.1 Hotspot areas that need immediate interventions

Crop	District / Division / Region
Groundnut	Anantapuram (A.P)
Sesame*	Rajkot (GJ), Jalore region (RJ), Cauvery Delta Zone (TN), Central Plain region (UP), Bundelkhand (UP)
Soybean	Malwa and Vindhya Plateau (M.P)
Rapeseed-Mustard	Pali, Jodhpur, (RJ)
Sunflower	Vijayapura, Bagalkote, (KA), Kadapa, Kurnool (AP), Marathwada region (MH)
Safflower	Marathwada region (MH); Hyderabad, Karnataka Region (HKR) comprising the districts of Bidar, Yadgir, Raichur, Koppal, Bellary and Gulbarga (KA)
Linseed	Balaghat, Chhatarpur, Damoh, Rewa, Satna, Seoni, Sidhi,(M.P), Chandrapur (MH),Hamirpur,Mahoba, Mirzapur, Sonbhadra (U.P)
Niger	Balrampur, Bastar, Jashipur,Sutguja (CG), Bidar, Mysore, Tumkur (KA),Annupur, Betul, Chindwara, Dindhri (M.P), Nasik (MH), Koraput, Kendujhar, Kandhamal, Rayagada (OD)

Table 9.2 Expected oilseeds area (mill.ha) and production (mill.tonnes) by 2022

Sources	Area	Oilseeds Production	Oil production (mill.tonnes)	Actions
Primary Sources	26.50	39.75	10.00	NFSM-Oilseeds & Oil palm is under implementation
Rice fallow	1.50	2.25	1.50	TRFA Scheme in place but need extension to Punjab, UP, Bihar, Guj, AP, Kar, TN
Inter-cropping	1.00	1.50		Separate intercropping demonstrations may be included (all states)
Non-traditional area	1.00	1.50		UP, Haryana , CH, Bihar Jharkhand, Telagana, NE States may be focused with separate project
TOTAL	**30.00**	**45.00**	**11.50**	

The broad strategies for higher income from oilseed cultivation encompass:

- Increase in productivity.
- Reduction in cost of cultivation.
- Increase in area under oilseeds.

9.2 Suggested Technological Interventions

9.2.1 Increasing productivity:

Improved varieties and hybrids: Productivity can be enhanced by 20-30 per cent by adopting promising varieties or hybrids as recommended for different agro-ecological situations. (see Annexure A4).

Seed Replacement Rate (SRR): The major improvement in oilseeds production can be expected from using improved varieties/hybrids with vigour for higher yield & quality, and tolerance/resistance to pest and diseases. The current SRR is low, ranging from less than 5 per cent in niger and linseed to about 70 per cent in rapeseed, soybean and groundnut crops. This is due to the weak seed chain link and this needs urgent strengthening.

It is desirable to achieve a SRR of 35 per cent in self-pollinated crops (groundnut, soybean, sesame, linseed); about 50 per cent in cross-pollinated crops (mustard, sunflower, castor, niger); and 100 per cent in case of hybrids.

In fact SRR alone is not adequate to reap the benefits that are possible from using a good seed. It is important to opt for the latest releases. Hence, adoption of optimal Varietal Replacement Rate (VRR) is critical to harvest high yield levels. While SRR is a sufficient condition, VRR is a necessary condition. This holds good, not only for oilseeds but in case of all crops. One of the important interventions needed in respect of seed chain is to weed out the long standing (>10 years) seed varieties and replace them with new releases. A roadmap for such a transition is necessary. Within a certain timeframe, all old varieties should be phased out and thereafter it should become an institutional system.

Soil and moisture conservation technologies: Adoption of recommended soil and moisture conservation measures as per the demands of soil and region will result in 30-50 per cent improvement in yield across oilseed crops. Some suggestions are:

- Contour cultivation for all crops.
- Broad Bed and Furrow (BBF) and Ridge & Furrow method for soybean, groundnut, safflower especially in black soils
- Paired row cultivation for sunflower

Irrigation management: Low productivity of oilseeds and year to year variation in production are due to their cultivation under rainfed and marginal land environments, with high proneness to drought. However, oilseeds have the highest return from investment for limited irrigation at critical stages of crop growth.

Utilizing the harvested rain water or providing supplemental irrigation at critical stages for oilseeds results in productivity improvement to the tune of 30-50 per cent.

Table 9.3 Response of oilseeds from limited irrigation

Oilseed crop	Increase in yield (%)
Groundnut	25-30
Soybean	10-20
Rapeseed & Mustard	16-42
Safflower	17-53
Castor	26-63
Sunflower	23-60

Improving water use efficiency (WUE) through proper land configuration and adopting micro-irrigation methods such as sprinkler for groundnut and all other crops upto flowering stage; and drip irrigation for all crops at all stages can enhance water productivity significantly, yielding thereby an opportunity to bring in additional area under irrigation using the same amount of water. Necessary institutional support in terms of financial assistance as being provided by the government may be further strengthened.

Balanced nutrient management: Oilseeds are energy rich crops and demand high intensity of nutrition. Nutrient management is a primary need for enhancing oilseeds productivity. Currently, only about 1/3rd of the total nutrient requirement is met from fertilizer application resulting in mining and low realization of genetic potential. Application of NPK fertilizers as per the recommended dose and balancing it with secondary (sulphur) and micronutrients (Zn, B, etc.) as per the soil test will enhance oilseed productivity and quality significantly to the tune of 15 to 35 per cent.

Fertilizer management based on cropping system that includes legume as a preceding crops would usher in higher use efficiency. Soil test based fertilizer application can result in reduced fertilizer application and improved yield. Integrated crop management by adopting 'Best Management Practices (BMP)' relating to land preparation, higher productivity, profitability and resource use efficiency. An increase in yield to the tune of 20 to 30 per cent across oilseeds can be expected.

9.2.2 Reducing cost of cultivation:

Resource use efficiency: The contribution of Total Factor Productivity (TFP) to change in growth of production in rapeseed-mustard, soybean and groundnut ranged from 6 to 27 per cent suggesting the need for higher technology infusion and improving efficiency of resource use in production of oilseeds. Some suggestions in this regard are:

- Ensuring quality seed could result in avoidance of use of excess seed rate (especially in soybean and groundnut) reducing cost of cultivation by 25 per cent.
- Optimum plant population maintenance ensures higher seed yield through enhanced resource use efficiency.
- The high seed rate requirement of groundnut and soybean could be significantly rationalised (upto 25 per cent) by selective grading for small and high quality kernels/seeds. Seed selection needs close attention.
- Seed treatment – chemicals, bio-inoculants (*Azospirillum*, *Azotobacter*, *Rhizobium*, PSB, Biophos, etc).
    - *Rhizobium* based seed treatment for groundnut and soybean to save N application by 20-25 per cent.
    - Seed treatment with *Azospirillum* and *Azotobacter* could save 20 to 30 kg N/ha in crops like sesame, sunflower and safflower under both rainfed and irrigated conditions.
    - Soil application of phosphorus solubilising bacteria (PSB) can mobilize fixed P in soil and reduce the need for its external application.
    - Bio-phos application can reduce P requirement for castor

More details are contained in the Annexure

Conservation principles: Reduced or zero tillage; and management of residues such as mulch-cum-manure are recommended, especially for paddy fallow situations. Some examples are:

- Mustard under zero tillage in paddy fallows.
- Sunflower under zero tillage in paddy fallows of Guntur and Nizamabad region.
- Sesame in rice fallows of coastal belt of A.P, Odisha, W.B.
- Castor in paddy fallows in Cauvery belt of Tamil Nadu.
- Groundnut under zero tillage in paddy fallows in Konkan region of Maharashtra.

Small farm mechanization – can improve farm management practices: Some of the useful machinery that will aid in timely harvesting & threshing of soybean, mustard etc include seed-cum-ferti drill, groundnut decorticator, castor thresher, sunflower and safflower combine harvester.

Custom Hire Services (CHSs) offer a good option of servicing the small & marginal farmers, who cannot afford to buy on their own.

9.2.3 Area expansion for higher production

Additional area can be brought under oilseeds cultivation by adopting different approaches brought out briefly hereunder:

- Increase in cropping intensity to enhance land use efficiency and higher production from the same acreage (details in Annexure).

- Inter-cropping with major crops of the region.
  - Sunflower with groundnut, pigeonpea and soybean.
  - Castor with groundnut, pigeonpea, clusterbean and mungbean.
  - Safflower with chickpea, coriander and rabi sorghum.
  - Linseed with wheat and chickpea.
  - Soybean with pigeonpea, maize, sorghum, cotton, sugarcane and orchard crops.
  - Groundnut with pigeonpea, cotton, pearlmillet, cowpea, maize, sesame, castor, sugarcane and plantation crops.
  - Mustard with chickpea and lentil.

- Extending oilseed cultivation to post-kharif fallows of rice and other crops
  - Sunflower and sesame in West Bengal and Eastern India at large.
  - Groundnut in rice & potato fallows; river basin in Odisha and West Bengal; and Dessa in Gujarat.

- Extending oilseed cultivation to non-traditional areas and non-traditional seasons
  - Spring sunflower in IGP (Indo-Gangetic Plains) region; rabi sunflower in West Bengal, Odisha.
  - Spring groundnut in Uttar Pradesh.
  - Safflower in Gujarat and Madhya Pradesh in rabi season.
  - Mustard in Andhra Pradesh, Telangana and Karnataka.
  - Soybean in Telangana.
  - Rabi castor in Telangana, Karnataka and Tamil Nadu; Castor in Haryana.

9.3 Cultivation Area and Production strategies

In the preceding sections, the broad technological and management practices have been discussed with or view to achieving higher farm profits from oilseed cultivation. The approach is based on the principles of productivity enhancements, resource use efficiency for reduced cost of cultivation and bringing additional area under cultivation.

In this section, the targeted productivity and production by the year 2025 as also the broad approaches to realise the same are presented.

Table 9.4: Productivity approach based targeted production by 2025

Improving crop productivity (kg/ha)		Production Target (mill tons) Year 2025
Soybean	1000-1600	20.00
Groundnut	1240-2000	13.00
R-M	1250-1820	14.30
Sunflower	620-1000	1.60
Safflower	580-950	0.32
Sesame	450-750	1.55
Niger	330-600	0.22
Castor	1454-1850	2.41
Linseed	410-650	0.32
	Total oilseeds production (1)	**53.72**

Table 9.5 Additional area approach based targeted production by 2025

Crop	Potential area (mill ha)	Production target (mill tons) Year 2025
Soybean	2.1	2.00
Groundnut	1.50	3.00
Rapeseed-Mustard	1.08	7.75
Sunflower	0.30	0.16
Safflower	0.20	0.10
Sesame	0.75	0.06
Niger	0.06	0.04
Castor	0.40	0.18
Linseed	0.42	0.09
	Total oilseed production (II)	**13.38**
	Grand total of oilseed production (I + II)	**67.10**
	Total availability of domestic vegetable oil	**20.00**

Table 9.6: Reduced crop duration approach and targeted production by 2025

Description	Crop	Reduction in maturity (days)
	Soybean	10
	Groundnut	10
Reduction in maturity duration and enhancing photo-thermo insensitivity in oilseed crops to address the issue of diversification of existing cropping systems and also to introduce them in new niches	R-M	10
	Sunflower	15
	Safflower	20
	Sesame	10
	Niger	10
	Linseed	15

Table 9.7 Approach-wise activity and action plans

Approach 1: Productivity enhancement

(i) Activity and action plan

Activity	Action Plan
Popularization of improved technology for bringing yield gap across oilseeds	• Large scale demonstrations • Capacity building of stakeholders
Production and timely supply of sufficient quantity of quality seed of latest released varieties for improving seed replacement rate (SRR)	• Advance planning for each state rolling seed plan; public-private partnership & participatory seed production; production of sufficient quantity of breeder seed & their conversion into foundation & certified seed; maintenance of seed buffer;
Provision for irrigation at critical stages in oilseeds districts	• Micro-irrigation through sprinklers/drip & rainwater harvesting
Ensuring availability of critical inputs in time	• Timely availability of critical inputs like bio-fertilizers, sulphur, zinc, gypsum, boron, bio-pesticides etc. at field level
Mechanization for oilseeds production	• Farm machinery for essential agricultural operations through cooperatives or custom hiring

(ii) Required policy support for enhancing productivity

- Delineating oilseed crops' eco-logical zones for higher production in the major oilseed growing states such as Gujarat, Rajasthan, Karnataka, Telangana, MP, MS, AP, TN.
- Credit, insurance, subsidies, MSP & procurement.
- Infrastructure for processing – innovative institutional models of processing & marketing like Amul, Parag, Dhara, Saffola etc.
- Marketing support in non-traditional areas, cooperative, contract farming.
- Referral Labs to estimate aflatoxins in groundnut & pesticide residue in sesame.
- Cold-storage for export-quality groundnut production in Gujarat, AP & TN.

(iii) Research strategies – Genetic enhancement

- Development of photo-thermal insensitive varieties of Soybean with high yield & wider adaptability across planting time and latitudes.
- Development of speciality soybeans for higher quantities & quality of oil, low/null anti-nutritional factors and vegetable types.

- Development of high yielding groundnut varieties with better confectionary/food qualities and tolerant to moisture heat and photoperiod stresses.
- Genetic enhancement of rapeseed-mustard for yield, quality and tolerance to abiotic & biotic stresses and identification of genes of breed climate resilient genotypes; and development of hybrid technology.
- Development of hybrids/varieties for high yield in castor, safflower, sesame, sunflower and linseed with tolerance to biotic and abiotic stresses.
- Breeding refinement of CGMS based hybrid seed production in safflower and development of CMS hybrids in seasame.
- Development of speciality type varieties – high oleic sunflower & safflower, white & large seeded sesame, dual purpose safflower with high petal yield and linseed with good quality fibre & high linolenic acid (70 per cent).

(iv) Research strategies – crop managment

- Developing climate resilient conservation agriculture practices for oilseed based cropping systems.
- Refinement of agro-techniques for high productivity of oilseeds.
- Biotic and abiotic stress management techniques in oilseeds.
- Development of bio-pesticides & bio-inoculants and SSNM based balanced nutrition and efficient weed control.
- Development of new agricultural machinery.
- Development/refinement of broad bed-furrow planting methods and fertigation through drips using liquid fertilizer for red soil areas of AP, TN and medium black soils of Karnataka & Maharashtra.

Approach 2: Increasing area under oilseed cultivation

(i) Through inter-cropping

Oilseeds	Potential crop for intercropping	Specific area/niche
Soybean	Sugarcane (IR), blackgram, greenpea, pigeonpea & sugarcane	MS, Telangana & Karnataka
Groundnut	Pigeonpea	AP, TN, MS, UP (Bundel), Karnataka & Gujarat
	Castor & soybean	AP, TN, Gujarat & MP
	Maize, sorghum & pearl millet	Raj., Bihar, Pun., NEH, MS, UP, Karnataka & Gujarat
	Cotton	Gujarat, MS, AP & TN
	Sugarcane	MS, UP, Bihar

Oilseeds	Potential crop for intercropping	Specific area/niche
	Coconut & Cassava	Kerala, AP & TN
R-M	Sugarcane (IR)	UP & Bihar
	Potato	UP
	Chickpea, lentil & wheat	Rajasthan, UP & MP
Sunflower	Groundnut, pigeonpea & soybean (kharif)	Karnataka & MS
Safflower	Chickpea, coriander & sorghum	AP, MS, Karnataka, MP, CG
Sesame	Greengram, blackgram & redgram	AP, TN & Karnataka
Castor	Groundnut & pigeonpea	Telangana & TN
Linseed	Chickpea	UP, MP, Gujarat, Rajasthan & MS

(ii) Through cultivation in rice fallow post the kharif

Crop	Area of rice fallows	Potential area (mha)
Soybean	Punjab	2.00
Groundnut	TN, AP, Odisha, WB & Goa	0.50
Rapeseed-Mustard	UP (E), Bihar, WB, NEH, Jharkhand, Odisha & CG	1.20
Sunflower	AP, Karnataka, Odisha & WB	0.50
Sesame	WB, Odisha, Gujarat, TN & AP	1.00
Linseed for Utera situation	CG, WB, Odisha, Bihar & Assam	1.00
	Total	**6.20**

(iii) Through cultivation in non-traditional areas

Crop	Non-traditional areas	Potential area (mha)
Soybean	MS, Rajasthan, Gujarat, Telangana, Jharkhand, NEH	2.00
Groundnut	UP (C&W), Gujarat, WB, Assam	0.51
Rapeseed-Mustard	Karnataka, Rajasthan(S), Ratlam (MP) & Vidarbha (MS)	0.30
Sesame	NEH	0.50
Safflower	Saline situation of Gujarat, MP and CG	0.10
Castor	TN, Haryana, Karnataka & Odisha	0.50
Linseed	NEH	0.03
Niger	AP, Karnataka & TN	0.05
	Total	**3.99**

Approach 3: Reducing the crop duration

(i) Research strategies

Crop	Research strategies
Soybean	• To bring down the crop duration to 80-85 days
Groundnut	• Development of early maturing (85-95 days) varieties with least reduction in biomass • Use of endophytic microbes to tide over extreme environmental conditions & reduce duration • Development of photo and thermo-insensitive pre-breeding genotypes which can be used in breeding programmes as donors to eventually reduce the crop duration
R-M	• Population improvement in toria for 75-80 days and recombination breeding for high seed yield with early maturity and development of high yielding early maturing hybrids for yellow sarson and Indian mustard for 90-95 days and 110-115 days, respectively
Sunflower	• Development of short duration hybrids for spring season cropping systems in Punjab, Haryana and UP (W); tail and regions of irrigation commands; tide over late onset or early cessation of monsoon in southern India and rabi summer in WB & Odisha for 90 days through pre-breeding programmes
Castor	• Development of short duration hybrids (90-100 days) with ideal plat type for mechanical harvest
Safflower	• Development of short duration varieties / hybrids (90-100 days) for late sowing and paddy fallows
Sesame	• Short duration varieties (80-90 days) for contingency cropping / new niches & season
Linseed	• Short duration varieties (100-105 days) for utera situation and residual moisture

9.4 Oilseeds – Anticipated Area, Production and Productivity by 2025

Table 9.8 Crop-wise area, production and productivity targets

Crop	Average TE ending 2013-14			Year 2025		
	A	P	Y	A	P	Y
Soybean	11.00	13.07	1.2	13.10	20.00	1.6
R-M	06.59	07.34	1.1	07.90	14.30	1.8
Groundnut	04.99	06.80	1.4	06.60	13.00	2.0
Sunflower	00.82	00.57	0.7	01.20	01.60	1.2
Sesame	01.60	00.71	0.4	01.80	01.55	0.8
Safflower	00.18	00.11	0.6	00.32	00.32	1.0
Linseed	00.33	00.14	0.4	00.48	00.32	0.7
Niger	00.28	00.09	0.3	00.36	00.22	0.6
Castor	01.20	01.75	0.5	01.25	02.41	1.9
Total Oilseeds	**26.99**	**30.58**	**1.1**	**33.01**	**53.72**	**1.7**

9.5 Developmental strategies

In the following table, the strategy consisting of various activities, action plan and agencies responsible is brought out.

Activity	Action Plan	Agencies responsible
Special pilot projects in high productivity zones for rapeseed-mustard	• Assured supply of quality seed • Balance application of micronutrients besides NPKS • Pressurised fertigation and application of biofertilizers. • Management of crop residues, soil health resilience, biotic & abiotic stresses. **In Haryana (**Rewari, Bhiwani, Mehendergarh); **MP (**Morena, Bhind); **Rajasthan** (Bharatpur, Dholpur, SawaiMadhopur, Bundi, Kota, Alwar and Tonk); **UP (**Agra Mathura) and **WB (**Nadia)	**ICAR, SAUs, SDA, KVKs Central seed agencies, SSCs**
Production and timely supply of sufficient quantity of quality seed of latest released varieties/ hybrids for improving seed replacement rate (SRR)	• Production of sufficient quantity of breeder seed. • Advance seed planning for each state rolling seed plan with appropriate emphasis to the newly released varieties/hybrids • Conversion of breeder seed to foundation & certified seed and maintenance of seed buffer. • Public-private partnership and farmers' participatory seed production for farmer-to-farmer seed spread	**ICAR, SAUs, KVKs, DAC&FW, Central seed agencies& SSCs**
Provision for irrigation at critical stages in oilseeds districts	• Micro-irrigation through sprinklers or drip • Rain- water harvesting in farm ponds and community reservoirs	**DAC&FW, SDA & SDI**
Ensuring availability of critical inputs in time	• Ensuring reliable soil testing facilities and encouraging the oilseed farmers for balance fertilization to use major, secondary and micronutrients (Zn, B and Fe), S through gypsum or super phosphate, biofertilizers like *Azospirillum*and *Azotobacter* • Timely availability of critical inputs like bio-fertilizers, sulphur, zinc, gypsum, boron, bio- pesticides etc. at field level	**DAC&FW& SDA**
Mechanization for oilseeds production	• Farm machinery for essential agricultural operations like tillage, planting, harvesting, inter-cultivation, threshing, processing etc. through cooperatives or custom hiring	**ICAR-CRIDA, ICAR-CIAE, SAUs & DAC&FW,SDA**
Ensuring adequate quality propagation material of oil palm	• Through clonal seed production through tissue culture of elite parents	**DAC&FW & SDA**

9.6 Incentivizing through Post-production Support

While the DFI Committee in general lays greater store by a robust market structure and efficient marketing system, it also is convinced that there is a critical role of encouraging MSPs and attendant procurement, when markets slump. There has been a steady increase in the level of MSPs for various oilseeds over the years. However, the procurement operations have begun to get more visible only recently. Under the government's Price Support Scheme (PSS), total procurement of oilseeds in the year 2016-17 was around 2.20 lakh metic tonnes (NAFED,

2017) accounting for 0.6 per cent of the year's output. The marketed surplus ratios for the oilseeds in general stand at 90 per cent.

Increased percentage of procurement will offer greater assurance to the oilseed growers and even out market fluctuations. Oilseeds are vulnerable at storage level. Post-harvest loss in India is estimated at 5 to 10 per cent (CIPHET, 2015) primarily due to poor storage and pest infestation. This needs to be addressed. Management of import-export regime is critical for incentivizing oilseeds production. For long, imports have been easy affecting domestic prices negatively. Suitable correction in respect of both refined and crude oil has been initiated in the year 2017-18 whose positive impact by way of higher domestic prices (favourable to the farmer-producers) will be felt over the period, provided such a favourable trade regime is sustained. India has been making good the domestic shortage by importing palm oil from countries like Malaysia, Canada etc. It is necessary to balance the import duty, in such a way that local oilseeds production and domestic refining capacity of the processing plants are both taken care of. As per the latest notification of the Department of Commerce, the duties on import of crude palm oil and refined palm oil are 30 per cent and 40 per cents respectively. This is an encouraging policy support towards achieving domestic sufficiency of both oilseed & vegetable oils.

Chapter 10
Roadmap for Promotion of Oil palm

Oilseed crops alone will not be able to meet the growing domestic demand for edible oil. Oil palm cultivation is another important activity, that can be leveraged to strengthen domestic production of vegetable oil. Oil palm is a perennial tree species with highest edible oil yield potential of 4-6 tonnes/ha/yr. It also enables utilization of its by-products, contributing to income enhancement of farmers. This chapter examines the constraints, strengths and strategies relating to promoting oil palm cultivation in the country.

10.1 Introduction

Oil palm is the crop that enjoys greater advantage in terms of productivity, which is much higher than that of annual oil seed crops. Oil palm produces 4 to 6 tonnes of crude palm oil per hectare and 0.4 to 0.6 t of palm kernel oil from 4^{th} to 30^{th} year of its productive life span. Government of India has been expanding the cultivated area under oil palm in order to bridge the gap between consumption and domestic production of edible oil, as its import is causing a great loss to the exchequer.

Though Oil Palm Development Programme in the country is progressing well, area expansion is not happening as per envisaged targets. As of 2012, various Expert Committees constituted by the Ministry of Agriculture, Government of India have identified a total of 19.33 lakh hectares in 18 states of the country as suitable for oil palm cultivation. By March 2017, an area of 3.15 lakh ha alone has been covered under oil palm through various programmes.

The production of Crude Palm Oil (CPO) is about 12.50 lakh tonnes. The yields obtained by progressive farmers of Andhra Pradesh and Karnataka, under optimum cultural and irrigated conditions, are between 20 and 25 tonnes of FFB ha^{-1} yr^{-1} i.e.4-5 tonnes of oil ha^{-1} $annum^{-1}$ from fourth year onwards. The highest yield of 30-35 tonnes of FFB ha^{-1} yr^{-1} during the seventh year was also recorded in many plantations. One of the farmers in Karnataka could achieve a record yield of 52.3 FFB ha^{-1} yr^{-1}.

Two major factors that influence the Indian farmers are market and monsoon plus irrigation availability. Oil palm is served by well-structured market facilities in terms of price fixation mechanism by the respective governments of oil palm growing states. Unlike in other countries viz., Malaysia and Indonesia where oil palm is grown over very large areas with assured rainfall, it is grown as small holders' crop under irrigated conditions in India.

Therefore, the strategies for enhancing the income of farmers in India have to be definitely different from that of other countries. Doubling the income within a short span of 6 years is a difficult task in oil palm as it is a long duration crop; and developing technologies for higher production including new planting material takes a very long time. The status of state-wise districts covered under oil palm cultivation is given in Annexure (Table A10).

The current and projected status of Oil Palm is as follows:

Area covered under oil palm by March 2017	- 3.15 lakh hectares
Production of FFB by March 2016	- 12.82 lakh tonnes
Production of CPO by March 2016	- 2.21 lakh tonnes
Projected additional area by 2022	- 1.00 lakh hectares
Projected additional production of CPO	- Approx 0.4 million tonnes

10.2 Projected Palm Oil Production

Being a perennial species with long gestation period, as well as long productive life, it would be appropriate to project production from a long term perspective, as in Table 10.1.

Table 10.1 Projected palm oil production

Year	Area (lakh ha)	FFB yield (tonnes/ha)	Oil yield (tonnes/ha)	Oil production (million tonnes)
2020	5.0	17	3.74	1.87
2030	15.0	20	5.76	7.20
2040	18.0	22	6.25	9.90
2050	20.0	26	7.02	14.04

FFB: Fresh Fruit Bunches; OER: Oil Extract Ratio
Oil Yield at Research Stations is projected to reach 12.00 tonnes/ha by 2050

10.3 Constraints in Increasing the Production

Some of the constraints particularly as viewed by the farmers are as follows:

- Labour shortage and high wages
- Ceiling limit on micro-irrigation installation subsidy
- Fluctuating prices of FFB (fresh fruit bunch)
- Not covered by Minimum Support Price
- Subsidy portion of planting materials is low and affects the poor farmers
- Inadequate application of fertilizers to the mature plants
- High transportation cost of harvested FFBs to Collection Centres
- Small holdings of farmers
- Inability to take up oil palm cultivation in large compact areas (captive plantations) due to Land Reforms Act
- Long gestation period
- Erratic monsoon and successive drought – drying of bore-wells
- High income from other competing crops
- Price instability and absence of MSP for oil palm

- High cost of nursery raising and maintenance of seedlings
- Low Oil Extraction Ratio (OER)
- Non-availability of flat land
- Difficulty in FFB collection due to scattered areas

10.4 Technological strengths of palm oil tree

- Identified germplasms that yield:
  - 10.4 t/ha of oil
  - 30.6 per cent oil to bunch ratio

This would enlarge the scope for oil palm crop improvement initiatives

- New hybrids with higher productivity potential:
  - 7-8 tonnes oil/ha (third generation planting materials)
  - dwarf hybrids with 6-7 tonnes oil/ha
- Technologies developed for:
  - nursery management
  - hybrid seed production
  - irrigation and fertilizer requirement
  - nutrient re-cycling
  - plant protection
  - micro-irrigation system
  - fertigation approach
- Ten (10) oil palm seed gardens with 70 lakh sprouts annually
- Production of advanced parent materials (>7.5 t oil/ha/yr)
- Twenty (20) best performing genera hybrids yielding more than 200 kg FFB/ha/yr identified
- Five suspected drought tolerant high yielding DxD palms (80) identified for high oil content
- Twenty five crosses (inter se and selfs) developed using best available Duras from various gardens and new Dura Improvement experiments
- Development of self propelled hydraulic operated machine, elevated platform on tractor trolley and motorized sickles
- Location specific fertilizer schedules were developed for the states of Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra

10.5 Strategies for Enhancing Oil Palm Production

10.5.1 Through resource management

- Irrigation is a critical input for higher production in oil palm. Practising micro-irrigation (drip/ micro-jet system) could save 25-50 per cent of water in different seasons and soils. Irrigation through micro-irrgation should be made compulsory for realising increased yields (to the tune of 25-30 per cent).
- Fertigation with a dose of 600-300-600 g NPK/palm/year and irrigation scheduling linked to potential evapo-transpiration would give 25 per cent increase in yields.

10.5.2 Through cropping system / farming system

- Growing of inter-crops in oil palm like cocoa, red ginger, heliconia, bush pepper, banana and ornamental crops would yield a cost: benefit ratio of 1:2.38 to 1: 2.86 and net returns ranging from 1.02 to 1.24 lakhs per ha.
- Adopting oil palm based mixed/ integrated farming system with fodder crops, dairy (a pair of cattle) and back-yard poultry (100 birds) would offer a cost: benefit ratio of 1:3.28.
- Nutrient recycling of oil palm bio-mass (15-17 t/ha/year) through vermi-composting and such other techniques could reduce the use of inorganic fertilizers by around 50 per cent.
- Mechanization of harvesting of oil palm FFBs would save labour costs. Establishing custom hiring centres (CHC) would help in promoting farm mechanisation among farmers, besides creating jobs for the youth.

10.5.3 Measures to increase area under oil palm

- Establishment of oil palm seed gardens with advance breeding materials.
- Ensuring planting material requirements proportionate to the targeted area expansion programme.
- Realistic fixation of targets for area expansion and to be planned 2-3 years in advance
- Declaration of assured FFBs prices as per cost of cultivation.

Table 10.2 Potential districts for expanding oil palm plantation

State	Oil palm growing districts
Andhra Pradesh	East Godavari, Krishna, Nellore, Srikakulam, Visakhapatnam, Vizianagaram, West Godavari, Anantapur
Telangana	Khammam, Nalgonda
Chhattisgarh	Bastar, Dantewada
Goa	North Goa, South Goa

State	Oil palm growing districts
Gujarat	Valsad, Navsari, Surat, Anand
Karnataka	Mysore, Mandya, Chamarajnagar, Hassan, Kodagu, Shimoga, Chickmaglur, Bijapur, Bagalkot, Gulbarga, Davangere, Haveri, Bellary, Gadag, Koppal, Raichur, Belgaum, Uttar Kannada, Yadigiri
Kerala	Trivandrum, Kollam, Pathanamthitta, Alappuzha, Kottayam, Ernakulam, Malappuram, Kozhikkode, Wayanadu
Odisha	Koraput, Rayagada, Ganjam, Gajapati, Dhenkanal, Jajpur, Mayrubhanja, Balasore, Bargarh, Navrangpur, Cuttack, Bhadrak, Nayagarh, Boudh
Maharashtra	Kolhapur, Sangli, Sindudurga
Mizoram	Kolasib, Lunglei, Mamit, Serchhip, Lawngtlai, Aizwl
Tamil Nadu	Karur, Nagapatnam, Perambalur, Thanjavur, Theni, Tiruvarur, Tirunelveli, Trichy, Cuddalore, Villuppuram, Vellore

10.5.4 Strategies for oil palm area expansion & FFBs yield

- Rapid area expansion programme
  - Assured price of FFB for at least 4-5 years
  - (Rs. 9500-10,000 per tonne FFB)
    - Models: Corporate - Limited captive plantation - Small holder
- Area identification – a scientific approach
  - Utilise services of NBSS&LUP, Nagpur, IMD, Remote sensing
- Reducing Price fluctuations
  - Price stabilization
- Special attention to north eastern regions
  - Vast potential that exists should be trapped
- Thrust on increasing productivity of existing oil palm gardens with best management practices for achieving yield target of 20 t FFB per ha
- Performance based incentives to farmers achieving better yield
- Better management of young gardens to achieve 20 tonnes per ha FFB yield from 4th year onwards
- Enact Oil Palm Act in all the oil palm growing states
- In mid land & upland areas, lay more emphasis on promotion of oil palm in command areas with canal irrigation for 3-8 months and areas with more than 900 mm rainfall
- Establishment of Harvesters' Banks by each Entrepreneur
- Levy higher duty on the imports of crude palm oil (CPO)

10.6 Strategies for Enhancing Farm Income

- Reduction in cost of cultivation & increase in productivity
  - Support for micro-irrigation system – saving of 25-30 per cent of water in different seasons & soils
  - Support for fertigation technique – yield increase of 25 per cent when recommended dose is adopted
  - Recycling of plantation and factory wastes

- Oil palm based cropping system
  - Through inter-cropping of cocoa, red ginger, helicona, bush pepper, banana & ornamental crops would yield a C:B ratio of 1:2.38 to 1:2.86
  - Through mixed farming system

- Oil palm based integrated farming system with fodder crops, dairy (2 nos.) and back yard poultry (100 nos.) would give a C:B ration of 1.3.28

- Mechanisation of harvesting through establishment of customized hiring centres would save labour costs and serves as a source of employment for farm youth

- Decomposition and nutrient recycling of oil palm biomass (15-17 t/ha/year) through vermi-composting could reduce 50 per cent of inorganic fertilizers in oil palm plantations

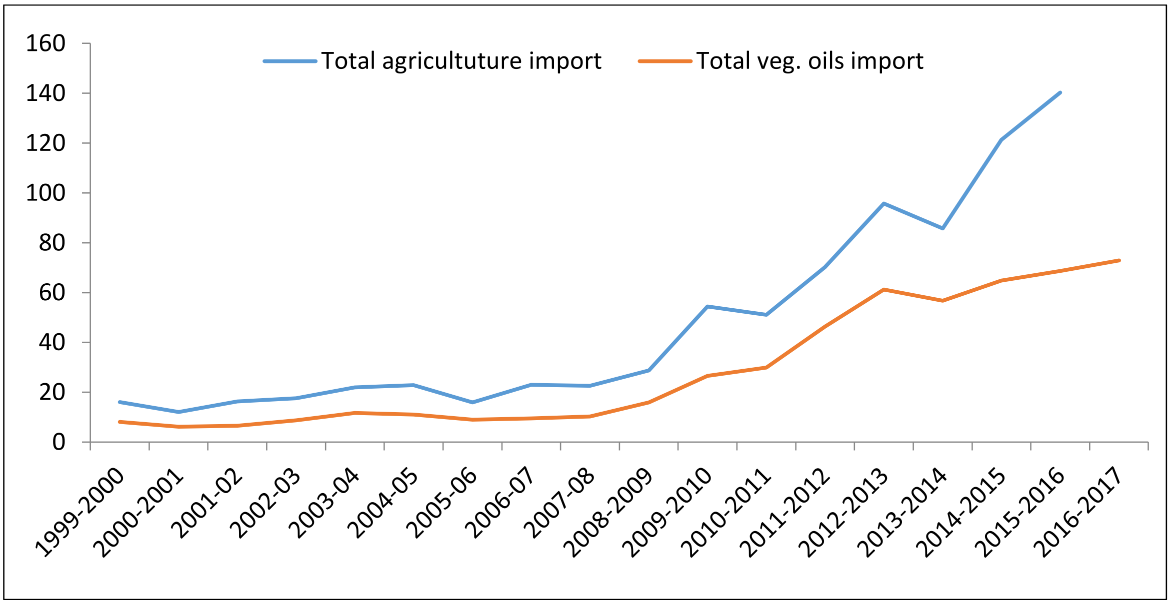
Chapter 11
Status of Imports and Policies

This chapter examines the status of export-import policy and its importance in creating a favourable terms of trade regime for the oilseed farmers. The major strategies discussed in chapter 2 for achieving higher output of oilseeds and vegetable oil from primary sources; and in chapter 3 with respect to palm oil will get further strengthened if supported by steady trade regime and robust policy intervention.

11.1 Import Status of Vegetable oils and Palm oils in India

Although, India occupies a prominent position in the world oilseeds industry, the domestic production of edible oils has not been able to keep pace with growing demand. Therefore, significant quantities of various edible oils have had to be imported from time to time to meet the domestic requirement. In recent years, edible oil has emerged as the single largest agri-import commodity accounting for more than 50 per cent of the value of total agricultural imports (Figure 11.1).

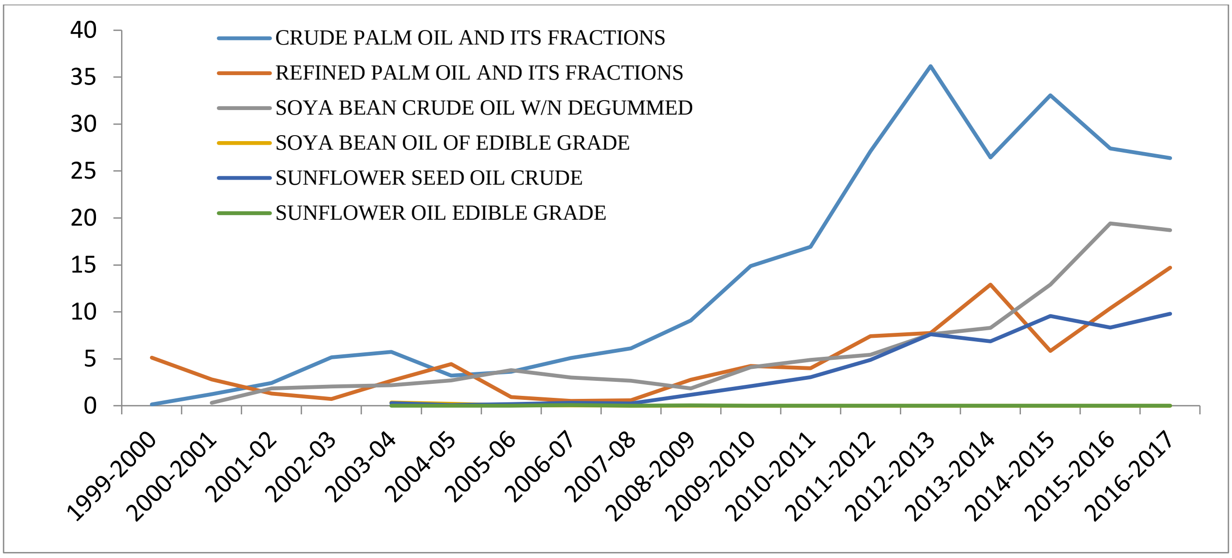
Figure 11.1 Total agriculture and vegetable oils imports (in Rs. 000' crore)



Source: Ministry Of Commerce and Industry,GOI

The Indian import basket of edible oils is dominated by palm oil followed by soya oil (Figure 11.2). The share of crude palm oil in total vegetable oil import has significantly increased from a triennium average of 18.47 per cent in 2001-02 to 42.08 per cent in 2016-17, while the share of refined palm oil declined from 44.67 per cent to around 15 per cent during the same period (Table 11.1). Amongst other oils, recently soya and sunflower oil have gained significant share in edible oil imports.

Figure 11.2 Major vegetable oils (crude and refined) imports in India (in Rs. 000' crore)



Source: Ministry Of Commerce and Industry,GOI

Table 11.1 Value share of vegetable oils import and its compositions

		Composition of vegetable oils in total vegetable oils import					
Period		**Palm oil**		**Soybean oil**		**Sunflower seed oil**	
	Vegetable oils in total agricultural import*	**(HS: 15111000) Crude**	**(HS: 151190) Refined**	**(HS: 15071000) Crude**	**(HS: 15079010) Refined**	**(HS: 15121110) Crude**	**(HS: 15121910) Refined**
TE 2001-02	46.78	18.47	44.67	15.78	0.00	0.00	0.00
TE 2009-10)	49.93	57.03	14.42	16.40	0.07	6.68	0.13
TE 2016-17	52.59	42.08	14.99	24.73	0.00	13.41	0.00

Source: Ministry Of Commerce and Industry, GOI
**Vegetable oils is sum of HS code 1507, 1508, 1509,1511,1512,1513 and 1514*

11.2 Import Duty

The historical pattern of import duty on vegetable oils (Table 11.2) indicates that it had been declining from 2006 to 2015, and it is in the following year, that doubling farmer's income came to be targeted. The import policy relating to vegetable oils has largely been influenced by the need to buffer the domestic requirement. It was mostly the consumers who remained the focal concern. A welcome change in policy approach came to be triggered by the 2022 targeted DFI. This necessitated the need for enabling the farmers to monetize their produce at reasonable levels, pushing the farmers' concerns into policy focus.

There has in the recent months (since October 2017) been greater acceptance of the need to balance the interests of both the producers and consumers. Thus the farmers' interests came to be addressed with steep hike in import duty with effect from 17-November-2017.

Table 11.2 Historical pattern of import duty on vegetable oils

Name of Oil	Rates of Import Duty(Per cent) / Effective Dates							
	2006	2007	2008	2009	2012	2013	2014	2015
Crude Palm Oil	70 (11 Aug)	60 (24 Jan) 50 (13 Apr) 45 (Jul)	20 (21 Mar) 0 (1 Apr)		0 (17 Mar)	2.5 (23 Jan)	7.5 (24 Dec)	12.5 (17 Sep)
RBD Palmolein	80 (11 Aug)	67.5 (24 Jan) 57.5 (13 Apr) 52.5 (23 Jul)	27.5 (21 Mar) 7.5 (1 Apr)		7.5 (17 Mar)		10 (20 Jan) 15 (24 Dec)	20 (17 Sep)
Crude Soyabean Oil		40 (23 July)	0 (1 Apr) 20 (18 Nov)	0 (24 Mar)	0 (17 Mar)	2.5 (23 Jan)	7.5 (24 Dec)	12.5 (17 Sep)
Refined Soyabean Oil		40 ((23 Jul)	7.5 (1 Apr) 7.5 (18 Nov)	7.5 (24 Mar)			10 (20 Jan) 15 (24 Dec)	20 (17 Sep)
Crude Sunflower Oil		65 (24 Jan) 50 (1 Mar) 40 (23 Jul)	20 (21 Mar) 0 (1 Apr)	0 (24 Mar)	0 (17 Mar)	2.5 (23 Jan)	7.5 (24 Dec)	12.5 (17 Sep)
Refined Sunflower Oil		75 (24 Jan) 60 (1 Mar) 50 (23 Jul)	27.5 (21 Mar) 7.5 (1 Apr)	7.5 (24 Mar)	7.5 (17 Mar)		10 (20 Jan) 15 (24 Dec)	20 (17 Sep)

Source: Ministry of Consumer Affairs food & Public Distribution (http://dfpd.nic.in/oil-division.htm)

In a move to support its farmers, Govt. of India has raised import duty on various edible oils ranging between 60 per cent to even 100 per cent. The duty increase will lift oilseed prices and their availability for crushing in the domestic market, helping the country in containing edible oil imports. India doubled the import tax on crude palm oil to 30 per cent (from the earlier 15 per cent), while the duty on refined palm oil was raised to 40 per cent from 25 per cent earlier.

The import tax on crude soya oil has been increased to 30 per cent from 17.5 per cent, while on refined soya oil it has been raised to 35 per cent from 20 per cent. What would, however, be required is sustaining such protection in the long run, so that market prices for oilseeds consolidate at levels that are beneficial to the farmers.

A stable EXIM (Export-Import) policy with farmer-favourable terms of trade is also an important criterion of influencing the agricultural market forces.

Table 11.3 Import duty on oilseeds, vegetable oils and palm oils

Commodity	Import duty before 17th November 2017 (in per cent)	Enhanced duty (in per cent) w.e.f. 17th November 2017
Soybean seed	30	45
Crude palm oil	15	30
Refined palm oil	25	40
Refined sunflower oil	20	35
Crude soyabean oil	17.50	30
Refined soyabean oil	20	35
Rapeseed oil including canola	12.50	25
Refined oilseeds oil	20	35

Source: Annual draft of NMOOP (National Mission on Oilseeds and Oil Palm)

11.3 Supportive Import Duty

As explained, there are signs of change in the approach to protecting the interests of oilseed growers. A facilitative import duty in respect of both crude oil and processed oil is necessary, so that the domestic market is not distorted to the disadvantage of the local farmers.

Imposition of higher duty on crude oil would also protect the local oil industry. The duty structure has to be graduated in such a way as to balance between the need for encouraging domestic oilseed production and simultaneously meeting the domestic consumer demand through demand. The country is not expected to become self-sufficient in vegetable oil even by 2025. The achievable target is to narrow the gap between domestic demand and supply.

The liberal policy of allowing blending of local oils using canola oil etc also needs to be revisited. It is seen in the market, that the brand name of oil under which various edible oil products are sold, actually contain a very small ratio of it and major portion comes from imported edible oil. In a way such open policy to blending amounts to accepting adulteration.

11.4 Role of Cooperatives and Oil Federations

National Agricultural Cooperative Marketing Federation of India Ltd. (NAFED) was established in the year 1958, with the aim of promoting co-operative marketing of agricultural produce to benefit the farmers. In the year 2014-15, NAFED procured only around 14,000 metric tonnes of oilseeds from the farmers, whereas the country imported around 109.76 lakh tonnes of edible oil.

Besides NAFED, the State Cooperatives and oil federations should play a pro-active role right from procurement, processing, value addition and marketing of produce at panchayet level. This will ensure distressed sale by farmers and assure locally available blending free vegetable oil. The produce of Farmers producers' organization (FPOs), Self Help Group can be linked with oil processing units. The cooperative structure and its rule & regulations of India need to be strengthened as per local requirements. Presently Cooperatives are playing a major role in supply of critical inputs (seed, fertilizers, pesticides, implements) to the farmers but are not involved in procurement and value addition of local produce.

Besides above, the Solvent Oil Extraction Associations, Oil palm processors should be involved to create awareness about "Optimum Use of Vegetable Oil" (OUVO) which is as high as 19 kg per annum per capita in India as against minimum requirement of 13-14 kg per annum per capita. The mass awareness will minimize domestic requirement and reduce the import burden.

The Associations/Cooperatives/Federations involved in manufacturing vegetable oil from secondary sources also need to be brought under the umbrella of oilseeds programme. The coconut and palm oil are already been look after by Government through Coconut Development Board and NMOOP. However, the production of oil from rice bran, cotton seed is not governed by any promotional schemes which need to be taken up through cooperatives/ government bodies.

Chapter 12
Oilseeds & Oil Palm Policy Recommendations

This chapter extracts major interventions as broad policy framework to achieve higher yield & production, apart from area in respect of both oilseeds and palm oil.

Following are the broad strategies needed to achieve the targets laid out in the preceding chapters.

1. The Oilseed Technology Mission launched in 1993 had succeeded in ramping up oilseed production to achieve near self-sufficiency by 1999. Unfortunately, there has been a huge slippage thereafter leading to wide gap between domestic demand & supply.

   In result, the country has been spending around Rs. 70,000 crore annually in importing edible oil to bridge the domestic shortage.

2. Oilseeds and oil palm, need special attention by way of a policy that supports both production and marketing, to incentivise the farmers to focus on area expansion and productivity gains.

3. Since area expansion would call for using post-kharif rice fallows and diversification from existing crops under irrigation systems, inter-crop advantages must describe oilseeds. This can happen only if both productivity and price returns (through markets & MSP / procurement) get more robust.

4. Import duty and import policy of edible oils (both crude and processed) should keep the interests of local farmers in mind.

5. In consonance with the DFI Committee strategy of promoting pulses, oilseeds and millets, there would be need to adopt well thought out cropping plan, as there can arise a competetion among these 3 for the same land and resources.

6. Most oil seeds except for soybean have seen a decrease in area over the last decade. An inter-crop comparison with those in whose favour oilseeds have ceded their past area may be made and appropriate interventions effected to regain the lost area.

7. Primary emphasis is needed on bridging the yield gaps between FLDs and farmers' fields. In the short run, the focus has to be on adoption of improved technologies already available and improved agronomic practices.

8. The target of increasing the output of 9 primary oilseeds from 30.06 million tonnes (QE 2016-17) to 45.64 million tonnes by 2022-23 is daunting, but is possible if concerted efforts are made based on adoption of a comprehensive roadmap.

9. The Ministry of Agriculture in response to the interim recommendations of the DFI Committee has recently (January 2018) constituted a Committee to develop a strategy and roadmap to enhance oilseed production in the country. This needs to be taken to logical conclusion. The Committee in its first meeting dated 26th February, 2018 agreed on a target of 45 million tonnes of oilseeds and 11.50 million tonnes of vegetable oils from primary sources by 2022. It also delineated the following broad interventions.

Oilseeds:

- In-depth analysis of decline in area coverage of different oilseeds and comparative advantages of the competing crops in various states/regions by ICAR.
- Focus on area expansion in non-traditional areas and states as also non-traditional seasons. States may prepare target oriented separate plan under NFSM-Oilseeds for identified districts/crops.
- Study on productivity enhancement in targeted oilseed crops where a particular crop has special niche advantage.
- Inter-cropping of oilseeds with other crops to be intensified. Cluster Demonstrations/FLDs/CFLDs for inter-cropping to be included under NFSM-Oilseeds as per norms of NFSM.
- Farm mechanization techniques including efficient crop harvesters need further promotion through custom hiring centers, FPOs group etc.
- Availability of quality seed is a major bottleneck in oilseeds production. Hence 30 Seed Hubs on Oilseeds by ICAR/KVKs to be targeted under NFSM-Oilseeds from 2018-19.
- Seed multiplication from breeder to foundation to certified seed is not satisfactory, which may be reviewed and efforts by State & Central Seed Agencies for seed production to be mobilized for required quantity of certified seed of oilseeds in the seed chain.
- Small oil extraction units to be promoted through farmers' group/FPOs and demonstration units by ICAR/KVKs/SAUs on project basis, integrating farmers into value added activities.
- Marketing of edible oil in pure form should only be allowed. Blending should be discouraged and if allowed should be within permissible limit with proper labelling. Proper scientific study to be undertaken in this regard.

Oil Palm:

- Eastern and North-Eastern States particularly Arunachal Pradesh, Assam and Mizoram that have vast potential should be specifically focused for oil palm area expansion including providing for special package for research, development and transport.

- Self-sufficiency in indigenous seedling production needs to be achieved through establishment of seed gardens so as to discourage import of exotic seedlings.
- The recent relaxation of area limitation beyond 25 ha and increased subsidy for planting materials, inter-cropping, maintenance cost, bore well by the Cabinet will encourage oil palm growers. However, imposing 0.5 per cent cess on import of CPO may be considered in the interest of oil palm growers. This will ensure fall of FFBs price below $800.
- Oil palm is categorized as secondary sources of vegetable oil. However, Oil palm being the highest oil producing crop, should be included as primary source of edible oil. This will bring it the desired attention.
- Secondary sources of edible oils (target 5.50 m.tonnes by 2022) such as rice bran, cotton seed and other edible oilseeds should be utilised to their fullest potential. Close coordination in respect of these sectors including on improved processing technology is needed.

10. The major contribution to the targeted increase in domestic edible oils will have to come from seasonal oilseeds. Since, oil palm will take time to show results, in the near term of upto 2022, improved agronomic practices can bring in higher yields from existing gardens and add an approximate of 0.4 million tonnes of crude palm oil. Hence, the focus should be on increasing the yield of fresh fruit bunches (FFBs) in existing gardens.

11. All the above suggestions are more in the nature of short and medium term, so as to realise maximum delivery of results by 2022-23. In the long run however, there has to be break through technology, that will effect pole vault to the current yield levels. It would be against and logic, that India should continue to spend a huge sum of Rs. 70,000 crore (which may only climb up over the years) on import of edible oils, particularly given the scope for domestic production. Hence, adoption of frontier technologies including G. M. technology, should be retained as an option, after securing bio-safety standards.

Key Extracts

- The potential of the eastern grid comprising the states of Odisha, Bihar, West Bengal, Chhattisgarh and Jharkhand and in NEH region including Assam needs to be harnessed considering favourable eco-region tailored to production of oilseeds.
- State-wise / AESR based technology assemblage coupled with output marketing can provide substantial fillip to the farm level income of the oilseed farming community.
- A clearly spelt out road map for diversification of rice-wheat eco-system towards oilseeds in the IGP (Indo Gangetic Plain) region holds high promise for enhanced income from oilseeds besides addressing the problems relating to natural resource management base (water table and salinity issues).
- Diversification through soybean, rapeseed-mustard and sunflower as in select agro-ecological regions of IGP would reap greater benefits through increased profitability to the farming community.
- Focused state level development policy(s) is/are to be chalked out for expanding oilseeds cultivation to newer niche areas; cultivation in rice fallows and inter-cropping in tailored agro-ecological conditions.
- Emphasis on PPP (Public Private Partnership) for specialty oils (high oleic in sunflower and safflower, low erucic / double zero mustard) would be useful in realizing higher premium price at the farm gate level; cluster approach in select agro-ecological regions of the country may be adopted for the purpose.
- Encourage large scale production of promising small farm machinery on custom hiring basis to improve farm level efficiency and augment increased income.
- Take advantage of the 3 (three) minimisation under NMOOP and adopt the 3 broad technology & management approaches to realise higher productivity, production and profits. Market support including encouraging MSPs and robust procurement would be needed to incentivise farmers.
- Encourage the discreet and healthy consumption of oils by the consumers.

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Annexures VIII-A

Table A1. Options to enhance annual farm household income in different states of the country.

Options	For all States	For States with 1.5 times income growth	For States with 2 times income growth	For States with 2.5 times income growth	For States with 3.5 times income growth
		Punjab, Lakshadweep, Haryana, Jammu & Kashmir, Kerala, Meghalaya and A & N Islands (FIZ 1, Increase income by 1.5 times)*	Arunachal Pradesh, Nagaland, Mizoram, Karnataka, Manipur, Himachal Pradesh, Gujarat, Maharashtra and Goa (FIZ 2, Increase income by 2.0 times)	Rajasthan, Daman & Diu, D & N Haveli, Tamil Nadu, Sikkim, Assam, Telengana, Madhya Pradesh and Andhra Pradesh (FIZ 3, increase income by 2.5 times)	Puducherry, Tripura, Chhattisgarh, Uttar Pradesh, Odisha, Jharkhand, Uttaranchal, West Bengal and Bihar (FIZ 4, increase income by 3.5 times)
Economic	• Subsidy on solar energy may be increased to encourage farmers. • Cover almost all farmers in crop insurance scheme. • Integrate all central and state subsidies	• Setting up Special Agricultural Export Zones	• Setting up Special Agricultural Export Zones • Creating crop-specific supply chains	• In addition to MSP special bonus should be provided to farmers of this Income Zone. • Creating crop-specific supply chains	• In addition to MSP special bonus should be provided to farmers of this Income Zone. • Creating crop-specific supply chains
Technological	• Linking of all weather stations to provide location specific weather information. • Soil health card programme to be given further impetus. • Bridging the gaps between achievable (FLD) and actual yields of crops • Popularizing insect-pest resistance crop varieties.	• Precision Agriculture in 1st Green Revolution states • Organic farming in NE states and hill states • Diversified Integrated Farming System for sustainability	• Popularizing Hybrid, Doubled Haploid and New Generation Plant seed production. • Organic farming in NE states and hill states • Diversified Integrated Farming System for sustainability	• Popularizing Hybrid, Doubled Haploid and New Generation Plant seed production. • Special emphasis on Animal husbandry for landless and marginal farmers. • Diversified Integrated Farming System for sustainability	• Popularizing Hybrid, Doubled Haploid and New Generation Plant seed production. • Emphasis on animal husbandry for landless/marginal farmers. • Organic farming in NE states and hill states • Diversified Integrated Farming System for sustainability
Infrastructural/ Information	• Setting up Agribusiness Incubation (ABI) Centres at District level in KVKs	• Expert system for Basmati rice	• Popularizing RiceXpert, Rice Crop Manager and Rice Doctor • A comprehensive production,	• Popularizing Rice Xpert, Rice Crop manager and Rice Doctor • A comprehensive production,	• Popularizing Rice Xpert, Rice Crop manager and Rice Doctor • A comprehensive production,

Options	For all States	For States with 1.5 times income growth Punjab, Lakshadweep, Haryana, Jammu & Kashmir, Kerala, Meghalaya and A & N Islands (FIZ 1, Increase income by 1.5 times)*	For States with 2 times income growth Arunachal Pradesh, Nagaland, Mizoram, Karnataka, Manipur, Himachal Pradesh, Gujarat, Maharashtra and Goa (FIZ 2, Increase income by 2.0 times)	For States with 2.5 times income growth Rajasthan, Daman & Diu, D & N Haveli, Tamil Nadu, Sikkim, Assam, Telengana, Madhya Pradesh and Andhra Pradesh (FIZ 3, increase income by 2.5 times)	For States with 3.5 times income growth Puducherry, Tripura, Chhattisgarh, Uttar Pradesh, Odisha, Jharkhand, Uttaranchal, West Bengal and Bihar (FIZ 4, increase income by 3.5 times)
	• National level information system on Soil health. • Setting up National Level export information system. • Setting up e-Surveillance monitoring system for insect & pest		preserving, value addition, storage processing, transportation and marketing system • Further emphasis for improving irrigation facility. • Expert system for rice	preserving, value addition, storage processing, transportation and marketing system • Special budget for water conservation or watershed development • Double the KVK numbers	preserving, value addition, storage processing, transportation and marketing system • Improving irrigation facility • Double the number of KVKs
Political / Policy	• Form Crop Planning Dept at national & state level. • Policy implementation for research on GM rice to reduce cost of cultivation. • Setting up more organic food certification agencies • Setting up of FPO for block level seed production with subsidy. • Integrated land-use policy particularly water use policy	• Policy to restrict cultivation of water intensive crops in 1st Green Revolution region. • Promotion policy for high protein, high Zn and scented rice in non 1st Green Revolution region	• Promotion policy for high protein, high Zn and scented rice. • Promotion policy for ancillary activities like poultry, beekeeping and fisheries	• Promotion policy for high protein, high Zn and scented rice. • Promotion policy for ancillary activities like poultry, beekeeping and fisheries	• Promotional policy for high protein and high Zn rice in public distribution system (PDS) and Mid-day meal schemes • Promotional policy for scented rice. • Promotion policy for ancillary activities like poultry, beekeeping and fisheries
Social	• Form comprehensive framework for community / corporate farming.	• Land consolidation, community farming, cooperative farming for farm mechanization	• Land consolidation, community farming, cooperative farming for farm	• Land consolidation, community farming, cooperative farming for farm	• Land consolidation, community farming, cooperative farming for farm

Options	For all States	For States with 1.5 times income growth	For States with 2 times income growth	For States with 2.5 times income growth	For States with 3.5 times income growth
		Punjab, Lakshadweep, Haryana, Jammu & Kashmir, Kerala, Meghalaya and A & N Islands (FIZ 1, Increase income by 1.5 times)*	Arunachal Pradesh, Nagaland, Mizoram, Karnataka, Manipur, Himachal Pradesh, Gujarat, Maharashtra and Goa (FIZ 2, Increase income by 2.0 times)	Rajasthan, Daman & Diu, D & N Haveli, Tamil Nadu, Sikkim, Assam, Telengana, Madhya Pradesh and Andhra Pradesh (FIZ 3, increase income by 2.5 times)	Puducherry, Tripura, Chhattisgarh, Uttar Pradesh, Odisha, Jharkhand, Uttaranchal, West Bengal and Bihar (FIZ 4, increase income by 3.5 times)
	• Online marketing of agricultural produce. • Nationwide multilevel training on Hybrid, Doubled Haploid and NGP for its popularization.	benefits in non 1st Green Revolution region	mechanization benefits.	mechanization benefits.	mechanization benefits.

Source: DFI Committee

Table A2. Improved practices, their potential and constraints for increasing farmers' income in different agro-climatic zones of Odisha

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
Agro-climatic zone: North-western plateau; Districts Sundargarh, parts of Deogarh, Sambalpur & Jharsuguda				
Upland	• Rice-Fallow • Ragi-fallow • Rice/Late Tomato-fallow • Goatery, Poultry, Orchard	• Rice - black gram • Ragi- Lathyrus/ other pulses • Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • Tank cum well system • Rainwater harvesting through check dam • Field bunding	Paddy yield-35.0 qtl./ha Black gram yield-7.0 qtl./ha Rs. 50,000/- extra net income/ha/ yr	Low yield (17-18 q/ha) High cost of construction Feasible in a moderate slope of 2 to 5%.
Medium land	Rice-Fallow	• Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310 • Rice –paira Chickpea/ field pea/ Blackgram • Flexi rubber check dam for water harvesting	Rs. 40,000/ha/yr	Difficulty in installing the dam and risk of damage to the dam
Shallow lowland	Rice-Fallow	• Rice- Pulses/ Paira cropping • Rice (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • Raised and sunken bed technique • Two stage rainwater conservation technique /farm pond/IFS	Additional net income of Rs.35,000/ha/ yr Rs 40,000-50,000//ha/yr	Timely availability of quality seeds and extension support
Irrigated land	Rice-Rice Rice-Vegetables (Tomato & Brinjal) Rice-Green gram, Rice-Sesamum, Rice-Vegetable (onion, cowpea, potato, chili, colocasia) Sesamum-Vegetable Rice-Chickpea/Black gram/ Lentil Dairy	• Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310, Luna Sankhi, Rajalaxmi (Hybrid), Geetanjali (Aromatic) • Improved irrigation infrastructure • Auxiliary storage system • Drip/sprinkler irrigation • Rice-green gram/maize/ red gram/sun flower/ mustard	Rs70,000-80,000/ha/yr	Seed availability Initial cost
Homestead	Goatery, Poultry, Dairy, Pisciculture, Bee- keeping	• Disease management (Deworming), • Shed and Nutrition management • Breed replacement	46% increase	

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
		• Nutrition garden • Paddy straw mushroom		
Agro-climatic zone: North Central Plateau - Mayurbhanj, major parts of Keonjhar, (except Anandapur & Ghasipura block)				
Upland	Maize- fallow Rice - Fallow	• Relay cropping (Maize-Cowpea) • Rice-vegetables • Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • Rainwater Harvesting Through Check Dam Tank cum well system • Field bunding • Reclamation of acid soils wherever applicable	Additional net income of Rs.30,000/ha/ year Rs.8000-9000/ha/yr Additional net income of Rs. 15,000/ha	• Relatively high initial cost • Extra labour requirement • Availability of paper mill sludge
Medium land	Rice - Fallow	• Rice- pulses/vegetables • Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310 • CLCC based N management		
Shallow Lowland	Rice - Fallow Rice - Chickpea/ blackgram/ lentil (paira crop)	• Rice-pulses/paira cropping • Rice (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • Raised and sunken bed technology	Additional income of Rs.35,000/ha/annum	• Timely availability of quality seeds and extension support. • Extra labour requirement
Irrigated land	Rice-Green gram Maize – Vegetables Rice- Vegetable (sol./ cole/ gourds etc) Rice-Chickpea/blackgram/ lentil Vegetables-Vegetables Mango orchard	• Auxiliary storage system • Drip/sprinkler irrigation • Rice- green gram/maize/ red gram/ sun flower	Rs70,000-80,000/ha/yr	Initial cost Seed availability
Homestead / Enterprise	Goatery, Poultry, Mushroom, Bee-keeping	• Poultry and mushroom • Nutrition garden	58% increase	
Agro-climatic zone: North Eastern Coastal Plain - Balasore, Bhadrak, parts of Jajpur & Hatadihi block of Keonjhar				
Upland	Rice-Fallow	• Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • Rice field bunding • Tank cum well system	Additional net income of Rs.7,000-8,000/ha/yr	- • Initial high cost • Difficulty in installing the dam

Ecology	**Conventional practices**	**Improved practices**	**Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})**	**Constraints in implementation**
			Rs.35,000/ha/ year	• Availability of paper mill sludge
Shallow Lowland	Rice-Fallow Rice-blackgram Paira Dairy	• Rice-pulses/mustard/ paira crop • Rice (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • Raised and sunken bed technology	Additional net income is about Rs.20,000-25,000 /ha/year	- • Timely availability of quality seeds and extension support. • Extra labour requirement
Medium deep lowland	Rice, pisciculture	• Salt tolerant varieties – Luna Sampad, Luna Suvarna, Luna Barial for saline areas • Raised and sunken bed technology • Infield refuge system for rice-fish integration	Rs20,000/ha/yr Rs50,000/ha/yr	-
Deepwater land	Rice, pisciculture	• Salt tolerant varieties – Luna Sampad, Luna Suvarna, Luna Barial for saline areas otherwise Rice var. CR Dhan 505, Jalamani, Jayanti Dhan, CR Dhan 508, Prasant, Varshadhan) • Planting of horticultural crops on the dykes • Cat tail (*Typha*) cultivation for Waterlogged Areas • Water Chestnut Cultivation and Aquaculture	160% increase	Acceptability to farmers and market Drudgery in farm operation due to waterlogged condition Requires special skill
Irrigated land	Rice, Groundnut Dairy, Poultry	• INM • Raised and sunken bed • Auxiliary storage system • Drip/sprinkler irrigation	Rs25,000-30,000/ha Rs100,000-120,000/ha/yr	High initial cost involved
Coastal saline land	Salt tolerant rice and crops like chili, water melon	• Salt tolerant varieties of rice Luna Sampad, Luna Suvarna, Luna Barial • Shallow tube wells • Sub-surface water harvesting technologies (SSWHT) • Sluice gate structure based on hydraulics and hydrology	Rs.30,000/ha/yr Rs.30,000-40,000/ha/yr Rs150,000-/ha/yr	Fluctuation in Salinity gradient and intrusion of sea water Cost intensive High Initial investment
	Coastal shrimp culture	• Improved shrimp culture	Rs250,000-300,000/h/crop	-
Homestead		• Fodder unit in homestead • Poultry • Value addition of milk products • Market linkage	65% increase	

Ecology	**Conventional practices**	**Improved practices**	**Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})**	**Constraints in implementation**
Agro-climatic zone: East and South Eastern Coastal Plain - Kendrapara, Khurda, Jagatsinghpur, part of Cuttack, Puri, Nayagarh & part of Ganjam				
Upland	Rice-vegetable Rice- Fallow Chilli/Okra - fallow	• Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • Tank cum well system • Field bunding	Additional income of about Rs.70,000-80,000 /ha/year	Relatively high initial investment
Medium land	Rice- Green gram (Desi) Rice- Vegetables (tomato, potato, Okra, Cole crop, chili)	• Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310 • Improved water harvesting technologies		
Shallow lowland	Rice-Fallow Rice-green gram Rice - vegetables	• Raised and Sunken Bed • Rice- *Utera/paira* Cropping • Rice (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • Two stage rain water harvesting with farm pond	Additional income of RS.25,000/ha/yr Additional income of about Rs.35,000 / ha /yr	More labour requirement and problems for using other land preparation technology
Medium deep lowland	Rice-Rice	• Integrated rice-fish • Rice (var. CR Dhan 500, Jalamani, Jayanti Dhan, CR Dhan 505, Prasant, Pradhan Dhan) • Duckery • Biological Drainage of Waterlogged Lands • Drainage Water Management with farm pond	Additional net income Rs35,000/ha/yr Rs35,000-40,000/ha/yr through yield - enhancement and fish production	Small holding and long gestation period
Deepwater land	Fallow - rice	• Rice (var. CR Dhan 505, Jalamani, Jayanti Dhan, CR Dhan 508, Prasant,) • Duckery • Pond Based Farming System • Water Chestnut Cultivation and Aquaculture • Cat tail (*Typha*) cultivation for Waterlogged Areas	Additional income of Rs.80000-100,000/ha/yr Rs.100,000/ha /yr	Acceptability by farmers and poor capacity of farmers to invest Problem of acceptability by farmers and poor capacity of farmers to invest
Irrigated land	Rice-Fallow Rice-green gram Rice - vegetables	• Paddy-Pulse/oilseeds / Vegetables • Field channels • Raised and sunken bed • Auxiliary storage system • Drip/sprinkler irrigation	Rs25000-30000/ha Rs100,000-120,000/ha/yr	High initial cost involved

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
Coastal saline land	Rice-Fallow Rice-green gram Vegetables - fallow	• Improved salt tolerant rice varieties • Shallow tube wells • Sluice gate structure • Sub-surface water harvesting technologies (SSWHT)	Rs.25,000-30,000/ha/ yr Rs150,000-/ha/yr Rs 30,000-35000/ha/yr	• Change in salinity gradient and intrusion of sea water • High Initial investment • Change in salinity gradient
	Coastal shrimp culture	• Improved shrimp culture • Aquaculture	Rs250,000-300,000/ha/crop	
Homestead /Enterprise	Pisciculture, Mushroom, Goatery, Poultry, Dairy, Fishery, Beetle vine	• Fodder unit in homestead • Poultry • Value addition of milk products • Market linkage • Nutrition garden		
Agro-climatic zone: North Eastern Ghat - Phulbani, Rayagada, Gajapati, part of Ganjam & small patches of Koraput				
Upland	Maize-fallow Rice/ Millet –fallow Mango Orchard Groundnut-fallow Groundnut – Fallow Cotton - fallow Turmeric	• Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • Acid soil management • CLCC based N management • Maize+ Arhar intercropping (2:1) • Check Dam • ICAR-Flexi rubber dam • Lining of Run-off Recycling Tanks for Seepage Control • Orchard with filler crops	Additional net income of Rs40,000/ha/yr Additional net income of Rs40,000/ha/yr Rs.35,000/ha/ yr through cost saving and increased income	High Initial cost Installation and maintenance
Medium land	Rice-fallow Rice – Green gram	• Rice-pulses/mustard • Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310		
Shallow Lowland	Rice – Green gram Rice-Rice Rice – Khesari (Lathyrus) Rice - fallow Pisciculture	• Rice- *Utera/paira* Cropping • Rice (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • Two stage rain water harvesting	Rs.30,000-35,000/ha/yr	-
Medium deep lowland	Rice-Fallow	• Integrated rice-fish farming • Rice (var. CR Dhan 500, Jalamani, Jayanti Dhan, CR Dhan 505, Prasant, Pradhan Dhan)	Additional income of about Rs.80,000/ha/ yr	

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
Deepwater land		• Pond Based Integrated Farming System • Rice (var. CR Dhan 505, Jalamani, Jayanti Dhan, CR Dhan 508, Prasant,) • Water Chestnut Cultivation and Aquaculture	Rs8,000-9,000/ha/yr Rs 80,000-90,000/ha/yr	- Acceptability by farmers and poor capacity of farmers to invest
Irrigated land	Paddy- Mustard Maize-Vegetable Rice-Vegetable Vegetable - vegetable Rice-Groundnut Cauliflower- Brinjal Rice-Rice Cotton -Vegetables Pisciculture Old mango orchard Cashew orchard	• Raised and sunken bed • Auxiliary storage system • Drip/sprinkler irrigation • Integrated Nutrient management	Rs25,000-30,000/ha/yr	High initial cost involved
Homestead	Poultry, Mushroom, Goatery, Bee keeping, Leaf plate stitching	Commercial production & value addition	}60% increase	
Agro-climatic zone: Eastern Ghat High Land - Major parts of Koraput, Nawarangpur				
Upland	Rice-Fallow Millet - Fallow	• Varietal replacement of rice and millet • Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • Ragi +blackgram (2:1) • ICAR-flexi dam (rubber dam)	Additional net income of the up to Rs.40,000/ha	High Initial cost
Medium land	Rice-Fallow	• Rice- pulses/ utera/paira crop • Improved pulse varieties • Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310		
Shallow Lowland	Rice-Rice	• Rice- *Utera/paira* Cropping • Rice (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • Two stage rain water harvesting • Raised and Sunken Bed	Additional income of RS.25,000/ha/yr Additional income of about Rs.35,000 / ha /yr	-
Irrigated land	Rice-Rice Vegetable-Vegetable	• Improved varieties • INM • Field channels • Raised and sunken bed	Rs25,000-30,000/ha	nitial cost involved

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
		• Auxiliary storage system • Drip/sprinkler irrigation	Rs100,000-120,000/ha/yr	
Homestead		• Mushroom cultivation • Fodder unit in homestead • Poultry • Value addition of milk products • Market linkage • Nutrition garden	45%increase	
Agro-climatic zone: South Eastern Ghat - Malkangiri & part of Koraput				
Upland	Rice - Fallow	• Rice-pulses/ utera/paira crop/mustard • Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • INM • Orchard with filler crops • Check Dams • ICAR flexi check dam • Spring Water Collection and Its Utilization	Additional net income of Rs 35,000-40,000/ha/yr	Initial cost
Medium land	Rice – Fallow Rice-Pulse	• Rice-pulses/ utera/paira crop/mustard • Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310 • Organic production of non-rice crop		
Shallow Lowland	Rice-Vegetables	• Rice (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • INM • *Rice-Utera/paira* Cropping • Raised and Sunken Bed • Two stage rain water harvesting	Additional income of RS.25,000/ha/yr Additional income of about Rs.35,000 / ha /yr	More labour requirement and problems for using other land preparation technology
Irrigated land	Rice-Vegetables	• Improved varieties • INM • Field channels • Raised and sunken bed • Auxiliary storage system • Drip/sprinkler irrigation	Rs25,000-30,000/ha Rs100,000-120,000/ha/yr	High initial cost involved
Homestead / Enterprise	Dairy Poultry, Vegetables	• Mushroom cultivation • Fodder unit in homestead • Poultry		

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
		• Value addition of milk products • Market linkage • Nutrition garden		
Agro-climatic zone: Western Undulating Zone - Kalahandi & Nuapada				
Upland	Rice /Arhar/Bt cotton/ Jhari maka – fallow Cotton-Fallow	• High Yielding Arhar, Cotton (Bt)+ Arhar, Kharif onion • Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • ICAR flexi check dam • Rice field bunding	Additional income of about Rs40,000/ha/yr Rs.7,000-8,000/ha/yr	High initial cost
Medium land	Rice – fallow Rice- Vegetable (sol./ cole/ gourds etc)	• Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310		
Shallow Lowland	Rice – green gram Rice-Rice	• Rice (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid)Rice- *Utera/paira* Cropping • Integrated crop management • Raised and Sunken Bed • Two stage rain water harvesting	Additional income of Rs.25,000/ha/yr Additional income of about Rs.35,000 / ha /yr	More labour requirement and problems for using other land preparation technology
Irrigated land	Rice/ Arhar/ Jhari & local Maize – Vegetables Rice-Rice Rice – Vegetable (cole crops, tomato, brinjal, okra etc)	• Improved varieties • Integrated crop management • Field channels • Raised and sunken bed • Auxiliary storage system • Drip/sprinkler irrigation	Rs25,000-30,000/ha Rs100,000-120,000/ha/yr	High initial cost involved
Homestead / Enterprise	Goatery Poultry Dairy	• Breed replacement Commercialization/ value addition • Nutrition garden • Fodder production	45% increase	
Agro-climatic zone: Western Central Table Land - Bargarh, Bolangir, Boudh, Sonepur, parts of Sambalpur & Jharsuguda				
Upland	Rice-Fallow Arhar – Fallow Vegetable - fallow	• Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • integrated crop management • Soil test based fertilizer application • Check Dam • ICAR flexi check(rubber) dam • Rice field bunding	Additional income of about Rs40,000/ha/yr Rs.70,000-8,000/ha/yr	

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
Medium land	Rice-Fallow	• Rice- Utera/paira Cropping • Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310 • ICAR flexi check (rubber) dam		
Shallow Lowland	Rice-Green gram Rice-Fallow	• Rice- Utera/paira Cropping • Rice Varietal substitution by (Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • Raised and Sunken Bed • Two stage rain water harvesting • Infield refuge rice- fish System • Planting of horticultural crops on raised bunds • Blackgram as intercrop on bund	24% increase Additional income of Rs.30,000/ha/yr Additional income of about Rs.35,000 / ha /yr	More labour requirement and problems for using other land preparation technology
Irrigated land	• Rice-Rice • Rice – Green gram • Cotton-Fallow • Rice- Mustard • Vegetable-vegetable • Groundnut-vegetable (Radish, cowpea, mustard, pumpkin, cucumber) • Vegetables (Brinjal, • Chili)+ Vegetables (Cucurbits)	• Groundnut + maize (6:2 ratio) • Single line trail system • Imp[roved vartieties • Field channels • Raised and sunken bed • Auxiliary storage system • Conjunctive use of canal and ground water • Drip/sprinkler irrigation With crop diversification	Rs25,000-30,000/ha Rs100,000-120,000/ha/yr	High initial cost involved
Homestead /Enterprise	Poultry, Dairy, Goatery,	• Breed replacement • Promotion of fodder cultivation • Value addition to milk • Production and value addition of oyster mushroom • Health and disease management	16% increase }75% increase	
Agro-climatic zone: Mid Central Table Land - Angul, Dhenkanal, parts of Cuttack & Jajpur				
Upland	Rice - Fallow Groundnut-Fallow	• Rice-*utera/paira* cropping • Improved short duration Rice (Var. Sahbhagidhan, Phalguni, Satyabhama, Ankit) • development of orchard and value addition		High cost of construction

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
		• Integrated weed management • Tank cum well system • ICAR flexi check dam	Leather-Rs.10,500/-(1.5 qtl) Dry powder-Rs.3,000/-(5 kg) Additional income of about Rs40,000/ha/yr Rs.70,000-80,000/ha/yr	
Medium land	Vegetable-Fallow Rice-Fallow Rice – Vegetable, Rice – Greengram, Rice - Blackgram	• Integrated crop management • Improved rice varieties Rice (Var. Pyari, CR Dhan 203 (Sachala), CR Dhan 209 (Priya), CR Dhan 300, CR Dhan 303, CR Dhan 304, Maudamani, CR Dhan 310 • Raised and Sunken Bed		
Shallow Lowland	Paddy-Blackgram	• Rice- *Utera/paira* Cropping • Rice Var. Swarna Sub-1, Reeta, Sumit, CR Dhan 407, Poorna Bhog, CR Sugandh Dhan 907, CR Dhan 701(Hybrid) • CLCC based N management • Raised and Sunken Bed • Two stage rain water harvesting	Additional income of Rs.30,000/ha/yr Additional income of about Rs.35,000 / ha /yr	
Medium deep lowland	Paddy-Blackgram	• Biological Drainage • Rice-fish Integrated System (in-field refuge system) • Rice (var. CR Dhan 500, Jalamani, Jayanti Dhan, CR Dhan 505, Prasant)	Additional net income Rs35,000/ha/yr Rs30,000-35,000/ha/yr through yield - enhancement and fish production	High cost of creating structures for conservation
Deepwater land	Pisciculture	• Deep water rice • Integrated rice-fish farming system • Integrated water chest nut – fish based farming system • Rice (var. CR Dhan 505, Jalamani, Jayanti Dhan, CR Dhan 508, Prasant)	Rs80,000-100,000/ha/yr	Problems of acceptability by farmers/special skill required
Irrigated land	Rice – Vegetable, Rice – Greengram, Rice- Groundnut Rice - Blackgram	• Improved Paddy cultivation (Mechanization/ management practices)	Rs25,000-30,000/ha	High initial cost involved

Ecology	Conventional practices	Improved practices	Gain in productivity (t ha^{-1}) and income (Rs. ha^{-1})	Constraints in implementation
		• Rice- Brinjal • Value addition • Raised and sunken bed • Auxiliary storage system • Drip/sprinkler irrigation	Rs100,000-120,000/ha/yr	
Homestead	Goatery, Mango, Mushroom, Dairy	• Paddy straw for mushroom cultivation • Improved Dairy farming with Fodder cultivation • Backyard Poultry • Scientific feed and housing management, health and disease management	Paddy straw mushroom cultivation (60 beds/month) 4 months Cultivation Productivity- ((1 kg/bed)-) Production- 600 kg Net Income- Rs.30,000/- Milk Yield – 30 ltr/ day Backyard Poultry Production - 5400 eggs and 220 kg meat goat unit Net Income- Rs. 20,000/-	

Table A3 Strategy, Possible Contribution and Requirements

Strategy	Possible contribution	Requirements	Interventions for support
Low cost technologies with high impact			
• Adoption of improved genotypes available in all crops: • Improve SRR	• 20 to 30% yield improvement	• Strengthening seed production chain especially for self-pollinated crops and varieties • Organising seed villages; • Seed Farmers Society • Technology, credit and insurance support	**-MOU with SSC/NSC and other central agencies.** **-Creation of 100 ha seed hubs in potential districts**
Adoption of soil and water conservation measures and rainwater harvesting – *in situ* and farm pond.	• 30-50% yield increase for same rainfall pattern	• Watershed based approach. • Agro-forestry, silvi-pasture, agri-hort, intercropping, etc., as per land use capability	**-Farm pond** **-Drip/Sprinkler** **-Water Carrying pipes**
Land configuration – BBF, dead furrow contour cultivation, paired row planting Reduced or zero tillage	• Reduced cost on tillage by 50%	• Support of required machinery/ implements • Custom hiring facility	**-Assistance on Farm Implements** **-Custom hiring facilities.**

Strategy	Possible contribution	Requirements	Interventions for support
Seed hardening and seed treatment – chemical and biologicals	• 15-20% yield improvement	• Chemicals and bioinoculants availability and quality • Skill demonstration on methodology	**-Seed treatment & awareness.**
Maintenance of optimum plant population: • Line sowing • Optimum sowing depth • Thinning	• Up to 35% yield improvement • Reduction in seed rate	• Fine seed bed preparation - rotavator • Seed cum fertilizer drill with precision metering • Custom hiring facility	**-Demonstration on Ridge & Furrow/BBF/paired row planting** **-Demonstration on drip/sprinkler**
Use of small and medium size quality seed in groundnut Reduce seed rate in soybean	• Reduce seed tonnage and by 25% • Cost reduction	• Assured and Graded quality seeds	**Awareness for Groundnut and Soybean farmers**
Gypsum use and application method in groundnut: Dry and finely ground to be applied at pegging zone:	• Increase pod yield (20%) • Increased shelling % (15%) • Increased oil content (10-15%) • Reduced gypsum quantity (25%).	• Availability of quality gypsum • Drying, Pounding and Applicator availability • demonstration standards and application method • Setting up local godowns stocking gypsum • Subsidized transport	**-Assistance on micro nutrients.**
Use of bio fertilizers Rhizobia for legumes and *Azospirillum* and *Azatobacter* for non-legumes and PSB/KSB/ZSB	• Reduce N requirement by 50% (20 to 30kg N and P/ha) • Reduced cost up to Rs.1200/ha • Improves the soil health • Improve FUE • Ecofriendly	• Availability bio inoculants • Quality assurance • Method demonstrations when used along with other seed treatment chemicals • Storage facility • Quality packing along with sticker	**Assistance on bio fertilizers/ PSB/KSB/ZSB**
Technologies with high impact			
Adequate NPK as per soil test results. Initial cost is high – subsequent cost is significantly low with higher yield, profits and soil fertility maintenance.	• 30 to 50% yield increase. • Arresting soil mining. • Balanced fertilization • Build up soil fertility • Reduced losses of nutrients	• Reliable soil testing support • Availability of required fertilizers and amendments • Credit provision • Method demonstration of technology • Demonstration of direct and residual effects • Long term impact demonstrations • Monitoring soil fertility status • Linking soil health cards with fertilizer/input subsidies	**Demonstration on soil test based nutrient application**
Increasing fertilizer use efficiency (Neem coated urea, split application, SSP use, etc.);			
Balanced nutrition with S for all oilseeds: Micronutrients especially B for sunflower and Zn and limiting micronutrients	• 15 to 25% yield increase • Significant residual effect in cropping systems; • Increased seed quality • Increase FUE		

Strategy	Possible contribution	Requirements	Interventions for support
Herbicide based IWM for effective weed management in all soil types.	• 15 to 45% increase in yield • Plant protection benefits	• Availability of recommended herbicides • Specialized application equipment – nozzle types • Method demonstration of technology and soil moisture and spraying method and time	**Herbicide based IWM**
Adoption of IPM modules with bio-intensive approaches.	Yield increase (15 to 45%)	• Method demonstrations • Provision of required chemicals and bioagents	**Demonstrations**
Providing one or two irrigations at critical stages Stop irrigation during Mid Dec to Mid Jan	Yield increase up to 60% Low risk of Sclerotinia stem rot + Saving of irrigation	• Provision of Micro irrigation facility to oilseeds. • Credit and subsidy for micro-irrigation • Demonstrations • Service and repair facility at village level • Skill development in installation and servicing at village level •	**Supply of drip/sprinkler & water Carrying pipes**
Extending castor area in *rabi* under drip	• Yield increase 50% • Reduce water by 50%		Awareness among farmers
Intercropping in major crops of region	• Risk minimization • Additional returns	• Agro-climatic region specific intercropping systems and row ratios •	• Demonstrations
Technologies with emphasis on quality improvement and value additions			
Oil content based premium pricing	Higher price realization	• Establishment of NMRs in market yards	**Value addition in oilseeds-** can be taken up by Ministry of food processing / Ministry of commerce/ Ministry of Petroleum
Aflatoxin free groundnut	• Increased farm income • Greater export earnings	• Testing facility	
Value addition of oilseeds Apiculture in mustard, sunflower and niger; Thalamus from sunflower Petals from safflower; Eri silk from castor;	• Additional net returns • Extended employment	• Necessary equipment for honey box • Eri silk production and rearing and weaving centres • Skill training and development • Demonstrations • Creation of FPO's for value addition / fortification	
Organic cultivation of sesame and HPS groundnut niche areas Organic mustard for organic honey	• Higher income through premium/ export earnings		**-Demonstration on Organic oilseeds** **-Demonstration on bee keeping**
Food use diversity of soybean;	• Supplements to the country's protein requirement		**-Setting up of cluster based oil extraction unit**

Strategy	Possible contribution	Requirements	Interventions for support
Cluster based oil extraction and marketing in non-traditional areas	• Home consumption of locally produced pressed oils. • Improves the nutritional security. • Additional income earnings through sale of pressed oils and oil cake. (20-25%)	• Machinery / Equipment support through KVIC/ MSME	
Expanding oilseeds in paddy fallows with limited irrigation	• Yield increase (30%) • Utilise residual fertility and moisture • Cost reduction (35%)	• Zero tillage machinery • Demonstrations • Custom hiring • Marketing support	**-Custom Hiring facilities**
Integrating oilseeds in Integrated Farming Systems	• Risk minimization, Profit maximization • Crop diversification, • Employment expansion.	• Skill development in handling different enterprises • Credit availability • Veterinary services locally • Development of other associated enterprises in the value system • Insurance • Marketing and storage	**-Training of farmers/Extension officials/enterprises / FPOs**
Small farm mechanization and custom hire services	• Yield increase • Timely sowing, • Harvesting	• Seed cum ferti drill, • Harvesting and threshing - combines. • Groundnut decorticator, • Castor thresher, • Sunflower and safflower combine harvester, • Soybean harvester, • Mustard seed planter etc.	**-Assistance on Farm Implements** **-Custom hiring**
Aggressive campaign for adoption of improved technologies through PPP model.	• Holistic yield increase (37 to 150%)	• Demonstrations • Model technology Farms in potential districts • Involving Farmer Producers Organizations	**-Model technology Farms** **-Model FPO**
Leveraging ICTs for dissemination of knowledge	• Reduction in information asymmetry • Enhanced productivity	• Mobile based dynamic updates in regional languages • Market updates	**-Mobile based advisories/apps**
Avoidance of excess usage of inputs, seed, chemicals, water, labour, tillage, etc.	• Reducing cost • Enhances the population of natural parasites and predators	• Demonstrations on dose and methods, Clean cultivation • Farmers' skill/awareness creation on technologies	Awareness among farmers

Strategy	Possible contribution	Requirements	Interventions for support
Contract farming	• Yield increase • Mechanization • Technology adoption • Credit facility • Insurance and risk minimization • Better price bargain and capacity utilization	• Legal framework • Processing plants linkage with oilseed growers • Private extension services	**-Contract farming-** Ministry of commerce
Awareness for excess use of vegetable oils	• **Reduction in imports** • **Health care**	• **Advertisement** • **Lecture series by nutritionist** • **KisanMelas /Seminar /Workshop**	**-Awareness campaign on vegetable oils**

Table A4 List of promising varieties/hybrids of oilseeds

Crop	**Name of variety/ hybrids**	**Source of the varieties/hybrids**
Castor	GCH-7, DCH-519, DCH-177, YRCH-1, DCS-107, Pragathi, Jwala	ICAR-IIOR, Hyderabad
Sunflower	DRSH-1, KBSH-44, KBSH-53, KBSH-51, DRSF-113, Prabat, PSH-996, RSFH-130, RSFV-901, CO-2	ICAR-IIOR, Hyderabad
Safflower	PBNS-12, AKS-207, PBNS-40, SSF-708, PKV Pink, NARI-57, NARI-NH-1, NARI-6, JSI-99,	ICAR-IIOR, Hyderabad
Sesame	PKVNT-11, G Til-4, JLT-408, RT-351, TKG-308, JT-14, RT-346, AKT-101, Subhra, Smarak, GT-3, Savitri, TKG-306, Amrit, JT-11, GT-10, Shekhar, Swetha Til,	PC Unit, AICRP, Sesame and Niger, JNKVV, Jabalpur.
Niger	JNS-28, IGPN- 2004-1, DNS-4, Utkal niger - 150, BNS-11, JNS-9, Jawhar niger composite-1,	PC Unit, AICRP, Sesame and Niger, JNKVV, Jabalpur.
Groundnut	Girnar 2, Girnar 3, GJG 31, GJG 9, GPBD 5, HNG 123, HNG 69, ICGV 00350, ICGV 00348, ICGV 91114, ICGH 00440, Kadiri, Harithandhra, Kadiri 6, Kadiri 9, Narayani, PhuleUnnati, Pratap Raj Mungphali, Raj Mungfali 1, TAG 24, TG 37A, TG 51, TPG 41, GPBD 4, VRI 2, GG20, GG21, Raj Mungfali 2, G2-52, Co 7, GJG 17, JGN 23, JL 501, Divya	ICAR-DGR, Junagadh
Soybean	JS 93-05, JS 95-60, JS 20-29, JS 20-34, RVS 2001-4, JS 20-69, NRC 86, MAUS-71, MAUS 158, MAUS 162, Pratap Soya 45, Pant Soya 1092, Pant Soya 1042, DSb-21, MACS 1188, MACS 1281, VLS 65, VLS 63	ICAR-IISR, Indore

Crop	Name of variety/ hybrids	Source of the varieties/hybrids
Rapeseed –mustard	Irrigated : RH 749, NRCDR 2, Giriraj, PM 21, PM 22, Urvashi, Maya, NRCHB 101, RGN 73, GM 3 Rainfed: RH 406, RGN 48, RB 50 Paddy fallow: Pusa agarni, NPJ 112, NRCHB 101, YSH 401 (yellow), NRCDR 05-02 Saline: CS 54	ICAR-DRMR, Bharathpur
Linseed	T 397, Garima, Padmini, JLS-9, Meera, Sheela, Shekher, Suyog, Deepika , Sharda, RLC-92, JL-41, Pratap Alsi-2, Parvati, Meera, Divya, Chhatisgarh Alsi-1, PKVNL-260, Arpita, Kota Barani Alsi-4, JLS-79	PC Unit, AICRP, Linseed, Kanpur

Table A5. Spread and productivity of important oilseeds in India (quinquennium ending 2013-14)

Crop	High Area – Low yield	Low Area – High yield
Groundnut	AP, KAR	OD, WB, CG, JH
Rapeseed - Mustard	AS, NEH	BH
Soybean	KA, CG	NG, PB, UC
Sunflower	KA, AP, MH	WB, OD
Sesame	RJ, UP, Bundelkhand	TN, AS, KAR
Safflower	KA, MH	GJ

Table A6 Oilseeds: Identified hotspot areas that need immediate interventions:

Crop	District/ Division/Region
Groundnut	Anantapuram Chittoor, Kadapa, Kurnool (A.P); Amreli, Bhavnagar, Jamnagar. Junagadh, Rajkot, Kutch, Porbandur (kharif), Bhavnagar, Junagadh,Vadodra, Kutch (rabi) (GJ); Dhule, Nashik (MH);Chitradurga, Tumkur, Bellary, Belgaum (KA); Kolhapur, Nasik, Sangli, Satara (MH); Bikaner, Churu, Jaipur, Jodhpur, Sikar (RJ); Chindwara, Shivpuri, Tikamgarh (MP); Erode, Namakkal, Pudukottai, Vellore, Villupuram, Salem, Thiruvanamallai (TN); Mahabubnagar, Karimnagar, Nalgonda, Rangareddy, Warangal
Sesame (excluding Bundelkhand region)	Rajkot, Amreli, Kutch (GJ), Pali, Jodhpur, Jalore, SawaiMadhapur, Sirohi, Bhilwara, Tonk, Nagaur, Ajmer, Bharatpur districts (RJ), Cauvery Delta Zone (TN), Central Plain region (UP); Sheopur, Singrauli (MP); Hoogly, Burdhman (WB)
Soybean	Malwa and Vindhya Plateau (M.P); Ahmednagar, Akola, Amravati, Beed, Buldhana, Chandpur, Hingoli, Latur, Nagpur, Nanded, Parbhani, Wardha, Washim,Yavatmal (MH); Baran, Bundi, Kota (RJ); Bemetra, Kabirdham, Rajnandgaon (CG); Adilabad (TS)

Crop	District/ Division/Region
Rapeseed-Mustard	Bundi, Pali, Jaisalmer, Jodhpur, Kota, Chittorgarh, Jhalawar, SawaiMadhapur, Tonk, (RJ); Barpeta, Darrang, Dheemaji, KarbiAnglog, Sonitpur (AS); Bhind, Gwalior, Morens, Shivpuri (MP);Budaun, Barabanki, Kanpur Dehat, Kheri, Mathura, Sitapur (UP); Bhiwani, Mahendragarh (HA);Banaskanta, Mehsana, Patan (GJ);
Sunflower	Vijayapura, Bagalkote, (KA), Kadapa, Kurnool (AP), Marathwada region (MH)
Safflower	Marathwada region (MH); Hyderabad Karnataka Region (HKR) comprising the districts of Bidar, Yadgir, Raichur, Koppal, Bellary and Gulbarga (KA)
Linseed	Balaghat, Chhatarpur, Damoh, Rewa, Satna, Seoni, Sidhi,(M.P), Chandrapur (MH),Hamirpur,Mahoba, Mirzapur, Sonbhadra (U.P)
Niger	Balrampur, Bastar, Jashipur,Sutguja (CG), Bidar, Mysore, Tumkur (KA),Annupur, Betul, Chindwara, Dindhori (M.P), Nasik (MH), Koraput, Kendujhar, Kandamal, Rayagada (OD)

Table A7 Area expansion to newer niches with intercropping

Crop	Potential crop/cropping systems/niche	Specific area	Agencies
Soybean	Sugarcane (irrigated), blackgram, greengram, pigeonpea& hybrid cotton	MS, Telangana & Karnataka	SDAs, KVKs
Groundnut	Pigeonpea	AP, TN, Karnataka, UP (Bundel.), Gujarat & MS	
	Castor & soybean	AP,TN, Gujarat & MP	
	Maize, sorghum &bajra	Rajasthan, Bihar, Punjab, NEH, MS, UP, Karnataka & Gujarat	
	Cotton	Gujarat MS, AP & TN	
	Sugarcane	MS, UP & Bihar	
	Coconut & Cassava	Kerala, AP & TN	
R-M	Sugarcane (irrigated)	UP & Bihar	
	Potato	Western UP	
	Chickpea, lentil & wheat	Rajasthan, UP & MP	
Sunflower	Groundnut, pigeonpea& soybean (Kh)	Karnataka & MS	
Safflower	Chickpea, Coriander &Jowar	AP, MS, Karnataka, MP, CG	
Sesame	Greengram, blackgram&redgram	AP, TN, Karnataka	
Castor	Groundnut &pigeonpea	Telangana, TN	
Linseed	Gram	UP, MP, Gujarat, Rajasthan, MS	

Table A8 Cultivation in rice and other fallow areas

Crop	Area of rice fallows	Agencies
Soybean	Punjab, Jharkhand, Odisha, CG, Karnataka, Nagaland, Manipur, Meghalaya, Maharashtra and Gujarat	SDAs, KVKs
Groundnut	Rice fallow: TN, AP, Odisha, WB, Goa Potato fallow: Dessa, Modipuram, WB Riverbed and upland: WB, TN, Odisha	
R-M	UP (E), Bihar, WB, NEH, Jharkhand, Odisha, CG	
Sunflower	AP, Karnataka, Odisha, Bihar and WB;	
Sesame	WB, Odisha, TN, AP	
Linseed for *Utera* situation	CG, WB, Odisha, Bihar, Assam	

Table A9 Crop expansion in non-traditional areas (NTA)

Crop	NTA	Agencies
Soybean	MS, Rajasthan, Telangana, Jharkhand, Gujarat, NEH	SDAs, KVKs
Groundnut	UP (C&W), Gujarat, WB, Manipur, Mizoram, Arunachal Pradesh	
R-M	Karnataka, Rajasthan (S), Ratlam and Indore (MP) &Vidarbha (MS), AP, NEH & low irrigated / low yielding wheat areas in the states of Haryana & UP	
Sesame	NEH	
Sunflower	Indo-Gangetic plain region	
Safflower (saline situation)	Gujarat, MP and CG	
Castor	TN, Haryana, Karnataka & Odisha	
Linseed	NEH	
Niger	AP, Karnataka & TN	

Table A10: State-wise districts covered under oil palm cultivation

SN	State	Nos. of Districts	Name. of District
1.	Andhra Pradesh	8	East Godavari, Krishna, Nellore, Srikakulam, Vishakapatnam, Vizianagaram, West Godavari and Ananatapur
2.	Telangana	4	Nalgonda, Bhadradri, Suryapet and Khammam
3	Chattisgarh	11	Kanker, Mahasammund, Dantewada, Jagadalpur, Sukma, Durg, Balod, Raigarh, Janjgir Champa, Bilaspur and Korba
4.	Goa	2	North Goa, South Goa
5.	Gujarat	11	Anand, Tapi, Narmada, Bharuch, Panchmahel, Kheda, Navasari, Surat, Vadodara, Valsad and Chotha Udepur
6.	Karnataka	23	Belagaum, Uttar Kannada, Davangere, Haveri, Bellary , Gadag, Koppal, Raichur, chamarajnagar, Hassan,

SN	State	Nos. of Districts	Name. of District
			Kodagu, Mandya, Mysore, Chikmagalur, Shimoga, Bagalkote, Bijapur, Gulbarga
7.	Kerala	9	Trivandrum, Kollam, Alappuzha, Pathanamihitta, Kottaym, Ernakulam, Kozhikode, Malappuram and Wyanadu
8.	Mizoram	7	Aizwal, Kolasib, Lawngtlai, Lunglei, Mamit, Saiha and Serchhip
9.	Odisha	15	Dhenkanal, Gajapati, Ganjam, Jajpur, Mayurbhanja, Balasore, Boudh, Cuttack, Nawrangpur, Koraput, Nayagarh, Rayagada, Sonepur, Bargarh and Bhadrak
10.	Tamil Nadu	26	Trichy, Karur, Cuddalore, Peramabalur, Thanjavur, Theni, Thiruvarur, Nagapattinam, Tirunelveli, Vellore, Villupuram, Pudukottai, Aryalur, Dindugal, Virudhnagar, Sivagangai, Kancheepuram, Triuvallur, Tiruvannamalai, Salem, Namakkal, Dharampuri, Krishnagiri, Coimbatore, Tiruppur and Erode
11.	Nagaland	6	Dimapur, Peren, Mokokchung, Wokha, Mon and Longleng
12.	Assam	3	Kamrup, Goalpara and Bongaigaon
13.	Arunachal Pradesh	8	Lohit, Changlang, Tirap, Lower Dibang Valley, East Siang, West Siang, L/Subansri and Papum Pare & East Kameng
	Total	**133**	

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