



सत्यमेव जयते  
Ministry of Agriculture &  
Farmers Welfare

# Report of the Committee on Doubling Farmers' Income

*Volume VII*

**“Input Management for Resource Use  
Efficiency & Total Factor Productivity”**

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**“Improving the Factors of Productivity & Efficient  
Use of Resources to Add to Farmers Income”**

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Document prepared by the Committee on 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 28<sup>th</sup> February, 2016. Further, recognising 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 organisations, farmers' organisations, 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 13<sup>th</sup> April, 2016 has held countless number of internal meetings, multiple stakeholder meetings, several conferences & workshops across the country and benefitted from many such deliberations organised 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 collate, 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
- Recognising 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 incentivising 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, organisation 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 realising the vision of doubling farmers' income by the year of India's 75<sup>th</sup> 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.

12<sup>th</sup> August, 2017

**Ashok Dalwai**  
Chairman, Committee on  
Doubling Farmers' Income

## **About Volume VII**

The seventh volume of the Report of the Committee on Doubling Farmers' Income (DFI) examines how resource use efficiency and total factor productivity can be improved in the agricultural sector. Improvements in the multiple factors that result in the final output being more than the sum of inputs is an important driver of change. Improvements in resource use efficiency will contribute to efficient economic conversion by way of higher productivity, lower cost per unit of output and sustainability.

The inputs in the agricultural sector are many, and involve natural resources, manmade inputs, power in form of labour or mechanisation, and finance. The broad areas involve soil, water, seed, pest management, agricultural mechanisation, short and long term credit, and capital formation. Utilising these resources to the most optimal level possible, not only makes the agricultural value system more effective, but also makes the system efficient and sustainable.

Material inputs during the cultivation phase of agricultural activities must be managed for better use efficiency and productivity, as well to mitigate possible shortfalls in other inputs such as labour and water. Resource use efficiency brings long term positive transformation in farmers' income and the agricultural economy. Making efficient use of natural resources, also ensures longevity and sustainability of the system and this volume is in a way, an extension of sustainable approach to agriculture, as enumerated in the previous two volumes of this Report.

This volume enlists the broad contours of input management, with a view to realise higher net returns from agricultural production besides reducing human drudgery. Volume-VIII that follows, will discuss the productivity aspects across the various agricultural production systems based on the current agro-ecological realities.

**Ashok Dalwai**

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# Doubling Farmers' Income

Volume VII

## “Input Management for Resource Use Efficiency”

### Contents

<b>Foreword</b> .....	<b>i</b>
<b>About Volume VII</b> .....	<b>v</b>
<b>Setting the Context for Input Management</b> .....	<b>1</b>
0.1. INTRODUCTION .....	1
0.2. CEREALS .....	1
0.3. PULSES .....	3
0.4. OILSEEDS .....	5
0.5. COMMERCIAL CROPS .....	7
0.6. CONCLUSION .....	8
<b>Chapter 1 Soil Health and Nutrient Management</b> .....	<b>11</b>
1.1. INTRODUCTION .....	11
1.2. SOILS OF INDIA .....	12
1.2.1. Alluvial soils.....	13
1.2.2. Red soils .....	13
1.2.3. Black soils.....	14
1.2.4. Desert soils.....	15
1.2.5. Laterite and lateritic soils.....	15
1.2.6. Forest and hill soils.....	15
1.2.7. Salt-affected soils.....	16
1.3. PARADIGM SHIFT IN FARMING .....	16
1.4. SECOND GENERATION PROBLEMS - NATURAL RESOURCES ARE A CASUALTY .....	17
1.4.1. Changes in soil organic matter under intensive cropping.....	18
1.4.2. Poor soil fertility status .....	18
1.4.3. Decline in Soil Physical Conditions .....	20
1.4.4. Acidification, Salinization, Alkalization and Waterlogging .....	21
1.4.5. Induction of Poor Lands into Agriculture .....	22
1.4.6. Imbalanced Use of Plant Nutrients .....	22
1.4.7. Decline in Factor Productivity .....	23
1.5. SOIL TESTING FOR SOIL HEALTH MONITORING .....	23
1.5.1. Weaknesses of Soil Testing Service .....	25
1.6. SOIL HEALTH CARD SCHEME .....	28
1.7. SOIL HEALTH MANAGEMENT .....	28
1.7.1. Site-specific nutrient management.....	29
1.7.2. Integrated nutrient management.....	29
1.7.3. Ingredients of INM.....	30
1.7.4. Real-time N management.....	34

1.7.5.	<i>Decision support tools for enhancing NUE</i> .....	35
1.7.6.	<i>Management of problem soils</i> .....	36
1.7.7.	<i>Conservation agriculture (CA)</i> .....	37
1.8.	RECOMMENDATIONS .....	38
1.8.1.	<i>Revamping soil testing services</i> .....	38
1.8.2.	<i>Strengthening Soil Health Card</i> .....	41
1.8.3.	<i>Promoting balanced and integrated use of fertilizers</i> .....	43
1.9.	ANNOTATION .....	45
<b>Chapter 2 Water Management in Agriculture .....</b>		<b>49</b>
2.1.	INTRODUCTION.....	49
2.2.	CURRENT PRACTICES AND CHALLENGES .....	51
2.3.	CONTOURS OF WATER MANAGEMENT .....	54
2.3.1.	<i>Irrigated areas</i> .....	54
2.3.2.	<i>Rainfed areas</i> .....	55
2.4.	GOVERNMENT INITIATIVES.....	55
2.5.	POLICY RECOMMENDATIONS.....	59
2.5.1.	<i>Suggestions for irrigated areas</i> .....	59
2.5.2.	<i>Suggestions for rainfed areas</i> .....	63
2.5.3.	<i>Suggestions common to both irrigated and rainfed area</i> .....	66
2.6.	ANNOTATION .....	68
<b>Chapter 3 Seed .....</b>		<b>71</b>
3.1.	SEED - A CRITICAL INPUT .....	71
3.1.1.	<i>Quality of breeder seed</i> .....	72
3.1.2.	<i>Millets and Wheat Over Rice and Wheat</i> .....	72
3.1.3.	<i>Changing climate puts India at risk</i> .....	73
3.2.	SEED DELIVERY SYSTEM.....	73
3.3.	ASSESSING SEED REQUIREMENT .....	74
3.3.1.	<i>District level committee</i> .....	75
3.3.2.	<i>State level consolidation of the requirement</i> .....	75
3.3.3.	<i>Block level committee</i> .....	75
3.3.4.	<i>Basis of assessing seed requirement</i> .....	76
3.4.	SEED PRODUCTION AND SUPPLY CHAIN .....	77
3.5.	BREEDER SEED PRODUCTION AND VARIETAL STATUS IN SEED CHAIN.....	77
3.6.	IMPACT OF CLIMATE .....	78
3.6.1.	<i>Production of abiotic &amp; biotic stress tolerant varieties</i> .....	78
3.7.	IMPROVING THE SRR, VRR AND SMR.....	79
3.7.1.	<i>Present status vs future prospects</i> .....	79
3.7.2.	<i>Varietal Replacement Rate (VRR)</i> .....	79
3.7.3.	<i>Production of certified seeds</i> .....	80
3.8.	STRATEGIES FOR ENERGISING SEED PRODUCTION AND SUPPLY CHAIN.....	81
3.8.1.	<i>Effective input management in seed sector</i> .....	82
3.8.2.	<i>Seed vision</i> .....	84
3.8.3.	<i>Strategy</i> .....	85
3.9.	SEED PROCESSING AND STORAGE.....	85
3.10.	SEED DISTRIBUTION.....	86



3.11.	FOCUS ON SEED CHAIN OF VEGETABLE/ OTHER HORTICULTURE CROPS .....	86
3.12.	FOCUS ON NUTRI-CEREALS .....	86
3.13.	PILOT MODEL SEED PLATFORM: .....	87
3.14.	SCOPE FOR SEED EXPORT.....	87
3.15.	USE OF ICT- REAL TIME DATA.....	88
3.16.	ANNOTATION .....	88
<b>Chapter 4 Pest Management .....</b>		<b>91</b>
4.1.	INTRODUCTION .....	91
4.2.	CHALLENGES .....	93
4.2.1.	<i>Quality of pesticides</i> .....	93
4.2.2.	<i>Optimum application of pesticides</i> .....	95
4.2.3.	<i>Limited reach of IPM techniques</i> .....	96
4.2.4.	<i>Price of generic pesticides</i> .....	97
4.3.	INTERVENTIONS .....	97
4.3.1.	<i>Interventions by central government</i> .....	97
4.3.2.	<i>State government interventions</i> .....	100
4.3.3.	<i>Interventions by research organizations (ICAR/SAUs)</i> .....	101
4.4.	REDUCING PESTICIDE CONSUMPTION IN INDIAN AGRICULTURE .....	102
4.5.	SOME STRATEGIC INTERVENTIONS.....	107
4.5.1.	<i>Access or Accessibility</i> .....	108
4.5.2.	<i>Cost</i> .....	108
4.5.3.	<i>Awareness &amp; education for effective and safe use</i> .....	108
4.5.4.	<i>Early warning and preventive measures</i> .....	108
4.5.5.	<i>Prophylactic measures</i> .....	109
4.5.6.	<i>Registration of pesticides</i> .....	109
4.6.	ANNOTATION .....	110
<b>Chapter 5 Agricultural Mechanisation .....</b>		<b>113</b>
5.1.	FARM MECHANISATION – MEANING AND RELEVANCE.....	113
5.2.	DEFINING AGRICULTURAL MECHANISATION.....	114
5.3.	AGRICULTURAL MECHANISATION AND SUSTAINABILITY.....	115
5.4.	STATUS OF FARM MECHANISATION .....	116
5.5.	STRATEGY AND RECOMMENDATIONS TO SUIT INDIAN AGRICULTURE.....	118
5.6.	AGGREGATION PLATFORM.....	119
5.7.	APPROPRIATENESS OF MACHINERY .....	120
5.8.	GOING BEYOND MECHANICAL POWER .....	120
5.9.	ANNOTATION .....	121
<b>Chapter 6 Credit and Capital Formation in Agriculture.....</b>		<b>123</b>
6.1.	CONTEXT .....	123
6.2.	GROWTH IN AGRICULTURAL CREDIT .....	124
6.3.	SHORT TERM CREDIT AND INVESTMENT CREDIT (LT).....	125
6.4.	GROUND LEVEL CREDIT – SHARE OF VARIOUS AGENCIES .....	126
6.5.	REGIONAL IMBALANCE IN CREDIT DISBURSEMENT .....	128
6.5.1.	<i>The regional trends in agricultural credit flow</i> .....	129

6.6.	INCLUSIVENESS OF AGRICULTURE CREDIT SYSTEM.....	129
6.7.	CONSTRAINTS IN FINANCING SMALL AND MARGINAL FARMERS .....	131
6.7.1.	<i>Declining size of land holding</i> .....	131
6.7.2.	<i>Lack of proper Record of Right</i> .....	131
6.7.3.	<i>Increased share of tenant farmers/share croppers</i> .....	132
6.7.4.	<i>Notion of high NPAs</i> .....	132
6.8.	COERCIVE ACTION FOR REPAYMENT .....	132
6.9.	ANOMALIES IN THE PRIORITY SECTOR LENDING (PSL) IN AGRICULTURE.....	132
6.10.	THE WAY FORWARD: STRATEGIES FOR FINANCING SMF .....	133
6.10.1.	<i>Strict adherence of target group stipulations</i> .....	133
6.10.2.	<i>Farmers' mobilisation</i> .....	133
6.10.3.	<i>Joint Liability Groups (JLGs)</i> .....	133
6.10.4.	<i>Land lease markets</i> .....	134
6.10.5.	<i>Land records and digitisation</i> .....	134
6.10.6.	<i>Infrastructure and common assets</i> .....	134
6.11.	OTHER BANK RELATED CONCERNS .....	134
6.12.	WAY FORWARD.....	135
6.13.	INCONSISTENT ABOUT CAPITAL FORMATION .....	136
6.14.	TRENDS IN AGRICULTURAL CAPITAL FORMATION SINCE THE 1990S .....	136
6.15.	INVESTMENT 'FOR' AGRICULTURE: RURAL INFRASTRUCTURE .....	137
6.15.1.	<i>Rural Infrastructure</i> .....	137
6.15.2.	<i>Crucial role of states/UTs</i> .....	137
6.16.	SHARE OF PUBLIC AND PRIVATE SECTOR IN GCFA .....	137
6.17.	PRIVATE SECTOR CAPITAL FORMATION AND LONG TERM CREDIT .....	138
6.18.	INCREASING INVESTMENT CREDIT .....	139
6.18.1.	<i>Investment Credit Achievements</i> .....	139
6.18.2.	<i>Tapping the potential for funding investment credit</i> .....	140
6.18.3.	<i>Interest subvention for direct investment credit</i> .....	140
6.19.	POLICY INITIATIVES FOR AGRICULTURE.....	141
6.20.	ROLE OF BANKS & FINANCIAL INSTITUTIONS.....	143
6.21.	STRATEGIC AREAS.....	144
6.21.1.	<i>Cost reduction strategies:</i> .....	145
6.21.2.	<i>Risk mitigation measures</i> .....	145
6.22.	AGRICULTURE CREDIT – MANAGEMENT INFORMATION SYSTEM .....	146
6.22.1.	<i>Returns as now submitted by Banks</i> .....	146
6.23.	RECOMMENDED APPROACH .....	146
<b>Chapter 7</b>	<b>Credit Guarantee Trust Fund for Term Loans` .....</b>	<b>147</b>
7.1.	BACKGROUND .....	147
7.2.	NEED FOR A GUARANTEE SCHEME: CGFT-TL .....	148
7.3.	OBJECTIVES OF THE SCHEME .....	148
<b>Chapter 8</b>	<b>Policy Recommendation .....</b>	<b>150</b>
8.1.	SOIL HEALTH MANAGEMENT – BALANCED NUTRIENTS.....	150
8.2.	WATER USE MANAGEMENT.....	152
8.3.	SEEDS.....	155
8.4.	PEST MANAGEMENT.....	157

8.5.	AGRICULTURAL MECHANISATION .....	164
8.6.	AGRICULTURAL CREDIT.....	166
<b>References</b>	.....	<b>171</b>
<b>Annexures</b>	.....	<b>173</b>

### **Index of Figures**

Figure 1.1 Changes in foodgrain production, net cultivated & irrigated area, fertilizer consumption and population in India since 1950-51 .....	17
Figure 1.2 Extent of multiple nutrient deficiency .....	19
Figure 1.3 Effect of continuous rice-wheat cropping on soil compaction (measured as bulk density).....	20
Figure 1.4 Temporal changes in land use in India .....	22
Figure 1.5 Temporal distortions in fertilizer consumption ratio .....	23
Figure 1.6 Expansion of soil testing service in India .....	25
Figure 1.7 Annual productivity and economic returns in rice-wheat cropping system under SSNM vis-à-vis farmer's fertilizer practice (FFP) and state recommendation (SR) .....	29
Figure 1.8 Nitrogen use efficiencies in wheat (average of 2 years) under conservation agriculture (CA) and conventional tillage (CT)-based maize-wheat system .....	38
Figure 2.1 Extent and sources of irrigation in Agriculture .....	50
Figure 2.2 Crop-wise ratio of rainfed and irrigated area.....	50
Figure 2.3 Coverage of micro-irrigation.....	58
Figure 4.1 Registration of Pesticides (2005-06 to 2016-17).....	92
Figure 4.2 Total number of Bio-pesticides Registered (2005-06 to 2016-17).....	93
Figure 5.5.1: Trend in farm power availability in India (kw/ha) .....	117
Figure 6.1 Trend in GLC and Term loan (Rs. crore) .....	126
Figure 6.2 Trends in Capital Formation in Indian Agriculture (at 2004-05 prices).....	137
Figure 6.3 Long term credit (disbursements) and private sector gross capital formation (GCF) .....	139

### **Index of Tables**

Table 0.1 Input use pattern and cost structure in paddy.....	2
Table 0.2 Input use pattern and cost structure in wheat.....	3
Table 0.3 Input use pattern and cost structure in arhar .....	4
Table 0.4 Input use pattern and cost structure in gram .....	4
Table 0.5 Input use pattern and cost structure in groundnut .....	5
Table 0.6 Input use pattern and cost structure in rapeseed & mustard.....	6
Table 0.7 Input use pattern and cost structure in cotton .....	7
Table 0.8 Input use pattern and cost structure in sugarcane .....	8
Table 1.1 Major soil groups of India and their per cent are coverage.....	12
Table 1.2 Effect of long-term nutrient management on soil organic C content (%) at different location over a period of two to four decades .....	18
Table 1.3 Extent of nutrient deficiency in Indian soils .....	19
Table 1.4 Harmonized area statistics of degraded and wastelands of India.....	21
Table 1.5 Effect of INM on economics of different cropping systems .....	35
Table 1.6 Effect of fertilization and liming on crop yields (t ha-1) in acid soils of different states .....	37

Table 2.1 Water Availability Status (billion cubic metres) .....	49
Table 2.2 Sector-wise demand for water .....	53
Table 2.3 Green water management interventions and implementation strategies in different rainfed regions ...	64
Table 3.1 Seed assessment committee .....	75
Table 3.2 Compensation of the state level committee .....	75
Table 3.3 Seed Replacement Rate (SRR) – Projection as per current and future requirements .....	79
Table 5.5.1: Share of farm mechanisation in farming operations .....	118
Table 6.1 Indebtedness status of farmers .....	124
Table 6.2 Agricultural credit - targets and achievements since 2007-08 .....	125
Table 6.3 Year 2016-17 – break up of agricultural credit (Rs. in crore).....	125
Table 6.4 Share of agencies in total agricultural GLC (Rs. crore).....	127
Table 6.5 Agency-wise number of agricultural GLC account (2007-08 to 2016-17).....	127
Table 6.6 Regional distribution of agriculture credit and real sector indicators (%) .....	128
Table 6.7 Region wise GLC flow under agriculture during 2015-16 & 2016-17 & target for 2017-18 .....	129
Table 6.8 Agency-wise share of SMF in total Agriculture credit (average for 2007-08 to 2016-17).....	130
Table 6.9 Ground level credit flow to Agriculture – share of SMF .....	130
Table 6.10 Share of public and private sector in total capital formation (in Agriculture and allied activities) ..	138
Table 6.11 Private sector GCF in Agriculture and long term credit-All India.....	138
Table 6.12 Target and achievement under Investment Credit .....	140

## **Setting the Context for Input Management**

*An income approach to agricultural enterprise demands treatment of 3 important variables – productivity, price and input cost. There is need to examine the critical inputs involved in crop production with respect to current practices and amendments needed to achieve their use efficiency. In this context, an analysis of the current pattern of input use and costs defining select crops over the decade of 2004-05 to 2014-15 is done, selecting 2 major crops under each of the crop groups, namely, cereals, pulses, oilseeds and commercial crops.*

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### **Analysis of Input Use Pattern and Cost in Major Crops**

#### **0.1. Introduction**

Past strategy for development of the agriculture sector in India has focused primarily on raising agricultural output and improving food security (Chand, 2017). Among all the strong measures needed to harness all possible sources for agricultural growth, resource use efficiency and minimizing cost of cultivation/production is critical. This is particularly important from the perspective of enhancing net returns from a farming activity. The cost of cultivation has been on the rise, eroding the profits. Lowering the costs without compromising on the output can increase the net income. It is possible to do so as there is a general tendency on the part of farmers to apply overdose of inputs in expectation of higher yields. Therefore, innovating input managerial solutions to maximize farmers' welfare rather than relying solely on modern farming to raise productivity and production is should be a preferred option.

The cost of cultivation of crops has been increasing over the years because of increase in wage rate of labour, input prices and other managerial costs (Narayanamoorthy, 2007; Raghvan, 2008). Previous studies have unanimously reported rising input cost as a major cause for agrarian distress. Input use pattern and cost structure of major inputs in cultivation of cereals, pulses, oilseeds and commercial crops in the last decade i.e. 2004/05-2014/15 is discussed in the subsequent tables. Two major crops under each category i.e. rice and wheat under cereals, chickpea and pigeon pea under pulses, groundnut and rapeseed under oilseeds, and, cotton and sugarcane under commercial crops have been taken as cases for illustrating the hypothesis.

#### **0.2. Cereals**

Paddy and wheat are the major cereals produced in the country and are corner stones of national food security. The input use scenario in the major producing states of paddy (Andhra Pradesh, Punjab, Uttar Pradesh and West Bengal) and wheat (Uttar Pradesh, Madhya Pradesh, Punjab and Haryana) has been depicted in Tables 0.1 and 0.2. Table 0.1 reveals that the seed used per hectare in paddy has reduced in all the major producing states over the decade. A constant increasing production despite reduced use of the planting material indicates inclination of the farmers toward high yielding varieties. The seed used for wheat in Haryana has also declined in the last decade. However, the use of the planting material for wheat has increased marginally in other major producing states over the same time period.

The share of seed cost in total operational cost has marginally changed or remained constant in

case of both the major crops. It is noteworthy to mention, that the share of seed cost in case of paddy has been comparatively lower than that of wheat in their respective major producing states, indicating that the planting material of paddy is more cost efficient than that of another major cereal i.e. wheat.

**Table 0.1 Input use pattern and cost structure in paddy**

Inputs	Andhra Pradesh		Punjab		Uttar Pradesh		West Bengal	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
<b>A2 Cost of production (Rs./Qtl)</b>	277	694	267	503	294	751	295	740
<b>Material &amp; Labour Input per Hectare</b>								
Seed (Kg.)	77	69	0	0	0	0	68	62
Fertilizer (Kg. Nutrients)	187	248	213	185	122	172	118	160
Manure (Qtl.)	24	17	21	20	7	1	13	17
Human Labour (Man Hrs.)	991	614	451	346	854	797	1200	1055
Animal Labour (Pair Hrs.)	37	7	2	0	19	3	104	36
<b>Item wise Breakup of Cost of Cultivation (Percentage of Total Operational Cost)</b>								
Human Labour	49.0	49.7	28.6	43.2	45.7	51.0	54.4	65.3
Animal Labour	5.1	1.1	0.5	0.1	4.1	0.9	13.9	3.0
Machine Labour	10.5	18.1	21.8	18.7	11.6	11.7	4.8	7.2
Seed	4.6	4.4	3.5	5.2	8.9	9.1	4.0	3.3
Fertilizer	13.4	14.3	14.4	9.8	11.7	10.8	9.7	9.1
Manure	3.0	1.9	0.7	1.0	1.0	0.2	2.1	2.0
Insecticides	6.4	5.2	7.7	11.5	0.5	0.5	1.0	2.6
Miscellaneous	8.1	5.3	22.7	10.3	16.6	15.9	10.1	7.5
<b>Total Operational Cost (Rs/ha)</b>	<b>17,531</b>	<b>51,821</b>	<b>16,764</b>	<b>34,041</b>	<b>12,952</b>	<b>39,481</b>	<b>17,180</b>	<b>54,259</b>

*Source: DFI Committee Estimates based on CACP data*

As regards another input, namely, fertilizer, which contributes majorly to productivity, there is a tendency among farmers consistently increase the application of agro-chemicals. Fertilizer use in paddy has drastically increased in the three out of four major rice producing states. Interestingly, the use of chemical fertilizer for paddy cultivation in Punjab has declined in the last decade. Fertilizer use has also shown upward trend in wheat but at a slower pace than that of paddy (Table 0.2).

The cost share of fertilizer has reduced in the major cereals growing states except for Andhra Pradesh (in case of paddy), and Uttar Pradesh (in case of wheat). Further, the lower share of fertilizer cost in paddy as compared to wheat indicates the cost efficiency of the former. Also the percentage share of the insecticide in the operation cost has also declined in all the selected states except Madhya Pradesh.

**Table 0.2 Input use pattern and cost structure in wheat**

Inputs	Uttar Pradesh		Madhya Pradesh		Punjab		Haryana	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
<b>A2 Cost of production (Rs./Qtl)</b>	338	752	311	525	289	515	270	503
<b>Material &amp; Labour Input per Hectare</b>								
Seed (Kg.)	144	148	114	115	105	106	121	111
Fertilizer (Kg. Nutrients)	156	179	94	112	237	247	195	195
Manure (Qtl.)	4	0	0	0	9	1	1	1
Human Labour (Man Hrs.)	447	393	316	285	164	124	293	268
Animal Labour (Pair Hrs.)	15	6	35	10	2	0	7	0
<b>Item wise Breakup of Cost of Cultivation (Percentage of Total Operational Cost)</b>								
Human Labour	26.1	36.0	25.4	33.1	16.7	22.9	27.1	37.3
Animal Labour	3.8	1.9	7.5	3.0	0.6	0.2	1.3	0.0
Machine Labour	22.3	20.3	17.2	25.9	33.1	34.9	26.2	26.0
Seed	9.3	10.4	11.2	10.1	7.4	8.3	7.1	7.1
Fertilizer	15.4	15.8	13.9	11.2	24.5	21.9	16.8	12.9
Manure	0.6	0.1	0.2	0.0	0.4	0.1	0.1	0.1
Insecticides	0.3	0.1	0.1	0.2	10.1	6.5	5.6	2.7
Miscellaneous	22.3	15.3	24.5	16.6	7.1	5.1	15.7	13.9
<b>Total Operational Cost (Rs./ha)</b>	<b>13,329</b>	<b>30,544</b>	<b>8,915</b>	<b>25,625</b>	<b>11,673</b>	<b>23,718</b>	<b>14,243</b>	<b>33,124</b>

*Source: DFI Committee Estimates based on CACP data*

It is no gainsay, that human labour accounts for a prominent share in operational cost in paddy cultivation. Even the share of human labour cost has increased drastically in Punjab from 29 per cent in 2004/05 to 43 per cent in 2014/15.

In case of wheat, unlike paddy, both human and machine labour constitutes a major cost component. Extensive mechanization prevails in wheat cultivation in Punjab as indicated by highest share of machine labour in total operational cost (Table 0.2).

### 0.3. Pulses

Two major pulses arhar and gram have been considered under pulse category to analyse input pattern and cost structure in their major producing states (Table 0.3 and 0.4). Between the two, seed rate in arhar is much lower than that of gram in their respective major producing states. Also, in case of arhar, except for Madhya Pradesh where seed rate has increased over time, the use of the planting material was either the same (Maharashtra) or declined (Karnataka and Gujarat). In comparison to other selected states, farmers in Karnataka spend significant part of their operational cost on insecticides.

**Table 0.3 Input use pattern and cost structure in arhar**

Inputs	Maharashtra		Madhya Pradesh		Karnataka	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
<b>A2 Cost of production (Rs./Qtl)</b>	731	3284	477	1759	1028	2249
<b>Material &amp; Labour Input per Hectare</b>						
Seed (Kg.)	18	18	19	24	14	12
Fertilizer (Kg. Nutrients)	36	104	3	20	73	74
Manure (Qtl.)	3	3	5	1	4	1
Human Labour (Man Hrs.)	642	718	355	426	435	361
Animal Labour (Pair Hrs.)	91	59	59	47	59	52
<b>Item wise Breakup of Cost of Cultivation (Percentage of Total Operational Cost)</b>						
Human Labour	39.5	43.3	45.8	53.9	31.4	42.8
Animal Labour	36.0	12.2	18.1	14.9	20.9	13.0
Machine Labour	6.2	15.9	15.5	11.6	9.1	13.3
Seed	6.2	2.9	8.9	9.0	4.5	3.8
Fertilizer	5.6	10.2	0.6	4.1	13.1	11.7
Manure	1.8	1.2	4.4	0.7	2.4	0.2
Insecticides	1.3	9.5	2.4	3.8	15.7	12.4
Miscellaneous	3.4	4.7	4.3	2.0	2.9	2.9
<b>Total Operational Cost (Rs./ha)</b>	<b>9,358</b>	<b>40,913</b>	<b>5,792</b>	<b>18,897</b>	<b>8,006</b>	<b>22,325</b>

*Source: DFI Committee Estimates based on CACP data*

The use of fertilizer in pulses has increased dramatically in major producing states, except for Gujarat which appears to be more fertilizer-efficient in cultivation of arhar. It is worth mentioning that, Gujarat has set an example by preferring manure over chemical fertilizer in the field as indicated by 17 times increase in manure application for arhar cultivation.

**Table 0.4 Input use pattern and cost structure in gram**

Inputs	Maharashtra		Madhya Pradesh		Rajasthan	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
<b>A2 Cost of production (Rs./Qtl)</b>	1060	2006	489	1490	522	1503
<b>Material &amp; Labour Input per Hectare</b>						
Seed (Kg.)	65	75	81	96	57	63
Fertilizer (Kg. Nutrients)	31	63	33	43	4	30
Manure (Qtl.)	0	1	1	0	0	0
Human Labour (Man Hrs.)	390	370	248	247	199	205
Animal Labour (Pair Hrs.)	37	14	31	11	13	4
<b>Item wise Breakup of Cost of Cultivation (Percentage of Total Operational Cost)</b>						
Human Labour	32.5	38.7	28.5	33.4	43.4	48.0
Animal Labour	16.3	5.0	9.8	3.3	6.6	2.6
Machine Labour	14.0	16.8	18.2	20.6	20.3	17.9
Seed	17.1	11.9	20.9	20.3	21.0	12.5



Inputs	Maharashtra		Madhya Pradesh		Rajasthan	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
Fertilizer	5.8	9.9	8.1	7.9	1.1	6.4
Manure	0.0	0.3	0.5	0.0	0.0	0.0
Insecticides	0.3	3.9	1.0	4.4	0.5	0.0
Miscellaneous	14.0	13.5	13.0	10.2	7.2	12.5
<b>Total Operational Cost (Rs/ha)</b>	<b>7,874</b>	<b>25,656</b>	<b>6,133</b>	<b>20,867</b>	<b>4,518</b>	<b>16,444</b>

*Source: DFI Committee Estimates based on CACP data*

As far as operational cost is concerned, seed has important share in case of gram which is obvious from high seed rate in raising of the crop. It can be concluded from Tables 0.3 and 0.4 that arhar is more seed efficient than that of gram. Fertilizer cost has escalated in Madhya Pradesh (four fold increase in arhar) and Rajasthan (six times in gram). The share of fertilizer cost in case of both the pulses has also increased from 6 per cent to 10 per cent in total operational cost in Maharashtra.

#### 0.4. Oilseeds

With a similar approach as in case of cereals and pulses, two major oilseeds grown in India viz., groundnut and rapeseed & mustard have been taken as a case under oilseeds category. The input use pattern and cost structure of both the oilseed crops have been presented in Tables 0.5 and 0.6. The seed rate of groundnut has increased in Maharashtra and Madhya Pradesh, while it has declined in Rajasthan. In contrast, the seed rate of rapeseed & mustard has almost remained same with marginal change in their major producing states (Maharashtra, Madhya Pradesh and Rajasthan) over period of time. Fertilizer rate has also increased over period of time in all the major oilseed growing states except for Rajasthan. Manure application has also increased in groundnut cultivation.

**Table 0.5 Input use pattern and cost structure in groundnut**

Inputs	Andhra Pradesh		Gujarat		Tamil Nadu	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
<b>A2 Cost of production (Rs./Qtl)</b>	901	2698	943	2148	882	2168
<b>Material &amp; Labour Input per Hectare</b>						
Seed (Kg.)	101	111	106	142	118	109
Fertilizer (Kg. Nutrients)	50	88	62	83	89	107
Manure (Qtl.)	16	51	29	36	31	40
Human Labour* (Man Hrs.)	546	537	508	677	1023	792
Animal Labour (Pair Hrs.)	101	111	106	142	118	109
<b>Item wise Breakup of Cost of Cultivation (Percentage of Total Operational Cost)</b>						
Human Labour	38.7	44.2	33.4	39.4	50.2	49.6
Animal Labour	11.1	4.7	13.9	7.0	4.3	1.4
Machine Labour	4.9	6.2	10.0	11.6	7.7	9.2
Seed	27.9	23.4	23.5	17.1	17.7	16.5

Inputs	Andhra Pradesh		Gujarat		Tamil Nadu	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
Fertilizer	6.5	7.9	6.6	5.2	6.0	6.9
Manure	4.5	8.4	4.7	7.6	4.9	8.0
Insecticides	1.5	1.1	2.1	5.2	1.6	1.2
Miscellaneous	4.8	4.1	5.8	6.8	7.6	7.3
<b>Total Operational Cost (Rs/ha)</b>	<b>10,789</b>	<b>36,803</b>	<b>12,956</b>	<b>54,325</b>	<b>18,903</b>	<b>56,989</b>

*Source: DFI Committee Estimates based on CACP data*

Seed posts prominent share in operational cost after human labour in groundnut cultivation. The share of seed cost has declined in total operational cost in all the major groundnut producing states over period of time. Contrastingly, seed exhibits marginal share in cost of cultivation of rapeseed & mustard (Table 0.6). However, except in case of Madhya Pradesh, the share of seed cost has doubled in the last decade in Haryana and Rajasthan.

**Table 0.6 Input use pattern and cost structure in rapeseed & mustard**

Inputs	Haryana		Madhya Pradesh		Rajasthan	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
<b>A2 Cost of production (Rs./Qtl)</b>	573	1104	371	850	406	1110
<b>Material &amp; Labour Input per Hectare</b>						
Seed (Kg.)	4	4	7	6	5	6
Fertilizer (Kg. Nutrients)	113	128	58	101	83	83
Manure (Qtl.)	0	0	0	0	2	0
Human Labour (Man Hrs.)	252	213	319	268	294	335
Animal Labour (Pair Hrs.)	10	0	65	3	5	1
<b>Item wise Breakup of Cost of Cultivation (Percentage of Total Operational Cost)</b>						
Human Labour	33.0	45.0	38.1	46.6	35.9	52.5
Animal Labour	2.7	0.2	16.7	0.9	2.6	0.6
Machine Labour	31.0	25.5	17.4	25.9	25.0	19.3
Seed	2.4	3.6	2.4	2.1	2.5	3.8
Fertilizer	15.9	13.7	13.1	15.5	14.8	9.7
Manure	0.0	0.0	0.4	0.0	0.7	0.0
Insecticides	0.7	0.4	0.5	1.4	0.4	0.1
Miscellaneous	14.3	11.7	11.5	7.7	18.1	14.1
<b>Total Operational Cost (Rs/ha)</b>	<b>9,181</b>	<b>24,229</b>	<b>6,262</b>	<b>18,367</b>	<b>7,528</b>	<b>23,514</b>

*Source: DFI Committee Estimates based on CACP data*

The share of fertilizer cost has marginally increased in case of groundnut, while it has declined in case of rapeseed & mustard in their respective producing states. However, a reverse pattern can be noticed in Madhya Pradesh as far as share of fertilizer cost in total operational cost is concerned.

## 0.5. Commercial Crops

The cost of cultivation for cotton and sugarcane under commercial crops category is presented in Table 0.7. In case of cotton the highest increase in component is in the case of fertilizer both in the state of Gujarat and Maharashtra. In contrast the cost has declined in context of human and animal labours thus showing trend towards mechanization.

The cost component in case of cotton doesn't show that much fluctuation in terms of per hectare cost in other components like seeds, manure, human labour and animal Labour. Also as the table suggests the major percentage of the operational cost has been used in the human labour. In all three selected states component of the human labour has increased over the years. As can be noted in comparison to other crops the percentage cost of insecticides in operational cost is quite significant in case of cotton.

**Table 0.7 Input use pattern and cost structure in cotton**

Inputs	Andhra Pradesh		Gujarat		Maharashtra	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
<b>A2 Cost of production (Rs./Qtl)</b>	1019	2731	877	2274	1493	2938
<b>Material &amp; Labour Input per Hectare</b>						
Seed (Kg.)	3	2	3	2	4	2
Fertilizer (Kg. Nutrients)	224	229	103	216	93	216
Manure (Qtl.)	18	13	34	32	11	14
Human Labour (Man Hrs.)	998	873	1073	1015	783	930
Animal Labour (Pair Hrs.)	86	49	42	18	119	84
<b>Item wise Breakup of Cost of Cultivation (Percentage of Total Operational Cost)</b>						
Human Labour	40.2	54.4	43.1	49.1	27.7	43.9
Animal Labour	13.0	7.2	6.3	3.2	31.9	13.6
Machine Labour	2.4	8.5	9.0	11.0	5.0	7.5
Seed	6.2	7.3	12.2	6.1	12.6	7.0
Fertilizer	15.1	12.0	7.8	9.6	8.4	12.4
Manure	3.7	1.1	3.8	6.1	3.3	4.8
Insecticides	15.4	6.2	5.7	6.4	4.4	4.0
Miscellaneous	4.2	3.3	12.0	8.5	6.7	6.9
<b>Total Operational Cost (Rs/ha)</b>	<b>20,803</b>	<b>56,039</b>	<b>17,329</b>	<b>55,323</b>	<b>15,783</b>	<b>53,897</b>

*Source: DFI Committee Estimates based on CACP data*

An average sugarcane cultivating farmer spent major part of his operational cost on human labour, clearly demonstrating that sugarcane production is highly labour intensive (Table 0.8). The input labour per hectare in actual terms (both human as well as animal) has declined over the previous decade in all three selected states. The seed input (kg per hectare) has increased only in the case of Karnataka, while it has declined in the remaining two states. In contrast there is sharp increase in manure input which has doubled in Karnataka and more significantly, has quadrupled in case of Maharashtra.

Decomposition of operational cost suggests that over the decade, labour cost (human, animal and machine) has remained a major constituent of the operational cost, and fertilizer is the other significant component. All the three selected states show an increase in the percentage of human labour as a component of total operational cost.

**Table 0.8 Input use pattern and cost structure in sugarcane**

Inputs	Karnataka		Maharashtra		Uttar Pradesh	
	2004-05	2014-15	2004-05	2014-15	2004-05	2014-15
<b>A2 Cost of production (Rs./Qtl)</b>	36	76	49	116	25	66
<b>Material &amp; Labour Input per Hectare</b>						
Seed (Kg.)	19	39	38	33	22	16
Fertilizer (Kg. Nutrients)	544	391	568	641	174	198
Manure (Qtl.)	6	14	9	36	12	4
Human Labour (Man Hrs.)	2586	1192	2037	1800	1234	1184
Animal Labour (Pair Hrs.)	61	40	68	66	12	4
<b>Item wise Breakup of Cost of Cultivation (Percentage of Total Operational Cost)</b>						
Human Labour	47.6	50.6	34.9	39.8	49.2	61.2
Animal Labour	4.1	3.6	4.1	5.5	2.2	0.9
Machine Labour	0.1	4.6	18.3	13.8	4.9	2.6
Seed	6.0	15.1	8.2	6.3	11.6	9.0
Fertilizer	19.9	15.4	13.7	13.2	11.7	7.3
Manure	0.7	0.8	0.9	4.3	1.2	0.5
Insecticides	0.8	0.2	0.1	0.5	0.1	0.7
Miscellaneous	20.8	9.8	19.8	16.6	19.1	17.8
<b>Total Operational Cost (Rs)</b>	<b>38,355</b>	<b>73,315</b>	<b>49,592</b>	<b>1,43,966</b>	<b>17,711</b>	<b>52,322</b>

*Source: DFI Committee Estimates based on CACP data*

## 0.6. Conclusion

The post-green revolution period is characterised by soil health deterioration by way of decline in organic matter levels, ever-widening multi-nutrient deficiencies and physical degradation, especially enhanced soil compaction.

Imbalanced use of fertilizers and low nutrient use efficiencies have further aggravated problems. Material inputs during the cultivation phase of agricultural activities must be managed for better use efficiency and productivity, as well to mitigate possible shortfalls in other inputs such as labour and water. Resource use efficiency brings long term positive transformation in farmers' income and the agricultural economy.

The analysis above in respect of important inputs relating to crops has been presented to

provide a context for a detailed examination in the following chapters. The inputs that have been comprehensively examined and strategies suggested for enhancing total factor productivity and comprehensive coverage include:

- Soil health management – soils & fertilizers
- Water
- Seed
- Plant protection
- Farm machinery Credit
- Credit

**Key Extracts**

- Seed, fertilizer and labour (both human and machine) account for a major cost component in case of all selected crops.
- The cost of cultivation in case of all crops in all select states has increased substantively in the end year compared to the first year of the decade (2004-05 to 2014-15) taken up for study.



## Chapter 1

### Soil Health and Nutrient Management

*The post-green revolution period is characterised by soil health deterioration by way of decline in organic matter levels, ever-widening multi-nutrient deficiencies and physical degradation, especially enhanced soil compaction. Imbalanced use of fertilizers and low nutrient use efficiencies have further aggravated problems. At present, soil health poses a serious threat to agricultural production and farm profit. Focused Research and Development (R & D) initiatives backed by matching policy interventions would, however, help restoration and improvement of soil health to realize higher productivity at low cost on sustainable basis and contribute to the goal of doubling farm income by 2022.*

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#### 1.1. Introduction

In the past few decades, public interest in soil health has increased visibly due to enhanced recognition of the fragility of natural resources, and the necessity to preserve them for societal well-being. Continued deterioration in soil health and ever-increasing population pressure on finite land resources in most of the developing countries has made it imperative to enhance crop productivity per unit area.

The challenge is much bigger in India, as it supports over 16 per cent of the global population through only 2 per cent of the world's geographical area. The per capita land availability (land: man ratio) has continuously decreased from 0.34 ha in 1951-52, to 0.14 ha in 2012-13, which is likely to come down further by the year 2022. Also, the diversion of arable land towards non-agricultural purposes is a concern to sustain food production, as any future addition to the net cultivated area has to come from less-productive marginal lands requiring substantial investment towards their amelioration.

In fact over the last decade, the net area under cultivation has declined by about 1 million ha. Unabated fragmentation of farm holdings over the years, has decreased average holding size from 2.28 ha in 1970-71 to 1.15 ha in 2010-11. About 85 per cent of the operational holdings belong to marginal and small categories with holding size < 2 ha, and further 67 per cent of the holdings are below 1 ha.

As the need for marketable surplus is greater at smaller farms to get cash income, it would be imperative to enhance the productivity of marginal and small farmers through judicious soil management to enhance overall resource use efficiency. The report of the National Commission on Farmers mentions, inter alia, that improving small farm productivity as a single development strategy can make a greater contribution to the elimination of hunger and poverty, and recognized soil health enhancement as a key to raising small farm productivity. Hence, various aspects related to soil health have to be discussed in detail in order to arrive at sound policies to strengthen this critical component for enhancing productivity and income.

Non-judicious fertilizer use is the prime cause for widespread soil fertility depletion. During the onset of Green Revolution, Indian soils were generally deficient in N, and the crops often produced optimum yields with supplemental N fertilizer alone. Hence, balanced nutrition did

not receive much attention. As a result of continuous mining of nutrients from soil's native reserves, not only the number of deficient nutrients kept increasing but also the extent of nutrient deficiencies in soils became larger and larger. The problem is more acute in agriculturally advanced regions, wherein annual nutrient removal under intensive cropping often far exceeds replenishments.

Diagnostic surveys in the Indo-Gangetic Plains (IGP) indicate that in several high productivity areas of irrigated ecosystems, farmers use excessive fertilizer N to maintain the yield levels attained previously with relatively less fertilizer. Such indiscriminate use of N fertilizers aggravates soil fertility depletion, and proves detrimental in terms of low nutrient use efficiency, poor quality of produce, enhanced susceptibility of crops to biotic and abiotic stresses, and a potential threat of groundwater pollution due to excessive leaching of nitrates beyond effective root zone. Enhancing nutrient use efficiency will be key for sustained agricultural production, lowering of unit cost of cultivation and for raising farm income in the years to come.

Surprisingly, several states still prescribe fertilizer schedules comprising NP or NPK only, whereas widespread deficiencies of secondary and micronutrients, especially those of sulphur, zinc and boron exist in the soils. Redressal of these complex problems of multi-nutrient deficiencies through soil test-based and crop-specific fertilizer recommendations, thus assumes great significance. Soil ailments are often reversible, and the soils suffering from soil fertility depletion and/or other kinds of degradation can be restored with the adoption of scientifically-proven diagnosis and management protocols, adequate investment and policy support.

Government initiatives, especially "Soil Health Card Scheme" would go a long way in restoring soil health through soil test-based fertilizer use. This chapter presents a brief account of soil-specific production constraints, status of soil testing services and fertilizer use scenario. Also, specific suggestions are offered for revamping soil testing service and promotion of efficient nutrient management.

## 1.2. Soils of India

India has a total geographical area of 328.79 million ha. Great diversity in physiography, climate and vegetation, and parent rocks has resulted in the development of a variety of soils across the country. The major soils of India can be grouped into alluvial, black, red, laterite and lateritic, and desert soils, while salt-affected soils are sparsely distributed in some of these major soil groups. Indian soils are classified taxonomically into seven orders.

**Table 1.1 Major soil groups of India and their per cent are coverage**

SN	Soil Order	Common name	Area coverage (%)
1	Inceptisol	Alluvial soils	39.4
2	Entisol	Alluvial soils (recent)	24.0
3	Alfisol	Red soils, alluvial soils (old), salt-affected soils	12.9
4	Vertisol	Black soils	8.1



SN	Soil Order	Common name	Area coverage (%)
5	Aridisol	Desert soils	4.1
6	Ultisol	Red, laterite and lateritic soils	2.5
7	Mollisol	Forest soils, Tarai soils	0.5
8	Others		8.5
Total			100

*Source: S.K. and Chandran, P. (2015) Soil Genesis and Classification. in: Soil Science- An Introduction, Indian Society of Soil Science.*

Brief description of major soil groups along with their potential and constraints is presented in the following sections:

### 1.2.1. Alluvial soils

Alluvial soils are distributed in the states/UTs of Jammu & Kashmir, Punjab, Haryana, Delhi, Uttar Pradesh, Gujarat, Goa, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Puducherry, Bihar, Odisha, West Bengal, Arunachal Pradesh, Assam, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, and Andaman & Nicobar Islands, with a total coverage of around 100 Mha. Apart from this, there are coastal alluvial soils, which occupy around 10 Mha. Coastal alluvial soils exist in Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, West Bengal, Gujarat, Odisha, Puducherry, Lakshadweep, and Andaman & Nicobar Islands.

#### Potential

- Alluvial soils are very important from agricultural point of view. These soils contain fairly sufficient amounts of phosphorus (P) and potassium (K).
- Under proper management, these soils can be used for intensive cropping with high productivity.

#### Constraints

- Generally, alluvial soils have low contents of organic matter (OM) and nitrogen (N).
- Stratification in these soils leads to restricted leaching and drainage.
- Fine-textured alluvial soils suffer from problems of waterlogging inducing reduced condition and poor aeration for plant growth.
- Coarse-textured alluvial soils have problems of excessive leaching of plant nutrients.
- Alluvial soils have problems of salinity, where evaporative losses of water exceed rainfall, particularly in arid and semiarid regions.

### 1.2.2. Red soils

Red soils are rich in sesquioxides and have been developed on rocks of Archean origin (granite, gneiss) under semi-arid to humid subtropical conditions on well-drained, stable and higher land forms. Such soils are predominantly found in Andhra Pradesh, Karnataka, Kerala, Tamil Nadu,

Puducherry, Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, Goa, Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Mizoram, Tripura, Delhi, Uttar Pradesh, Himachal Pradesh, and Andaman & Nicobar Islands, covering an area of about 88 Mha.

### **Potential**

With proper management, agricultural crops like rice, millets, maize, groundnut, green gram, soybean, pigeon pea, jute, etc.; and horticultural crops like cashew, cocoa, tea, grapes, papaya, banana, mango, etc. can be profitably cultivated on these soils.

### **Constraints**

- In general, these soils are poor in nitrogen (N), phosphorous (P), potassium (K), sulphur (S), calcium (Ca), zinc (Zn) and organic matter (OM).
- Water and nutrient holding capacity are also low in these soils.
- Red soils often exhibit problems of surface crusting and hardening, excess drainage and runoff.
- On hill slopes, these soils have the limitation of shallow depth.

### **1.2.3. Black soils**

Black soils are dark in colour, turn sticky on wetting and extremely hard on drying, which have been developed on basaltic parent material under semi-arid to sub-humid climatic conditions. These soils are found in Madhya Pradesh, Maharashtra, Rajasthan, Puducherry, Tamil Nadu, Uttar Pradesh, Bihar, Odisha, Andhra Pradesh and Gujarat with a total coverage of around 54.7 Mha.

### **Potential**

- Under rainfed conditions, crops like cotton, sorghum, soybean, millets, pigeon pea, etc. can be grown in these soils.
- Under irrigated conditions, field crops like sugarcane, wheat; and plantation crop like citrus can also be grown.

### **Constraints**

- Soils become very hard on drying, and plastic and sticky on wetting making cultivation and management very difficult.
- Soils have poor drainage due to low infiltration rate.
- Poor availability of moisture and nutrients to plants is often encountered.
- Some black soils are calcareous in nature, which badly affects the availability of micronutrients.

#### **1.2.4. Desert soils**

These soils are found in arid (both hot and cold) climate. Hot desert soils occupy about 26.3 Mha in western Rajasthan, Gujarat, Punjab and Haryana. Cold desert soils are found in Leh and Ladakh region of Jammu & Kashmir.

##### **Potential**

- The sandy desert soils in the inter-dunal valleys receive additional rain water as runoff and are used for the cultivation of millets and pulses during monsoon.
- The gypsum-rich desert soils should be used as pasture land to avoid the formation of sink holes due to gypsum dissolution.
- With assured irrigation, these soils can very well be used for raising two crops in a year.

##### **Constraints**

Water scarcity is the most important constraint, which severely restricts the use of these soils for cultivation.

#### **1.2.5. Laterite and lateritic soils**

The laterites have very high contents of sesquioxides, and are low in base saturation and primary silicate minerals. They have been developed in tropical climate with alternate wet and dry seasons. Such types of soils are generally found on hill-tops and plateau landforms of Odisha, Kerala, and Tamil Nadu. The lateritic soils are formed under conditions almost similar to that of laterites, but do not require alternate wetting and drying. Lateritic soils are widely distributed in the states of Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and North-East region. These soils cover an area of about 18 Mha.

##### **Potential**

Cashew, cocoa, tea, coffee, rubber, etc. can be grown in the laterites at higher topographic positions; and rice, banana, arecanut, coconut, etc. can be grown in the laterite soils developed on lower topography.

##### **Constraints**

- These soils exhibit high acidity, and toxicity of manganese (Mn) and aluminium (Al).
- These soils are generally deficient in P, K, Ca, Zn, B (boron), etc.

#### **1.2.6. Forest and hill soils**

These soils are formed under forest canopy and found in Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Sikkim, Madhya Pradesh, Kerala, North-East Region and Andaman & Nicobar Islands.

##### **Potential**

*Podsol*ic forest soils are used for the cultivation of rice, maize, soybean, etc. on terraces, and tree and other fruit crops on slopes.

### **Constraints**

- Hill soils on slopes are prone to erosion.
- *Podsol*ic forest soils are deficient in P, mainly due to its precipitation as Al or Fe-phosphates.

#### **1.2.7. Salt-affected soils**

Salt-affected soils include saline soils, sodic soils and saline-sodic soils. These soils occupy about 6.74 Mha and occur in arid and semi-arid (<850 mm rainfall) climatic conditions covering almost all the states except the North-East region.

### **Potential**

- Saline soils have poor productivity and are not considered suitable for cultivation, except few salt tolerant perennial crops. However, salt concentration in such soils can be brought down within tolerable limits for crop cultivation, by leaching with freshwater and interlinking drainage network.
- Sodic soils can be ameliorated by gypsum/organic amendment application. Thereafter, crops like barley, rice, wheat, linseed etc. can be grown successfully.

### **Constraints**

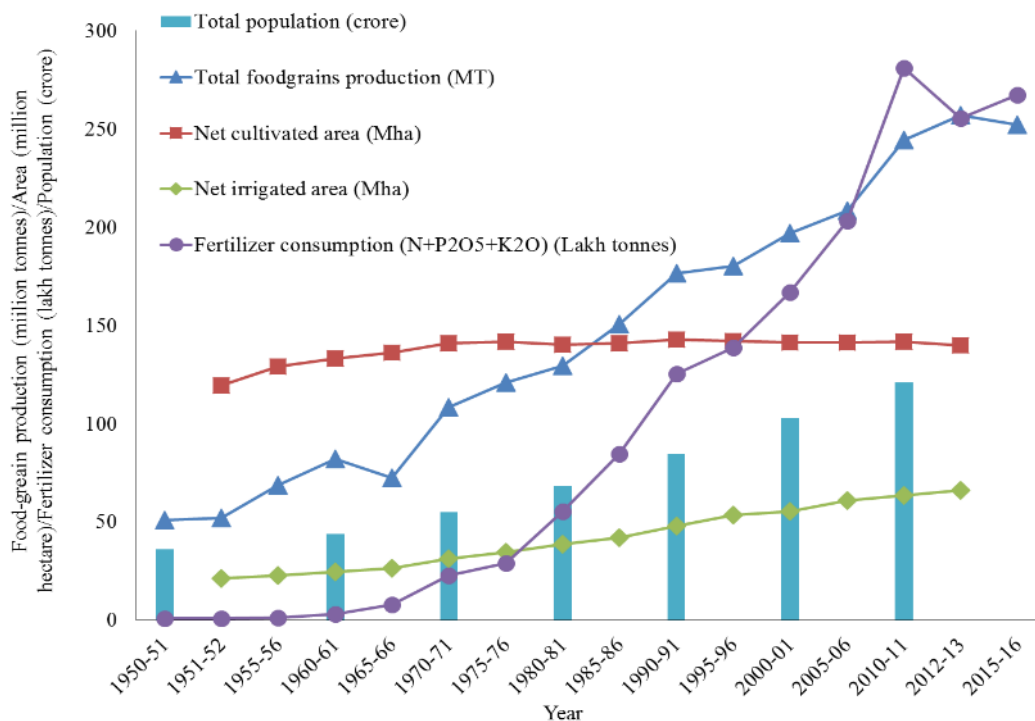
- Saline soils are usually barren, but potentially productive.
- High salt concentration in saline soils creates the problems in absorption of water and nutrients. During dry seasons, excessive salt concentration in soil solution may result in exosmosis of water from plant roots.
- High salt content causes root injury, inhibition in germination, etc.
- Sodic soils have high exchangeable sodium (Na), which results into soil dispersion, compactness, poor aeration, reduced condition and restricted drainage.
- High pH in sodic soil decreases the availability of several plant nutrients like N, P, Ca, magnesium (Mg), iron (Fe), copper (Cu) and Zn.

### **1.3. Paradigm shift in farming**

The agro-technological innovations, their large-scale adoption and proactive policies during mid-1960s and onwards, collectively termed as green revolution, transformed Indian agriculture, and brought desired resilience to ward-off hunger owing to acute food shortage. High yielding varieties of rice and wheat, expansion in irrigated area and increased use of fertilizers alongwith other improved management practices were the major drivers of green revolution. Over the last six decades, farming scenario has changed radically , and so has the total population (Figure 1.1). Human population in India was 36.1 crores in 1951; which steadily increased to an estimated 127 crores during 2017. Keeping pace with this burgeoning

population growth, foodgrain production has also registered sharp increase over the years. Foodgrain production in India which was merely around 50 million tonnes (MT), grew to a record 275 MTs by 2016-17 which crossed 260 MT mark by now. However, net cultivated area did not increase much over the years. From 1950s to 1970s, net cultivated area increased from 120 to 141 Mha, and stagnated at 140-142 Mha thereafter. Consumption of major fertilizers (N+P<sub>2</sub>O<sub>5</sub>+K<sub>2</sub>O) increased from a negligible amount of 70,000 tonnes (1950-51) to 26.7 million tonnes (2015-16). Thus, fertilizer use intensity has increased from 0.49 kg ha<sup>-1</sup> to 137.6 kg ha<sup>-1</sup> during this corresponding period. Likewise, net area under irrigation also registered an increase from 21 Mha (1951-52) to 66 Mha (2012-13), and further to 68 Mha (2014-15). This converts into gross irrigated area of 91 Mha (2014-15).

**Figure 1.1 Changes in foodgrain production, net cultivated & irrigated area, fertilizer consumption and population in India since 1950-51**



*Source: Fertiliser Statistics 2015-16. The Fertiliser Association of India.*

#### 1.4. Second Generation Problems - Natural Resources are a Casualty

The remarkable progress in food production has enabled the country to graduate from its ‘ship-to-mouth’ status to ‘self-sufficient’ and even ‘food-exporting’ nation by now. The impact of green revolution was so dramatic, that India became a role model for emulation by other developing countries. However, misuse and abuse of the technologies that were responsible for agricultural transformation resulted in several problems, often called ‘second generation problems of green revolution’, in terms of dwindling natural resources (soil, water, biodiversity) and in consequence challenging the long term sustainability of agriculture. Over-exploitation of natural resources, mostly due to unawareness and occasionally due to greed, as also abuse of different technologies and inputs are the reason behind these problems, and not

the green revolution *per se*. A few major soil-health issues and associated problems that have emerged over the years are listed hereunder:

#### 1.4.1. Changes in soil organic matter under intensive cropping

Soil organic matter (SOM) is the epicentre of soil health. It serves as soil conditioner, nutrient source, substrate to soil microbes, preserver of environment and a major determinant for sustaining agricultural productivity. Tropical Indian soils, majority of which belong to arid and semi-arid climate, rarely exhibit soil organic carbon (SOC) levels exceeding 0.6 per cent. Multi-location long-term studies continuing under different agro-ecologies reveal that the initial organic C content of soils could be maintained or even increased in most of the locations over the years with the application of NPK fertilizers at recommended rates. Hence, application of fertilizers should not be blamed for declining SOC (Table 1.2). Higher the productivity greater would be SOC, for incorporation of larger amounts of root, stubble and leaf tiller. Skipping fertilizer input altogether or imbalanced use often caused a decline in SOC, obviously due to poor yield and lesser quantity of biomass incorporation. Conjoint use of fertilizers and organic manure maintained invariably higher SOC levels compared with fertilizer alone.

**Table 1.2 Effect of long-term nutrient management on soil organic C content (%) at different location over a period of two to four decades**

Location	Initial	No fertilizer/ manure	N	NPK	NPK+ FYM
Akola	4.6	2.9	4.5	5.3	7.85
Bangalore	4.6	5.3	5.0	5.2	5.8
Barrackpore	7.1	5.5	5.9	6.3	8.2
Bhubaneswar	4.3	3.2	4.4	4.5	5.8
Coimbatore	3.0	3.7	4.4	5.3	6.3
Jabalpur	5.7	4.2	5.3	7.7	9.9
Jagtial	7.9	8.1	8.0	8.4	10.8
Ludhiana	2.2	2.9	3.9	4.3	5.4
Palampur	7.9	8.2	9.0	10.0	13.6
Parbhani	5.5	5.7	5.6	6.3	6.7
Raipur	6.2	5.1	5.2	5.9	6.8
Ranchi	5.0	3.0	4.0	4.0	5.0
Udaipur	6.8	5.3	6.4	7.5	9.0

*Source: Annual Report 2012-13. AICRP-LTFE, ICAR-Indian Institute of Soil Science.*

#### 1.4.2. Poor soil fertility status

The soil test data on available N (organic C), P and K obtained from soil testing laboratories (STLs) have been compiled from time-to-time for soil fertility appraisal. Considering low and medium fertility soils as fertilizer responsive ones, about 95 per cent of the districts represented fertilizer N and P responsive category. Nearly half of the districts were placed in K responsive category. Among secondary and micronutrients, widespread deficiencies of S, Zn and B were recorded (Table 1.3).

**Table 1.3 Extent of nutrient deficiency in Indian soils**

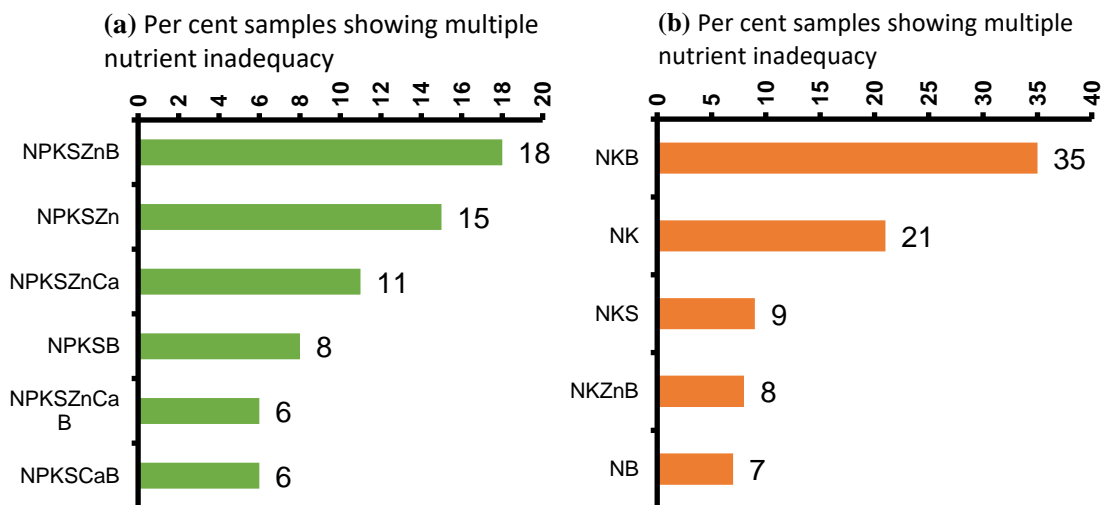
Nutrient	Per cent districts in different fertility classes <sup>1</sup>		
	Low	Medium	High
Nitrogen	59	36	5
Phosphorus	49	45	6
Potassium	9	39	52
	Per cent deficient samples <sup>2</sup>		
Sulphur	28		
Zinc	40		
Iron	13		
Manganese	6		
Copper	4.3		
Boron	17.5		

<sup>1</sup>Muralidharudu, Y., Sammi Reddy, K., Mandal, B.N., Subba Rao, A., Singh, K.N. and Sonekar, S. (2011) *GIS Based Soil Fertility Maps of Different States of India. All India Coordinated Project on Soil Test Crop Response Correlation, Indian Institute of Soil Science, Bhopal. pp. 1-224*

<sup>2</sup>Shukla, A.K. and Tiwari, P.K. (2014) *Micro- and Secondary Nutrients and Pollutant Elements Research in India. Coordinator Report - AICRP on Micro- and Secondary Nutrients and Pollutant Elements in Soils and Plants, IISS, Bhopal.*

In contrast to common belief, sulphur (S) deficiencies are no longer confined to coarse-textured soils and oilseed growing regions, but have expanded to almost all soils and all major crops/cropping systems. Similarly, boron (B) deficiencies are not confined to acid and calcareous soils alone. Recent studies reveal occurrence of B deficiencies even in the soils of arid and semi-arid regions, which were hitherto considered adequate in B supply. Soil fertility problems have become further complicated with the occurrence of multi-nutrient deficiencies. Studies at IARI confirmed simultaneous deficiency of 2 or more nutrients in different agriculturally important agro-ecological sub-regions (AESRs), though the type and extent of such deficiencies varied amongst the AESRs (Figure 1.2).

**Figure 1.2 Extent of multiple nutrient deficiency**



(a) Chhotanagpur Plateau (AESR 12.3; Village Barhu; Ranchi) and (b) Bengal Basin (AESR 15.1; Village Ghoragacha; Nadia)

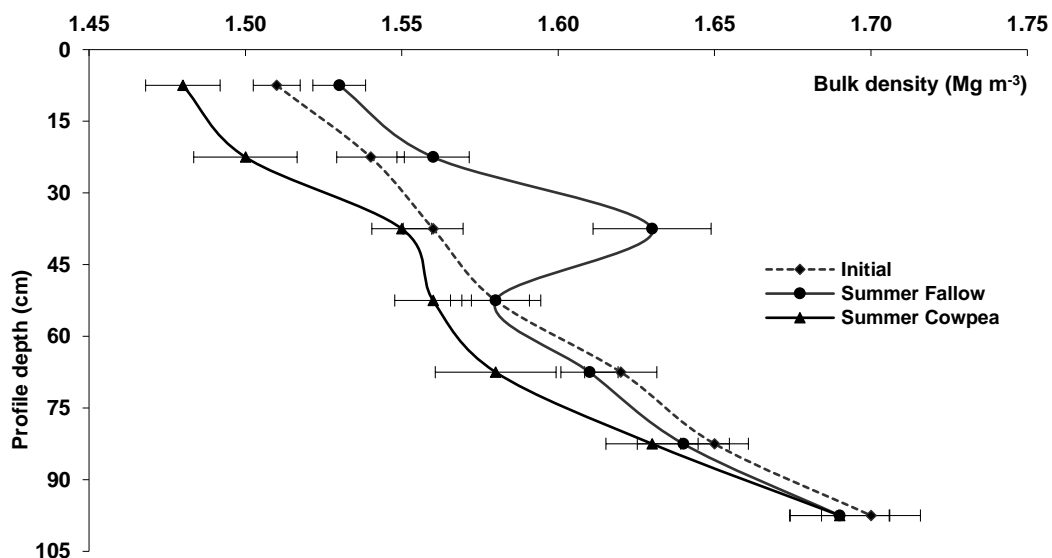
*Source: IARI-IPNI Collaborative Project, ICAR-IARI, New Delhi*

Earlier compilations of STL data helped generation of NPK fertility maps. As soil sampling details *i.e.* sampling site, time and year of collection etc. were not available along with the soil test data, these compilations enabled only a gross idea of soil fertility status. Lack of data on secondary and micronutrient fertility status was another weakness of these compilations. However, in recent years, GIS maps depicting soil fertility status and multi-nutrient deficiencies have been developed for over 180 districts under a DAC & FW (Department of Agriculture, Cooperation & Farmer' Welfare) and ICAR-IISS (ICAR\_Indian Institute of Soil Science) Collaborative Project. Also, AICRP-MSPE (ICAR) delineated secondary and micronutrient status of soils in more than 500 districts. Similarly, district-wise GIS maps have been developed by some states, which are indeed more informative and useful compared to earlier databases. The upcoming data on soil fertility status being generated under Soil Health Card Scheme would certainly be more accurate and comprehensive, and therefore more useful, after due validation/reconciliation with previous reports.

### 1.4.3. Decline in Soil Physical Conditions

Excessive tillage, use of heavy machinery, excessive puddling for rice, removal of crop residues and low organic matter turnover are mainly responsible for deterioration of soil physical conditions. Poor status of soil structure, bulk density, aggregate stability, water holding capacity, hydraulic conductivity, aeration, etc. not only cause a decline in availability of nutrients and soil microbial activities, but also decrease crop productivity by way of modifying crop growth, germination and emergence, and root growth. The contrasting edaphic environment of rice and wheat is a major reason for deterioration of soil physical health under rice-wheat cropping systems. Sub-soil compaction consequent to long-term cultivation of puddled rice-wheat with no crop in summer (summer fallow) is very common, that adversely affects establishment and root growth of succeeding wheat crop. Inclusion of a legume crop in the cropping system may, however, mitigate this problem to a great extent (Figure 1.3).

**Figure 1.3 Effect of continuous rice-wheat cropping on soil compaction (measured as bulk density)**



*Source: Indo-Gangetic Plains of India - Field Crops Research 84, 399-418.*



#### 1.4.4. Acidification, Salinization, Alkalization and Waterlogging

Harmonized area statistics of degraded and wastelands are presented in Table 1.4. Whereas soil erosion continues to be major degradative process, significant areas suffer from chemical degradation. In acid soils, solubility of elements like aluminium (Al), Fe and Mn is high, at times causing toxicity and impairing the normal growth and development of plants. Soil acidity causes deficiencies of Ca and Mg. The irrigation-induced waterlogging and salinity problems are increasing at an alarming rate in the canal command areas owing to increase in water table, poor water management and lack of drainage. Presence of excess salts in saline soils impairs soil productivity. The direct effects of salts on the plant growth are mainly physiological, whereas the indirect effects manifest through undesirable changes in chemical, physical and biological characteristics of the soil. Nitrogen is the most limiting nutrient in these soils because of low inherent fertility, low SOM, poor biological N fixation and higher volatilization losses leading to low efficiency of applied fertilizer N. Alkali soils contain medium to high amounts of available P. The available P of soil decreases on reclamation due to leaching from the surface layers, decreased solubility due to lowering of pH, and higher fixation due to decrease in pH/exchangeable sodium percentage (ESP). Alkali soils contain low amounts of available Zn due to high pH, ESP and calcium carbonate, and also low SOM content.

**Table 1.4 Harmonized area statistics of degraded and wastelands of India**

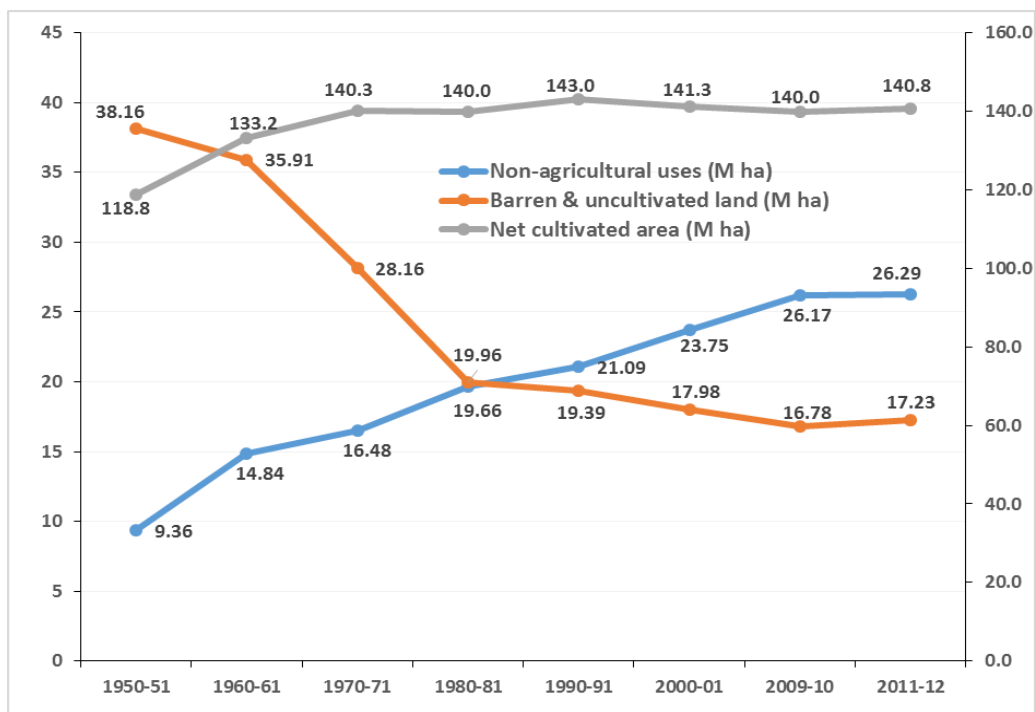
Degradation type	Arable land (Mha)	Data source
Water erosion (> 10 Mg ha <sup>-1</sup> yr <sup>-1</sup> )	73.27	Soil Loss Map of India–CSWCR&TI
Wind erosion (Aeolian)	12.40	Wind Erosion Map of India–CAZRI
Sub-total	85.67	
<i>Chemical degradation</i>		
Exclusively salt-affected soils	5.44	Salt-affected Soils Map of India–CSSRI, NBSS&LUP, NRSA and others
Salt-affected and water eroded soils	1.20	
Exclusively acidic soils (pH < 5.5)	5.09	Acid Soil Map of India–NBSS&LUP
Acidic (pH < 5.5) and water eroded soils	5.72	
Sub-total	17.45	
<i>Physical degradation</i>		
Mining and industrial waste	0.19	Wasteland Map of India–NRSA
Waterlogging (permanent surface inundation)	0.88	
Sub-total	1.07	
Total	104.19	
Grand total (Arable land and open forest)	120.72	

*Source: Degraded and Wastelands of India- Status and Spatial Distribution (2010) ICAR.*

### 1.4.5. Induction of Poor Lands into Agriculture

It is interesting to note that the area under non-agricultural uses has increased by about 10 Mha since 1970-71, whereas that under barren and uncultivated lands declined by like extent during this period (Figure 1.4). The often overlooked fact behind almost stagnant net-cultivated area is significant diversion of prime agricultural lands for non-agricultural purposes and simultaneous induction of barren and uncultivable lands. An apparent logic behind this statement is that the expansion of cities and towns and other developmental/infrastructural activities often take place in prime agricultural lands around cities/townships. As new lands inducted to croplands are extremely poor in terms of fertility status and overall health, a careful monitoring and management is obviously needed to make them productive and economically remunerative.

**Figure 1.4 Temporal changes in land use in India**



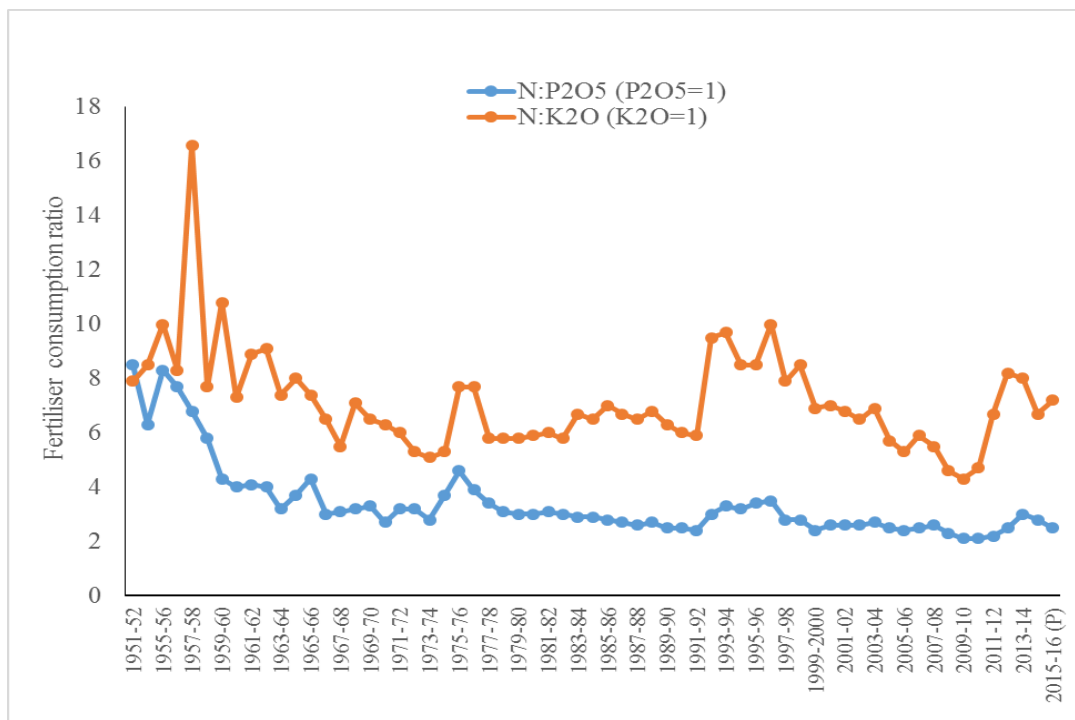
*Source: Fertiliser Statistics 2015-16. The Fertiliser Association of India.*

### 1.4.6. Imbalanced Use of Plant Nutrients

Despite very high growth in fertilizer consumption in recent past, the nutrient demand of crops could not be met through fertilizers alone. In fact, an annual demand-supply gap of 8-10 MT persists, suggesting excessive mining of the soils' native reserves. The pace of nutrient mining from soil gets further aggravated due to imbalanced use of fertilizers. Fertilizer consumption is grossly imbalanced, and skewed towards N. With the fractured implementation of nutrient-based subsidy (NBS) during 2010 (keeping urea out of ambit of NBS), the P and K fertilizers became costlier rendering their decreased consumption. As a result, fertilizer consumption ratio (N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O) widened from 4:3.2:1 (2009-10) to 7.2:2.9:1 (2015-16). Temporal distortions in fertilizer consumption ratio are shown in Figure 1.5.

As fertilizer K application is often neglected by the farmers, especially in the intensively-cropped Indo Gangetic Plains, despite the fact that plant K requirements are similar to N requirements, K constitutes the major part of demand-supply gap. Except Zn, application of other secondary and micronutrients is also ignored by the farmers either due to unawareness about their deficiencies or due to their unavailability in the market. Such fertilizer practices obviously result in poor use efficiency, increased input costs and low profits, and pollution of groundwater, air and soil through nitrate leaching, denitrification losses etc. Emission of N<sub>2</sub>O from different sources in Indian agriculture is highest through nitrogenous fertilizers.

**Figure 1.5 Temporal distortions in fertilizer consumption ratio**



*Source: Fertiliser Statistics 2015-16. The Fertiliser Association of India.*

#### 1.4.7. Decline in Factor Productivity

Soil productivity, total factor productivity (TFP *i.e.*, output: input ratio) and total natural resource productivity (TNRP *i.e.*, soil productivity per unit change in soil property) are often used to determine agricultural sustainability. With nearly constant or even declining cropped area, the production growth in recent decades has largely come from productivity enhancement. Total foodgrain productivity has registered a phenomenal increase from 522 kg ha<sup>-1</sup> in 1950-51 to 2042 kg ha<sup>-1</sup> in 2015-16. On the contrary, decline in factor productivity of fertilizers and also in the compound annual growth rate (CAGR) of foodgrain production has been reported, indicating a deterioration of the resource base. In pursuit of pushing intensive agriculture, no due attention was given to ensuring long-term soil quality, and sustained high productivity.

### 1.5. Soil Testing for Soil Health Monitoring

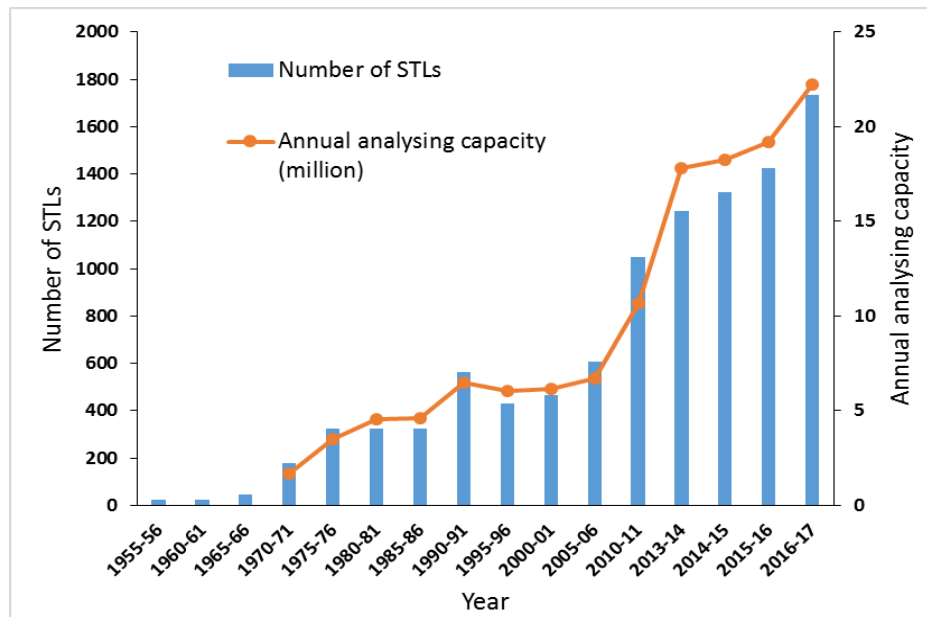
Conceptually, the intrinsic health or quality of a soil can be viewed simply as ‘its capacity to function’. Soil health could be defined as ‘the capacity of soil to function within the ecosystem

boundaries, to sustain biological productivity, maintain environmental quality and promote plant and animal health'. Many a time, the state of the soil is also explained loosely in terms of soil health, soil productivity, or soil environment. On the other hand, soil quality connotes the soil's usefulness for a particular purpose over a longer time scale. Nonetheless, the terms 'soil health' and 'soil quality' are often used inter-changeably; farmers prefer the former and scientists the later. Even use of the joint term 'soil quality/health' has been proposed for a better communication, knowledge sharing, and understanding of the management techniques by different stakeholders. The basic soil health indicators should (i) integrate soil physical, chemical and biological properties and processes; (ii) be sensitive to variations in management; and (iii) measurable or accessible by as many people as possible.

In Indian context, monitoring of soil health is often considered synonymous to soil testing, carried out for assessment of soil fertility status or appraisal of soil problems such as acidity, salinity or alkalinity. The infrastructure for soil health monitoring has only over the last 3 years begun to be upgraded to support the analysis of even minimum soil fertility parameters required for formulation of balanced fertilizer schedules; and measurement of biological and physical characteristics of soils by soil testing laboratories would require further strengthening & therefore time. Research laboratories, however, study the impact of input use, cropping systems, climate change, etc. on different soil health parameters.

Soil testing is a time-tested tool for soil fertility evaluation and monitoring. It also helps restoration of depleted soils by offering soil-test based recommendations on plant nutrients and amendments. Soil testing operates on the principle of probability, meaning, if all other factors of productivity are at the optimum, there is high probability to obtain more profitable response to applied nutrients based on soil testing than to those applied on *ad hoc* basis. So far, the results have been impressive, provided the recommendations are formulated suiting the specific crops grown. Began in 1955-56, soil testing service in India have constantly expanded over the years, and more particularly since the last 3 years. The present network is described by 1735 soil testing labs (STLs) (1459 static labs + 276 mobile labs) with an annual analysing capacity of 22.24 million soil samples (Figure 1.6).

**Figure 1.6 Expansion of soil testing service in India**



In addition, soil testing facilities have also been created at almost all Krishi Vigyan Kendras (KVKs), numbering 676. The state agricultural universities (SAUs), some of the ICAR institutes and private/cooperative industrial & service organisations also offer soil testing service on a limited scale. In order to further strengthen the service in different states, 5846 mini labs (digital soil testing kits) have been sanctioned during the year 2016-17 onwards by the DAC & FW. Of this network, only 911 STLs are equipped with micronutrient analysis facilities. With the governments' initiative to distribute soil health cards (SHCs) to ~138 million farm holdings once in every cycle of 2 years, soil testing service has come to occupy centre stage, and is now considered critical infrastructure for soil health management.

### 1.5.1. Weaknesses of Soil Testing Service

Despite large network of STLs and personnel engaged therein, the service is yet to gain desired mass acceptability. As a result, the voluntary demand for soil testing is low, as even innovative and resource-rich farmers are often not enthusiastic to get their soil tested for fertilizer use and soil amendment decisions. This is due to lack of trust in the services offered by STLs, and also on account of not realizing the importance of soil test based nutrient-management. Soil testing, therefore, is yet to transcend beyond a government-driven service. However, all stakeholders have since the role out of comprehensive and universal SHC scheme in 2014-15 begun to pay greater attention. Further, among a large number of farmers there is now greater awareness about its tahnks to aggressive advocacy & promotion by the government over the last 3 years, and can become a demand driven initiative at the farmers' level. This responsibility on the shoulders of all concerned agencies including researchers, State Departments of Agriculture, fertilizer industry, and policy makers at national level. A critical analysis of the major weaknesses of soil testing service is presented hereunder:

#### Soil sampling protocols

Soil sample is the first and foremost component of soil testing that decides ultimate value of

the service to the farmers. As small amount of soil in the form of sample represents the entire delineated area, a poor soil sample becomes the primary source of error in soil testing and interpretation of results for nutrient recommendation or any other intended purposes. Prior to initiation of SHC Scheme, no well-defined norms for sampling density, time or frequency was laid down. As a result, the soil test data could neither be used meaningfully for generation of area-specific soil fertility maps, nor for monitoring of management-induced temporal variability in soil fertility status.

Since universal coverage of individual farm holdings for sampling and analysis is not possible with existing technology & infrastructure, soil sampling norms need to be standardized. The GPS-enabled sampling at a uniform grid of 2.5 ha for irrigated areas and 10 ha for rainfed areas envisaged under SHC Scheme is a welcome initiative. However, the sampling protocols can be further refined so as to capture maximum variability in soil fertility and generate site-specific prescriptions.

#### **Lack of farmers' participation in soil sampling**

As soil samples are collected by the extension personnel without farmers' involvement, -often without knowledge of the farmers, they obviously remain unconcerned, and seldom own the outcome. In the absence of a feedback mechanism, the benefit accrued to the farmers in terms of adoption of soil test-based recommendations cannot be evaluated properly to bring in need-based improvements, if any in the service.

#### **Poor analytical facilities and their maintenance**

Majority of STLs analyze soil samples for pH, EC, organic C, available P and available K status, and offer recommendations for NPK only, as not all STLs are as yet equipped with atomic absorption spectrophotometer (AAS) – an essential equipment for micronutrient analysis. Other analyses are also done often using very old and outdated equipments. Some of the STLs having AAS or inductively-coupled plasma spectrophotometer (ICP) are not able to generate quality data on micro-nutrients for lack of support services such as uninterrupted power supply, utmost care in collection, processing and storage of soil samples, absence of analytical grade reagents, double distilled water, etc.

Repair and upkeep of lab equipments is another major challenge in the STLs located in remote areas or in the KVKs. Where needed infrastructure has been put in place under the soil health management (SHM) scheme, over the last about 3 years, the critical weakness that remains to be addressed is in absence of appropriately qualified and adequate number of personnel at the laboratories.

#### **Quality of analysis**

The quality of soil analysis is extremely important for the desired impact of soil testing service. The quality of analysis in the STLs is often compromised on account of inadequate infrastructure, operating facilities, poor human resource, and/or lack of essential support services. Besides, there is no organic linkage between staff who test the samples, and the extension staff who collect the sample. In such cases, soil testing simply meets the set targets,

not the farmers' expectations. Unless soil test data is reliable and accurate, fertilizer prescriptions are unlikely to perform in the field as expected.

### **Poor and incomplete fertilizer prescription**

One of the most important reasons for poor salability of soil testing service among the farmers is sub-optimal and incomplete fertilizer prescriptions offered by the STLs. This may fail to meet high yield or high profit aspirations of the farmers. The recommendations as given in the package of practices of different states are generally confined to NP or NPK, and this is not enough in current situation of widespread multi-nutrient deficiencies.

Since fertilizer recommendations with “one size fits all” approach overlook location-specific and crop-specific nutrient status the outcome may turn out to be only a shade better than farmers' fertilizer practice. In result, it may not yield the desired impact on yield levels or soil health and consequently become a bad demonstration. A bad demonstration is worse off than no demonstration. Since SHCs follow general fertilizer recommendations of different states as modified by soil test results, the old fertilizer recommendations need to be revised so as to offer robust recommendations to the farmers, and in sync with local agro-climatic conditions.

Fertilizer prescriptions based on targeted yield approach of ICAR's AICRP on Soil Test Crop Response Correlation (AICRP-STCR) take into account nutrient demand of the crop for a targeted yield goal and relative contributions from soil and fertilizer sources. Fertilizer adjustment equations of the AICRP-STCR may be used as these suggest a change in fertilizer requirement with changing yield targets. This approach, however, offers fertilizer recommendations for moderate yield targets only. Hence, AICRP-STCR as well other approaches need to be examined critically and improved so as to keep them relevant for high production agriculture. As examined in the succeeding Volume VIII, dealing with production targets across the crops, it will be seen that productivity gains are the only rational approach to achieving higher production, since the scope for bringing additional land under cultivation is not much.

### **Poor human resource**

Soil testing is a specialized job which requires involvement of a subject matter expert with thorough understanding of soil test methods, data interpretation and formulation of recommendations. Unfortunately human resources deployed in several STLs possess inadequate knowledge and skill essential for the job. Sometimes trained officers heading the STLs are replaced with those not having even a basic training in soil testing. Also, there has not been a provision for regular training/refresher courses for the STL staff, prior to launching of SHC Scheme. This needs to be addressed suitably on priority.

### **Weak linkage with research institutions**

Professional linkages of the STLs with research institutions (ICAR or SAUs) are either absent or very weak, resulting in restricted transmission of any new knowledge or developments from the latter institutions to the former. Simultaneously, research institutions too do not get feedback from the STLs. Two way diffusion of information and knowledge would benefit both

to the advantage of soil test system as a whole. It would help to create effective linkage/interface amongst organisations associated with soil testing service (mostly State Departments of Agriculture and ICAR institutes and SAUs).

### **1.6. Soil Health Card Scheme**

Government of India has been promoting soil health management through several central-sector and centrally sponsored schemes launched from time-to-time. In recent years, Soil Health Management (SHM) sub-mission of the National Mission on Sustainable Agriculture (NMSA) and some components of National Food Security Mission (NFSM) have been covering different issues related to soil health. The biggest initiative by the Government so far is the Soil Health Card (SHC) Scheme, launched by the Hon'ble Prime Minister on 19 February, 2015. It aims at issuing SHC to each one of ~120 million farm holdings at 2-year interval on a continuing basis.

Under this Scheme, soil samples are to be collected using GPS at a uniform grid of 2.5 ha in irrigated areas and 10 ha in rainfed areas. The SHC would include analysis of 12 soil parameters viz., pH, EC, SOC, available primary nutrients (N, P, K), available secondary nutrient (S), and available micro-nutrients (Zn, Fe, Cu, Mn, B). Based on analyses for these values, fertilizer and soil amendment recommendations are to be formulated for three prominent crops each of *kharif* (monsoon) and *rabi* (dry) seasons. Besides, necessary provision has been made for strengthening of existing soil testing infrastructure, training of the soil testing personnel, field demonstrations and publicity campaigns for enhancing farmers' awareness regarding soil health and SHCs.

During the first 2-year cycle (2015-16 & 2016-17), a target for collection and analysis of 25.3 million samples was set for preparation of 119.8 million SHCs. The achievement was impressive with hundred per cent of targeted soil sample collection, analysis of 23.6 million samples and distribution of about 93.2 million SHCs by the end of October, 2017, the balance work is expected to be completed soon. In the meantime, second cycle (2017-18 and 2018-19) commenced in April 2017, under which a soil sampling target of 12.6 million for issuing 59.9 million SHCs has been fixed for the year 2017-18. Soil sampling, analysis, and preparation of SHCs for the second cycle is under progress.

### **1.7. Soil Health Management**

Soil health ailments could be effectively addressed through judicious management. *Ad hoc* fertilizer prescriptions over broad areas (e.g. districts, state or agro-ecological zones) do not address differences in indigenous soil fertility, crop management practices, yield responses to added nutrients, or differences in attainable yield potential across sites or years. Precision nutrient management (PNM), on the other hand, ensures a better synchrony between nutrient supply and crop demand. It involves assessment of soil fertility variation and suggesting nutrient prescriptions following the principle of 4R (right rate, right source, right time and right method). Extensive studies at research stations and farmers' fields underlined the significance of PNM techniques such as integrated nutrient management (INM), site-specific nutrient



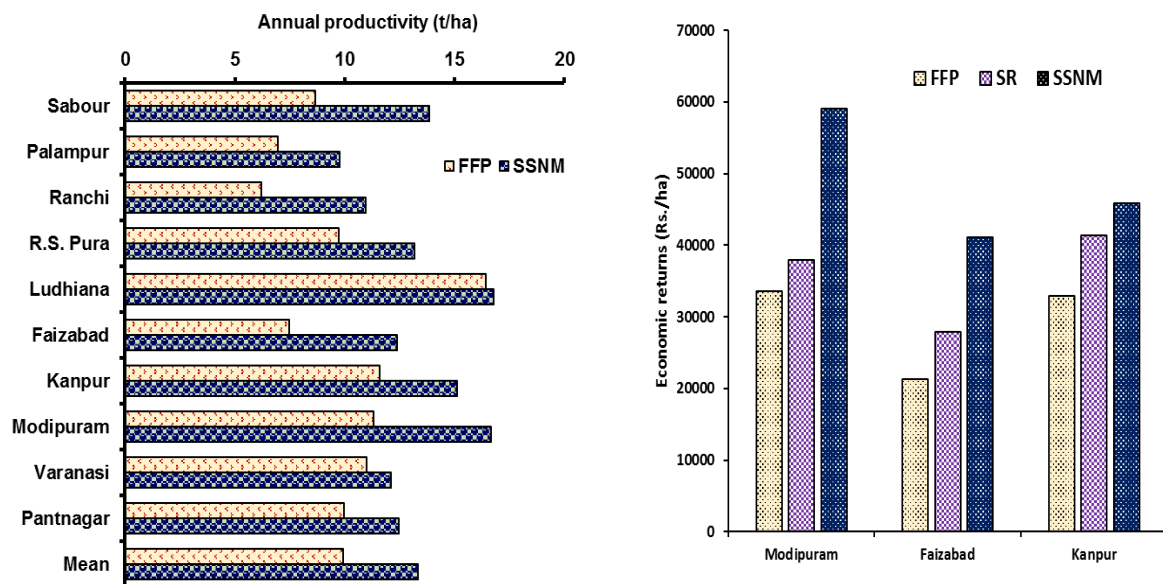
management (SSNM), in-season real-time N supply, and use of decision support tools.

### 1.7.1. Site-specific nutrient management

Site-specific nutrient management (SSNM) is the dynamic, field-specific management of nutrients in a particular cropping season for optimizing the supply and demand of nutrients according to their differences in cycling through soil-plant systems. This approach aims to increase profit through high yield and enhanced nutrient use efficiency, and also provides a locally-adapted nutrient best management practice.

Apart from soil test based prescriptions, plant analysis-based SSNM approach would help move towards greater accuracy. The latter considers nutrient status of the crop as the basis for fertilizer prescription, whereas soil test-based approaches take into account soil nutrient values. Studies have brought out that high productivity goals, say up to 80 per cent of the variety-specific genetic yield potential, could be attained following SSNM. Multi-location studies with intensive cropping systems *viz.*, rice-wheat, rice-maize, pearl millet-wheat, pearl millet-mustard, and sugarcane-based systems underlined the superiority of SSNM as against general fertilizer recommendations or farmers' fertilizer practice (FFP). The SSNM improved nutrient use efficiency and economic returns over FFP. In rice-wheat cropping system, it was possible to attain 14-16 ton ha<sup>-1</sup> annual grain productivity along with significantly greater economic returns with the adoption of SSNM *vis-à-vis* other options at different locations (Figure 1.7).

**Figure 1.7 Annual productivity and economic returns in rice-wheat cropping system under SSNM vis-à-vis farmer's fertilizer practice (FFP) and state recommendation (SR)**



*Source: PDCSR, Modipuram and PPIC-India Programme*

### 1.7.2. Integrated nutrient management

Different terms, namely, integrated nutrient management (INM), integrated plant nutrient supply (IPNS) and integrated nutrient supply and management (INSAM) are used to denote the practice of using one or more sources of plant nutrients along with fertilizers. The broad

objective of INM is improvement of soil health for sustaining crop productivity on long-term basis. Although INM is an age-old practice, it has assumed great significance in the post-green revolution era, mainly for three reasons: (i) continued increase in agricultural production based on increase in per hectare yields requires growing application of nutrients, and the present level of domestic fertilizer production in India and export would not be enough to meet the total plant nutrient demand; (ii) large number of experiments on nutrient management conducted in India and elsewhere, especially the long-term experiments (LTEs) underlined, that neither the chemical fertilizers nor the organic sources alone can achieve the production sustainability under intensive cropping system; and (iii) growing environmental and economic concerns would not likely to allow liberal import and use of fertilizers in foreseeable future.

The advantages of INM can be broadly enumerated as: (i) restoration and sustenance of soil fertility and crop productivity; (ii) preventing/ delaying the emergence of nutrient deficiencies; (iii) enhancing use efficiency of nutrients and other inputs; and (iv) improving farm income.

### **1.7.3. Ingredients of INM**

Under INM, bulky and concentrated organic manures, legumes, crop residues/wastes, industrial by-products, municipal solid wastes and biofertilizers are mainly used in conjunction with fertilizers. A systematic database on the usage, potential and actual production of the ingredients other than fertilizers is scarce, which need to be generated. Major ingredients of INM and their advantages are discussed in brief as under:

#### **(i) Organic manures**

Organic manures like farmyard manure (FYM), composts, poultry manure, bio-gas slurry etc. are useful inputs for maintaining soil fertility and ensuring yield stability. Following are the important organic manures used in India:

***FYM:*** Farmyard manure or cattle-shed manure is the most commonly prepared and used organic manure. However, less than 50 per cent of the manurial potential of livestock is utilized at present, as a large proportion of cattle dung is lost as fuel and droppings in non-agricultural areas. The manure is often prepared in unscientific way, resulting in poor quality in terms of nutrient content and decomposition state. It is possible to build a system of systematic collection of dung into a bank and composting it. It can be a Swwachha Bharat initiative integrating with agriculture to mutual benefit.

***Composts:*** are categorized as rural and urban compost depending on the raw material used. Besides, there are other variants of this manure *viz.*, NADEP compost, vermi-composts and enriched-composts. Enrichment of compost is of immense significance, because the limitation of bulky nature can be overcome to some extent by this technique. It increases the nutrient content of compost, reduces the bulk to be handled per unit of nutrients, and offers a potential for the utilization of indigenous low-grade minerals such as rock phosphates, waste mica etc. P-enriched compost prepared from crop residues, animal feed wastes, grasses, weeds,

tree leaves, cattle dung, biogas slurry and rock phosphate is known as phospho-compost. It contains between 2.6-3.5 per cent of P depending on the degree of decomposition. Phosphate-rich organic manure (PROM) is now incentivized by Govt. of India through different schemes.

**Poultry manure:** The value of poultry manure as a nutrient source has long been recognized. Rate of N mineralization from poultry manure is much faster than FYM, and nutrient content is also higher than FYM or conventionally-prepared composts. Poultry manure contains high amount of uric acid and urea substances that help faster release of N.

**Bio-gas slurry:** is the end product of bio-gas units when organic materials are converted into CH<sub>4</sub> (methane) and CO<sub>2</sub> (carbon dioxide) Biogas slurry is generally richer in N than FYM, and contains 1.2-2.0% N, 0.5-0.7% P and 0.5-1.0% K (dry weight basis). It can be applied directly with irrigation water or as manure after drying. Anaerobic digestion of organic wastes conserves nutrients needed for crop production. Studies show that application of 20 t ha<sup>-1</sup> of wet slurry (5% drymatter) each with first and second irrigation in conjunction with 60 kg N ha<sup>-1</sup> produced wheat yield that was at par with 120 kg N ha<sup>-1</sup>.

(ii) **Inclusion of legumes:** A large number of experiments carried out under All India Coordinated Research Project on Integrated Farming Systems (AICRP-IFS) and elsewhere underline the beneficial effect of legumes (grown as inter-crop, catch crop, substitute crop, forage or green manure) on crop productivity, soil fertility and NUE (nutrient use efficiency) in different cropping systems. Experimental evidences suggest existence of vast scope for inclusion of legumes in cereal-cereal systems.

Alternatively, from a long-term perspective, one of the cereal crops can be substituted with a legume crop which generally acts as a soil health restorer on account of its ability to fix atmospheric N, and utilize soil nutrients from deeper layers through its tap root system. Legumes such as pigeonpea, black gram, green gram and soybean are ideal inter-crops for monsoon season. The scope of legume inter-crops under rice (direct seeded)-wheat system further increases under water-scarce conditions or under aberrant weather, as inter-cropping not only increases total productivity of the system but also plays an important role in economizing the use of resources. In rice-wheat system (RWS), the time slot between wheat harvesting and rice planting can be utilized for growing short duration (60-70 days) summer green gram. Multi-location experiments under AICRP-IFS have revealed that incorporation of summer green gram bio-mass into soil after pod-picking was as effective as *Sesbania* green manuring for improving succeeding rice yields.

Inclusion of legumes as a substitute crop depends on growing situations. In Trans-Gangetic Plain, where water table depletion is a serious concern, pigeonpea could substitute rice in coarse-textured upland situations. Similarly, in Lower Gangetic Plain, where wheat productivity is generally low because of climatic constraints, it can be substituted with

chickpea, lentil, pea or groundnut. Extensive studies on comparative performance of RWS vs. rice-legume or legume-wheat systems at different locations have demonstrated that inclusion of legumes with recommended fertilizer application helped to improve total productivity and net profit.

Beneficial effects of substituting wheat or rice with a legume on soil organic C, mineral-N and Olsen-P content has been documented. In other words, inclusion of legumes may help better crop establishment and root growth of the crop(s) following rice, by way of reducing sub-soil compaction. Induced defoliation, imposed by foliar spray of 10 per cent urea solution at physiological maturity stage of extra-short duration pigeon-pea, has proved further advantageous in improving labile and very labile SOC content. Inclusion of fast-growing forage legumes during summer is another promising INM option, although the advantage of forage legumes in terms of nutrient recycling and improvement in soil physical and chemical properties has not been studied so extensively.

Green manuring with fast-growing legumes such as *Sesbania*, sunnhemp or cowpea is an age-old practice. However, with the intensification of agriculture involving double/multiple cropping, it left no time gap between two crops became and the practice of green manuring did not remain popular under irrigated regions. However, there are green shoots of interest in this practice in recent years. In fact, green manure N is as efficient as urea N, and hence green manuring is considered one of the most promising INM practice. Alternatively, short-duration grain legumes like green gram (maturing in 60-70 days) can be grown in summer, and after pod-picking green bio-mass may be incorporated to the field. This produces 0.6 to 0.8 t ha<sup>-1</sup> of legume grain, in addition to imparting soil health benefits. A green manure crop should be turned in one-day prior to rice transplanting in order to get maximum advantage.

### **(iii) Crop residues and farm wastes**

Crop residues have great manurial potential. Current estimates of production of crop residue in India<sup>1</sup> range from 510 to 836 MT year<sup>-1</sup> which include cereals, oilseeds, pulses, sugarcane, horticulture and fibre crops. Cereal crops are reported to be maximum producer of residues, with rice being the most important. These crop residues have traditional and modern competing uses. Modern uses of crop residues include those with value addition for energy production (e.g., gasification, bio-methanation, co-combustion) and as industrial raw material. Traditionally, crop residues are used for cattle feed, cooking, thatching, and making household products (e.g., baskets, floor mats, artistic products, toys). Above all, the most relevant and the current need of crop residues is for soil C sequestration to adapt and mitigate climate change, and enhance resilience of soils and agro-ecosystems to extreme climatic events, improve soil health, and sustain agricultural production.

Stubbles left in the field even under traditional harvesting methods range from 0.5 to 1.5 t ha<sup>-1</sup> in different crops. Under mechanical harvesting, this amount is much greater. There is a need

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<sup>1</sup> Lal, R. (2017) Restoring soil and water resources and mitigating climate change in India by judicious management of agricultural and urban wastes. *Journal of the Indian Society of Soil Science* 65, 105-117

to evolve appropriate management practices to make use of those residues either by applying a part of fertilizer N recommended for the succeeding crop during land preparation, or by adding appropriate microbial cultures to hasten *in situ* decomposition. It is estimated that around 141 Mt of cereal residues are left after meeting competitive demands, which may gainfully form a part of INM. Farmers in north-west India often prefer *in situ* burning of rice residues which has serious environmental implications besides colossal loss of precious nutrients. Long-term studies under AICRP-IFS have shown improvement in NUE in different cropping systems, consequent to integration of crop residues with fertilizers. Long-term studies on sandy loam soils of Ludhiana have brought out an increase in SOC, available P and available K contents due to incorporation of residues compared with their removal. Cereal crop residues are rich source of K as 70-80 per cent of K taken up by these crops is retained in straw. Therefore, residue recycling may be the best option to replenish K to the soil and avoid excessive mining of soil K reserves.

#### **(iv) Bio-fertilizers**

Bio-fertilizers or microbial inoculants hold great promise as an INM ingredient, though their effectiveness depends on several factors namely, robustness of the strains used in the inoculants, selection of right kind of bio-fertilizer, number of living cells present at the time of application, inoculation technique, etc. As these products (liquid or solid carrier-based) contain living micro-organisms, any negligence during production, packaging, transport, storage or actual usage would result in poor effectiveness.

Different types of microbial inoculants *viz.*, N-fixers (*Rhizobium*, *Azotobacter*, *Azospirillum*), P-solubilisers and mobilisers, K-solubilisers and Zn-solubilisers are now available for augmenting the supply of specific nutrients to the crops.

Whereas *Rhizobium*-legume symbiosis may meet upto 80 per cent of the N requirement of a legume crop, *Azotobacter* and *Azospirillum* usually contribute 20-25 kg N ha<sup>-1</sup> and 15-20 kg N ha<sup>-1</sup>, respectively. Experimental evidences suggest possibility of curtailing upto 50 per cent of fertilizer P rates with the use of P-solubilisers, through dissolution of sparingly soluble P in soil. Similarly, a part of fertilizer N requirement of transplanted rice could be substituted using blue green algae (BGA) and *Azolla*, especially in the humid climatic conditions. As a result of promotion of biofertilizers by Govt. of India and also due to active participation of fertilizer industry, total biofertilizer production registered significant growth during past two decades *i.e.*, from 6.7 thousand tons in 1995-96 to 113 thousand tons in 2015-16.

#### **(v) Municipal wastes and industrial by-products**

The by-products of agro-industry like spent-wash from distillery, molasses, press-mud etc., from sugar industry, and wastes from food processing industry have good manurial value. In the wake of technological growth, waste accumulation has increased rendering its disposal a serious challenge. The wastes are of different kinds including domestic wastes, city garbage, vegetable wastes, rice mill and sugar mill wastes, sewage effluents, sludge, and distillery wastes. As India is one of the major coconut producing countries, coir-pith accumulates in large amounts in the factories. Coir-pith (pH 5.4) contains 0.25 per cent N and 0.8 per cent K, and

after composting it can be used as manure. There is need to integrate different sources in appropriate crops and cropping systems at the locations where these are available. However, these nutrient-carriers have not been properly evaluated to establish their fertilizer equivalents.

Press-mud (by-product of sugar industry) is another precious nutrient source. About 10 Mt of pressmud is produced annually in India. At present, only few old sugar factories follow carbonation process, which are gradually changing to adopt sulphitation process of juice cleaning, carbonation press-mud (CPM) produced during carbonation process. It contains high amounts of  $\text{CaCO}_3$  and, therefore, can be used as an ameliorant in acid soils. The press-mud produced from the sulphitation process (called sulphitation press-mud, SPM) contains about 1.8, 0.8 and 0.6 per cent of NPK respectively in addition to several other plant nutrients especially S (~0.6%). Long-term use of SPM in conjunction of NPK not only raises available nutrient status and crop productivity but also enhances lability of SOC under RWS.

#### **Effect of INM on economic returns**

Adoption of INM either helps curtailing fertilizer rates or enhances productivity levels at recommended fertilizer input. Thus, reduction in cost of purchased inputs (fertilizers) and/or enhanced gross returns due to additional yield owing to INM should improve net income in most cases. Unfortunately, INM studies are often restricted to measurement of yield, nutrient uptake/NUE and soil parameters, ignoring economic impact. Nonetheless, sporadic studies involving computation of economic returns gave mixed results, rather than suggesting superiority of INM over sole fertilizer application in terms of net income and B:C ratio in different cropping systems (Table 1.5). The extent of advantage obviously depends on factors such as annual productivity level and price of organic manures. Usually, organic manure purchased from off-farm sources/market adds to the cost of cultivation, rather than decreasing the same on account of reduced fertilizer application. In an ongoing long-term experiment at IARI Farm, New Delhi, use of FYM along with NPK (*i.e.*, recommended NPK+ 5 t FYM ha<sup>-1</sup>) was not very much remunerative in maize, but the annual net return under this option in maize-wheat system was significantly greater than fertilizer NPK alone. This was mainly due to substantial residual effect of FYM in wheat following maize. In fact, the methodology for computing economics of INM needs to be standardized.

#### **1.7.4. Real-time N management**

One approach to increasing N use efficiency is to synchronize the rate and timing of N fertilizer application with the N demand of the crop. Unlike fixed N-scheduling as usually prescribed and adopted, this approach requires *in situ* monitoring of crop N status, so as to take a decision on N application. At least, three decision gadgets, namely, leaf color chart (LCC), chlorophyll meter (SPAD) and GreenSeeker are available for *in situ* monitoring of leaf N status.

A chlorophyll meter can provide a quick estimate of the leaf N status, but it is relatively expensive. The LCC, on the other hand, is an inexpensive, simple and easy to use tool to monitor the relative greenness of leaf as an indicator of crop N status. In the on-station and on-farm studies conducted with RWS, fertilizer N scheduling based on LCC proved superior to conventional practice *i.e.* application of recommended N in pre-scheduled 2 or 3 splits.

In some cases, even a saving of fertilizer N (up to 30 kg N ha<sup>-1</sup>) was recorded with the use of LCC, obviously on account of increased N use efficiency. For using LCC, threshold score has to be ascertained for individual crops and also for distinctly different varieties (e.g. *Basmati*, inbred and hybrid rice). Real-time N management studies further revealed that basal application of N could be safely skipped under modified N scheduling, so as to enhance N use efficiency and minimize N losses.

**Table 1.5 Effect of INM on economics of different cropping systems**

Nutrient management options	Cost of Cultivation (Rs. ha <sup>-1</sup> )	Net return (Rs. ha <sup>-1</sup> )	B:C ratio
Rice-wheat (Modipuram)			
Fertilizer alone	62032	51402	1.94
INM	66497	48647	2.12
Rice-wheat (Jabalpur)			
Fertilizer alone	35591	53997	2.56
INM	37200	52388	2.40
Rice-wheat-mungbean (Ludhiana)			
Fertilizer alone	58385	118083	2.24
INM	58604	92515	1.92
Rice-maize (Karjat)			
Fertilizer alone	78975	87791	2.17
INM	91457	55947	1.62
Soybean-wheat (Bhopal)			
Fertilizer alone	18606	36240	2.96
INM	37954	40351	3.20
Soybean-wheat (Raipur)			
Fertilizer alone	25224	35702	1.49
INM	30827	31571	1.04
Cauliflower- radish-tomato (Bajaura)			
Fertilizer alone	107494	66633	0.92
INM	105613	90163	1.12
Maize-garlic (Bajaura)			
Fertilizer alone	72170	108781	2.12
INM	71909	133201	2.42

INM= 25 to 50% of fertilizer nutrient was substituted through organics at different locations.

*Source: ICAR-Network Project on Organic Farming, Consolidated Report (2004-11)*

### 1.7.5. Decision support tools for enhancing NUE

In India, more than 85 per cent of the farm holdings belong to marginal and small farmers, which exhibit substantial spatial variability owing to variable crop management (cropping systems, cultivars, input use, irrigation etc.) adopted by the farmers. The possibility of site-specific N prescription for these small holders is remote unless a decision support system (DSS) is used to address spatial variability in indigenous nutrient supply (INS), and link the same with crop nutrient demand to arrive at rational prescription.

In recent years, International Plant Nutrition Institute (IPNI), in collaboration with CIMMYT and Indian National Agricultural Research System (NARS), have developed a tool named 'Nutrient Expert' for wheat, maize and rice. This tool maintains the background databases on geo-spatial variability in INS and relationship between crop nutrient status and productivity. Evaluation of Nutrient Expert in pre-dominant cropping systems involving above crops revealed marked increase in grain yield, besides curtailing fertilizer N rates wherever farmers used excessive N. Another such tool named 'Nutrient Manager' developed by IRRI (International Rice Research Institute) has not been validated in India so extensively. There is ample scope to develop robust decision support tools and validate the same under diverse farming situations.

### **1.7.6. Management of problem soils**

#### **Acid soils**

Management of acid soils should aim at realization of production potential either by addition of amendments (lime) or manipulation of agricultural practices to enhance NUE and crop yields. Also, cultivation of crops and varieties adapt that can to low pH regime is desirable. Extensive studies have shown, that liming at the rate of 10 to 20 per cent of total lime requirement (LR), which amounts to around 200 to 500 kg ha<sup>-1</sup> in furrows to each crop is as effective as one-time application of entire LR. Application of lime along with recommended fertilizers increases crop yields in acid soils significantly, compared with application of fertilizers alone (Table 1.6). Application of paper mill sludge @ 10% of LR for cereals and 20 per cent of LR for pulses, vegetables and oilseeds was found to increase the productivity by 18–35 per cent in cereals, 20–40 per cent in pulses, 21–44 per cent in oilseeds and 21–37 per cent in vegetables.

Application of biofertilizers along with soil test-based fertilizers increased the yield of cereals (7–27%), pulses (10–21%), oilseeds (12–21%) and vegetables (10–17%) in strongly acid soils. Agroforestry is a viable technology for acid soils on hill slopes. Raising of agricultural crops over the bottom 1/3<sup>rd</sup> slope with bench terracing; horticultural crops and pastures over the mid 1/3<sup>rd</sup> slope with half-moon terracing, and agro-forestry over the top 1/3<sup>rd</sup> slope with contour bunding is recommended for higher productivity and resource use efficiency under these soil conditions.

#### **Saline and alkali soils**

Sodic soils are inherently poor in N fertility. Hence in addition to use of gypsum as per lab-estimated gypsum requirement, application of 25 per cent additional N over the recommended rate is prescribed. Among micro-nutrients, Zn deficiencies are common in these soils, and application rates are higher (generally double) compared to normal soils. *Sesbania (Dhaincha)*, green manuring helps in faster amelioration of sodic soils.



**Table 1.6 Effect of fertilization and liming on crop yields (t ha<sup>-1</sup>) in acid soils of different states**

State	Crop	Grain yield (t ha <sup>-1</sup> )			
		Farmers' practice (FP)	FP+lime	NPK	NPK+lime
Assam	Rapeseed	0.73	0.86 (17.8*)	1.05 (43.8)	1.29 (76.7)
	Green gram	1.01	1.15 (13.9)	1.23 (21.6)	1.51 (49.0)
Himachal Pradesh	Maize	2.35	2.74 (16.6)	3.40 (44.7)	3.75 (59.6)
	Wheat	1.74	2.02 (16.1)	2.79 (60.3)	3.17 (82.2)
Jharkhand	Maize	1.71	2.15 (25.9)	2.51 (46.9)	2.96 (73.3)
	Pigeon pea	0.74	1.00 (34.4)	1.20 (61.3)	1.52 (105)
Kerala	Black gram	0.35	0.44 (25.6)	0.40 (14.8)	0.56 (58.3)
Maharashtra	Groundnut	1.42	1.67 (17.7)	1.99 (40.1)	2.43 (71.2)
Meghalaya	Maize	1.06	1.38 (30.0)	2.11 (99.1)	3.06 (189)
Odisha	Groundnut	0.86	1.25 (45.3)	1.43 (66.3)	1.79 (108)
	Pigeon pea	1.05	1.51 (43.8)	1.64 (56.2)	2.02 (92.4)
West Bengal	Mustard	0.48	0.65 (35.4)	0.70 (45.8)	0.91 (89.6)
	Wheat	1.02	1.50 (52.0)	1.50 (47.1)	1.90 (86.3)

\* Figures in parentheses indicate per cent increase over FP

Source: Sustainable management of acid soils: technologies and their transfer. Indian Journal of Fertilisers 12(7), 16–24.

In waterlogged saline soils frequently occurring in canal commands, the crops suffer due to excess of soluble salts. In addition to lowering watertable depth through sub-surface drainage and leaching of soluble salts, recommended fertilization is necessary to supply adequate nutrients and to increase tolerance of the crops against soil salinity. Raising salt tolerant crops, cultivars and trees is economically most viable option to raise the productivity of these soils.

### 1.7.7. Conservation agriculture (CA)

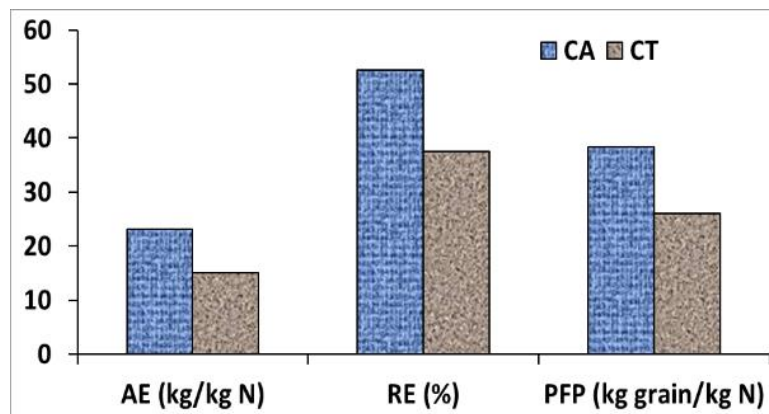
Conservation agriculture (CA) is a production system involving minimum soil disturbance, soil cover through crop residues or other cover crops and crop rotations for achieving high productivity with most efficient resource use. Crop residues retained on the soil surface with no or minimum tillage has potential to enhance soil quality through improvement in SOC content and other soil parameters. Reduction in tillage provides enough turnover time to form stable soil aggregates, which in turn provide protection of SOM. Mineralization of SOC to CO<sub>2</sub> is thus moderated, paving way for stable humus formation. Improved aggregation leads to improvement in total soil porosity, continuity of soil pores and pore size distribution, thus facilitating water infiltration.

On the other hand, improved aggregation and less traffic under CA reduces surface and sub-surface soil compaction. Permanent organic soil cover protects the soil from erosive forces *i.e.*, wind and rainfall, shields soil surface from direct exposure to sun, minimizes extremes of soil temperature, and reduces soil water evaporation. Nutrient cycling is enhanced due to nutrients drawn from stubble and other residues from the previous crops. Slower decomposition of the surface-placed residues prevents rapid leaching of nutrients through soil profile.

Improved SOM status and greater aggregation result in congenial micro-climate for improved

microbial activity. Diversified rooting depth of crops explore different soil layers for nutrients ensuring better nutrient recycling within soil profile and increased nutrient use efficiency. In an ongoing experiment at IARI, N use efficiencies in wheat computed as agronomic efficiency ( $AE_N$ ), partial factor productivity ( $PFp_N$ ) and recovery efficiency ( $RE_N$ ) were 23.2 kg grain  $kg^{-1}$  N, 38.4 kg grain  $kg^{-1}$  N and 52.5%, respectively under CA, as against 15.1 kg grain  $kg^{-1}$  N, 26.1 kg grain  $kg^{-1}$  N and 37.5%, respectively under conventional tillage and residue removal (CT) (Figure 1.8).

**Figure 1.8 Nitrogen use efficiencies in wheat (average of 2 years) under conservation agriculture (CA) and conventional tillage (CT)-based maize-wheat system**



*Source: Nutrient dynamics and management under conservation agriculture. - System based conservation agriculture*

Further studies suggested the possibility of curtailing fertilizer N and P application rates in wheat under permanent raised-bed planting compared with conventional flat-bed planting owing to greater NUE and better crop establishment in the former case. Fertilizer prescriptions for CA-based systems need to be developed through systematically planned multi-location studies.

## 1.8. Recommendations

In the light of a detailed examination in the preceding paragraphs, specific recommendations for improving soil health monitoring and nutrient management are offered as under:

### 1.8.1. Revamping soil testing services

#### Establishment of modern high output STLs

In order to strengthen the soil testing service, a few new STLs are established every year in different states. As the infrastructure, human resource and functioning of these new labs is no way different from the STLs established earlier, their output in terms of quality and credibility also remains the same. Poor mass acceptability of the service among the end users (farmers) in past 6 decades of its existence is enough to indicate that this model of expanding the STL network needs fresh look for complete overhauling of the service. There is need to establish fully-automated STLs with modern analysis facilities and adequately-trained manpower. These labs may maintain series of advanced equipments for faster and precise analysis.

An exposure of apex authorities involving bureaucrats and technical experts to modern STLs

in the developed countries would help grasping the idea of establishing such STLs in India. These duly-accredited high output STLs with daily analysing capacity of say 500 or more samples may be established under public sector or in a PPP mode, initially on a pilot scale (may be one STL in each state). Depending on the success of this experiment, establishment of such STLs at divisional level in each state could be thought of. It can then be driven as an enterprise model. Proliferation of small STLs in the name of strengthening soil testing service is not a professional approach in the long run.

The universal SHC contains a substantive potential for promoting private enterprise. Credit linked subsidy back-ended scheme can incentivise the educated youth to set up static and mobile testing laboratories (STLs/MTLs), besides mini-laboratories. While there is space for setting up new facilities, there also exists scope for Public Private Partnership (PPP) models, under which the government set up labs can be outsourced to private agencies for management, preferably to youth with education in agricultural science.

#### **Creation of a dedicated service cadre for soil health monitoring**

In order to hire trained human resource and ensure their retention in the soil testing service, creation of a state-level dedicated service cadre named 'Soil Health Monitoring Service' appears an innovative option. These officers should be exposed to advanced level professional trainings and orientation courses at a regular interval. At present, the STL personnel are frequently transferred from/to STLs within the State Department of Agriculture. Hence, they hardly own the service. Even a training imparted to such officers turns out to be wasteful as they may not continue with the STLs after their transfer to some other job. Creation of a separate cadre would also enhance self-esteem of the officers, who will work hard to compete and rise up to the highest position within the cadre.

Alternatively, private sector service may also be encouraged, so that both infrastructure and manpower get built up as per desired standards & quality.

#### **Short-term diploma in soil health management**

The SAUs may launch short-term (say 6 month duration) diploma courses on soil health management for 10+2 pass rural youth, so as to make available para-soil health monitoring and management staff to facilitate collection, labelling and processing of samples as per prescribed protocols, and also day-to-day maintenance and upkeep of the STLs. The diploma should also provide due exposure and training in different soil health management technologies like preparation of bio-fertilizers, different types of composts etc. This would improve overall quality and efficiency of soil testing service and other soil health management enterprises, besides raising farm income directly by way of generating employment opportunities to the rural youth.

#### **Maintenance of lab equipments**

The lab equipments need constant maintenance and timely repair whenever these go out of order. In addition to adequacy of budget, visit of a service-engineer on phone call is necessary, particularly for STLs located at district headquarters and small townships. In fact, timely

services are a challenge even in the metropolitan cities. Maintaining standby equipments (namely pH meter, EC meter, shaker, balances, spectrophotometer and flame photometer), along with a mandatory annual maintenance contract (AMC) of the equipments would be helpful.

### **Deployment of trained human resource**

The In-charge of a STL should essentially be a post graduate in Soil Science, and the technical staff not less than an agriculture/science graduate. In many STLs, the officers with training in subjects other than Soil Science are Lab In-charge. The In-charge and technical staff need to periodically undergo advanced training in soil testing and fertilizer recommendation to keep themselves abreast of the recent developments and to refresh their analysis skills. This component is rightly included in the ongoing SHC Scheme, though an efficient mechanism for the same needs to be developed. The SAUs and ICAR institutes should be given the responsibility of organising regular trainings/refresher courses for the STL staff.

### **Using ICTs for effective monitoring**

Use of information and communication technologies (ICTs) enhances efficiency, ensures accurate documentation of databases and enables proper monitoring. Launching of SHC portal by the DAC & FW is an excellent example of the use of ICT in soil testing service.

Linking GPS with the portal in the way that GPS coordinates are automatically recorded in the portal at the time of collection of soil sample would help effective monitoring of the soil sampling. Similarly, the STLs should have software to link the soil test data generated by different lab equipments with auto-generation of soil test reports, which could subsequently be transmitted to the SHC portal. Such interventions would avoid possibility of human error/negligence in manual data recording, and also improve faster delivery of results.

### **Establishment of quality control mechanism**

There has never been any quality control mechanism in the soil testing service. As the expectations from the service have increased with launching of SHC Scheme, and a substantial budget is infused annually, it is essential to ensure the quality of analysis. For this, at least one well-equipped STL in each state and 2 in larger states should be designated as Referral STL, and charged with the responsibility of monitoring the quality of analysis of other STLs in addition to routine soil testing. Ultimately, the modern STLs as suggested earlier in this section should serve as Referral STLs.

A sample exchange programme could also be initiated within the states as well as across the states to compare the quality of analysis. Some kinds of incentives in the form of career advancement, increment etc. for star performers would be a great initiative to inculcate professional excellence.

### **Soil testing kits and other alternative tools**

Besides static and mobile STLs, which use standard soil test methods, digital soil testing kits (mini labs) are gaining popularity in recent years. As the present STL network is not adequate

to cater to the soil testing needs of ~120 million farm holdings, there will always be scope for these kits to compliment the STLs. However, it has to be understood that soil testing kits are not a substitute to STL, as the methods followed in these kits may not give reproducible and accurate results comparable with the STLs.

Further, they are not as yet capable of testing all the 12 parameters identified under SHC scheme. There is need to constantly improve the quality and reproducibility of the output of the kits. Besides, newer technologies like hand-held hyper-spectral tools need to be rigorously validated using diverse soils, and standardized for soil fertility evaluation. Once validated, these tools may prove immensely useful.

### **1.8.2. Strengthening Soil Health Card**

The SHC scheme is a great initiative in the known history of Indian agriculture that underlines the concern of the Government regarding precious soil resource for the well-being of current and future generations. Based on the experiences of just-completed first cycle of SHC scheme, a few suggestions are offered to make the SHC more robust and useful to the farmers.

#### **Revisiting soil-test parameters in the SHCs and expansion to include water testing**

At present, SHC includes 12 parameters *viz.*, pH, EC, SOC, N, P, K, S, Zn, B, Fe, Mn and Cu. As determination of available N is cumbersome and time-taking, STLs do not measure this parameter. Rather soil organic C (SOC) is determined as an index of N availability, and the values are used for fertilizer recommendation. The values of available N are derived from SOC. Hence, available N may be excluded from SHC, or a more sophisticated and speedy process identified and adopted.

Continuous irrigation with poor quality (high salinity or alkalinity) water often leads to serious soil health ailments, especially in arid and semi-arid ecosystems. Soil problems like sodicity and salinity are often associated with the use of poor quality irrigation water. Also, any adverse effect of poor quality water on crop productivity cannot be mitigated through soil test-based fertilizer use, unless safe use of water is adopted. Irrigation water quality should, therefore be included in SHCs. Similarly, gypsum requirement (GR) for sodic soils and lime requirement (LR) for acid soils need to be measured. **Assessment of water quality, GR and LR is very much possible in all STLs, and no additional equipment/infrastructure is needed.**

#### **Periodicity for renewal of SHC**

As per current provisions, the SHC has to be renewed at 2-year interval. As soil is a fairly resilient natural body, crop management-induced changes in soil fertility are often not measurable at short time-interval. Hence, any perceptible change in recommendations is not expected at such narrow time-interval. Increasing the SHC cycle from present 2-year to 3-year period may, therefore, be considered, as this change in periodicity is not likely to affect the utility of the SHC. Rather, it may help reducing annual analysis targets of STLs, thus bring greater emphasis on the quality of soil test data. And, additionally if water quality, GR and LR are included, the annual test capacity is bound to lower down further.

It may be more useful to offer the farmer 'on demand service' using the same soil sample test data. This would include generating nutrient recommendation for any of the crops that the farmer may demand, and any number of times within the cycle of (2 or 3 years as the case may be). While at the first instance, when the SHC is distributed to the farmers, it may be a common generic based crop cafeteria for kharif & rabi. The subsequent response can be demand-led, and may be charged nominally on line with electronic-Aadhaar (e-Aadhaar) card, that a resident is allowed to generate, if he loses his original, the facility of an electronic. SHC (eSHC) may be enabled.

### **Revisiting grid-based SHCs**

As per current provision of grid-based sampling, same SHCs are generated for the farm holdings falling within the grid size of 2.5 ha (irrigated areas) or 10 ha (rainfed areas). For example, if 5 or 10 farm holdings fall within the above grids, all will receive the same SHC. This would lead to poor credibility of the SHCs among the farmers, especially when the management (cropping system, fertilizer and manure input etc.) of all such fields may not be the same. The soil test data may, therefore, be subjected to development of variograms using geo-statistical tools in the GIS software, so as to get variable fertility status of the fields falling within the grids, and generate separate SHCs for each individual field. This will not require any extra effort, except for integrating a GIS software with SHC portal with support from experts in geo-statistical tools. However, with the establishment of modern high output STLs as suggested earlier, even narrowing the grid-size could be considered to bring-in more site specificity in recommendations.

### **Integration of best management practices with SHC**

The SHC-based fertilizer recommendation is a component of best management practices, that a farmer is expected to adopt for enhancing productivity and income. Adoption of SHC-based recommendations alone may not lead to the desired outcome.

As SHC offers an opportunity to reach individual farmers, it can very well be used to enhance farmers' awareness on best management practices so as to avail full benefit of SHC by adoption of a package in holistic manner. For this, the SHC needs to be transformed to a small 2-4 page folder (rather than a 1-page sheet) to accommodate important package of practices for major crops of the region. As this information is already available with the states and remains unchanged for a large area, it needs to be simply hooked with SHC portal for inclusion in the SHCs.

### **Reconciliation of SHC data with existing soil fertility databases**

The data on soil fertility status generated under SHC Scheme would be extremely valuable for several purposes, given its magnitude and versatility. There is likelihood of linking of SHC with other schemes like fertilizer subsidy, customized fertilizers etc. in future for better convergence. Hence, verification of the quality of SHC data is of utmost significance.

The soil test data available on SHC portal for different states needs to be reconciled with other available databases involving soil scientists working in SAUs/ICAR institutes of these states, so as to ascertain the quality and rule out possible inadvertent errors on account of magnitude of targets handled. Even the SHC data needs to be compared with the existing databases available with ICAR-NBSS & LUP, AICRP-Micronutrients and AICRP-STCR.

### **Impact assessment mechanism**

It is important to assess the adoption level of SHC recommendations and consequent benefits accrued. For this, an impact assessment mechanism need to be evolved in order to constantly improve SHCs so as to enhance their utility to the farmers. What is needed is to involve a technically-competent agency like National Academy of Agricultural Sciences (NAAS) for an impassionate analysis of the outcome/impact of the Scheme, and also offer suggestions for further improvement, if any, in the quality and utility of SHCs.

### **1.8.3. Promoting balanced and integrated use of fertilizers**

#### **Revise general fertilizer recommendations**

The general fertilizer recommendations (GFRs) included in the package of practices of different states as modified on the basis of soil testing, are now followed in the SHC. If the GFRs are incomplete or outdated, the SHC recommendations would automatically stand compromised.

Long-term studies have already underlined that the existing fertilizer recommendations are sub-optimal for several crops, and need to be revised. It is, therefore, important for all states to review the GFRs for need-based improvement/revision in consultation with the SAUs/ICAR institutes. In fact, it should be mandatory for all states to review and update the package of practices including GFRs at some reasonable (say 5-year) interval.

#### **Look for newer fertilizer recommendation approaches**

Current fertilizer recommendations do not ensure field-achievable maximum economic yield (MEY) from the existing cultivars/hybrids. The MEY is the yield that gives highest possible net return per hectare. It is very close to the maximum yield. The SSNM approaches harnessing all possible interactions among nutrients and other inputs following broad principles of '**Law of maximum**'<sup>2</sup> needs to be developed and standardized for different crops so as to offer balanced and adequate fertilization to maximize the profitability. This is critical from the view point of targeted doubling of farmers' income.

#### **Revisit customized fertilizer policy**

The customized fertilizers (CF) were introduced in 2008 with the objective of promoting crop - and area-specific fertilizers to address soil fertility variations and meet nutrient demands in a more balanced manner. So far, the growth of CF has not been impressive, and different stakeholders offer different explanations for the slow growth. There is need to promote CF

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<sup>2</sup> Wallace, A. (1990) Crop improvement through multidisciplinary approaches to different types of stresses-law of maximum. Journal of Plant Nutrition 13, 313-325

through small-scale industry by allowing them to manufacture required fertilizer grades for smaller domains (say talukas or districts), besides streamlining the approval mechanism for 'ease of doing business'.

### **Introduce community-level 'waste-to-wealth' model of composting**

The Government has recently (2016-17) initiated co-marketing of city compost by fertilizer companies. Likewise, on-farm and off-farm by-products and wastes in rural areas could be converted to good quality compost by introducing a community level 'waste-to-wealth' model. The mechanized composting units established at *taluka*-level should purchase segregated biodegradable raw material (wastes/garbage) from farmers, prepare compost using efficient microbial cultures and machinery, and provide quality compost to the farmers at reasonable rates. This would encourage farmers to offer the needed raw-material to the composting units as it is linked with income, thus promoting INM for soil health improvement on one hand, and rural hygiene on the other.

The conventional composting methods *e.g.* preparation of compost pits and filling/turning them to prepare compost are no longer viable in the current age. The Union Budget 2018 has announced setting up 'gobar dhan bank' integrating the principles of Swachha Bharat and sustainable agriculture. This is a positive step towards resource utilization by creating wealth from agricultural waste.

### **Incentivize crop residue recycling**

Crop residue management has emerged as a major challenge in recent years, especially in machine-harvested areas. In absence of viable alternatives, farmers opt for residue burning, thus losing precious nutrients and causing severe environmental problems. Whereas technologies for faster *in situ* decomposition of residues need to be perfected, equally important is to incentivize residue retention by way of subsidizing CA machinery (*e.g.* Happy Seeders and Stubble Management Systems) and promoting custom hiring services to facilitate large-scale use of machinery. There also exists vast scope for encouraging multiple use of residues *e.g.* feed blocks, fuel, bio-energy production etc, in private sector. What is important is to create the value of crop residue as a wealth.

### **Develop protocols for economic analysis of INM**

The protocols for computing economics of nutrient management options involving organics have not been standardized so far. And, the economics is computed simply on input-output basis like that in case of fertilizers. Improvement in soil physical properties, change in microbial population, SOC build-up and resultant benefits of organic and legumes remain unaccounted in routine computations of economics, rendering INM as less remunerative compared with fertilizers. Thus, it is important to develop and standardize protocols for economic analysis of INM in order to evaluate these options in holistic manner.

### **Invest in fertilizer product research**

So far, innovation in fertilizer products has not been a priority area of research in India. As a



result, 3 or 4 conventional fertilizers rule the market, notwithstanding their low use efficiencies. However, development of sustained release fertilizers using nano-formulations and other novel approaches would be important to enhance nutrient use efficiency and minimize losses to the environment. Adequate public investment is needed to encourage research in this important area. Also, the fertilizer industry must come forward to support such research.

#### **Ensure timely availability of fertilizers**

Timely availability of all fertilizers recommended in the SHC is a pre-requisite for adoption of SHCs. At present, secondary and micronutrient fertilizers (except zinc sulphate) are often not available with fertilizer retail outlets/agri-input dealers. The availability of quality fertilizers supplying these nutrients should be ensured so as to get desired benefits of SHCs. Once an awareness is generated among farmers, they will generate a demand and the market is more likely to respond.

#### **Capacity building of input dealers**

The dealers of fertilizers and other agri-inputs are (and would remain) most easily available and accessible extension functionaries. Hence, their regular orientation/training is most desirable to empower them with necessary technological advancements to guide the farmers. In fact, minimum qualification has been fixed for pesticide dealership by amending the Insecticide Act, 2008 in 2015. However, it has generated a lot of resistance from the established network of dealers, and the initial prescription of a graduation in agricultural science or science (chemistry) has been diluted. A minimum qualification of diploma should come to be the accepted norm. This would improve the quality of services and farm advisory in respect of inputs like fertilizers & pesticides, apart from creating employment for trained youth.

### **1.9. Annotation**

Enhanced pace of nutrient mining due to non-judicious and *ad-hoc* fertilizer use has emerged as one of the most important causes of soil health decline in recent years. A nutrient-starved soil cannot support high crop productivity. Any yield gains achieved on such soil owing to varietal or crop management interventions other than judicious nutrient input would be temporary and encourage mining, leaving the soil further depleted of its native nutrient reserves.

The physical and biological environment of a low fertility soil that supports low yields is often unhealthy because of lesser recycling of belowground root mass. It is, therefore, inevitable to precisely monitor the existing as well as emerging soil fertility problems, generate pragmatic recommendations, and ensure their timely delivery to the farmers.

Equally important is it to enhance awareness of farmers regarding the threats of extractive farming practices, and simultaneously the long-term benefits of investing in soil health improvement. This calls for strengthening of soil testing infrastructure and manpower so as to make the system more accountable and sensitive towards farmers' expectations. For this, soil

health monitoring and maintenance needs to be taken-up as a campaign at national level.

With the Government initiative of providing SHC services to all farmers in a given time frame, soil testing facility has come to occupy centre stage of soil health management, and expectations from the service have seen a palpable rise.

In order to address the demand credibly, not only the infrastructure and functioning of STLs necessitate complete overhauling, soil testing research should also be simultaneously strengthened to bridge critical knowledge gaps. Emphasis has to be laid on the establishment of modern STLs with high output, deployment of trained manpower, geo-referenced soil sampling, use of ICTs for effective monitoring, and establishment of quality control mechanism.

In order to avail desired benefit of SHC Scheme, steps like revisions of GFRs by the states, bringing in necessary reforms in fertilizer policies particularly NBS (nutrient based system) and CF (customized fertilizer), and promotion of INM warrant consideration. Promotion of community level mechanised composting as a small-scale farm industry would enhance availability of quality compost to partially curtail fertilizer input and restore soil health. Also, investment in fertilizer product research would pay significant dividends in the times to come.

**Key extracts**

- Constant deterioration in soil health has emerged as major threat to sustainability of agricultural production systems.
- For effective soil health monitoring and management, Government of India launched Soil Health Card (SHC) Scheme during 2015, in addition to several other initiatives under on-going schemes. The SHC Scheme envisages distribution of SHCs to ~120 million farm holdings at 2-year interval.
- With the launching of SHC Scheme, soil testing service assumed centre stage of soil health management, and expectations from this service have increased.
- The STL network is barely adequate to cater the soil testing needs envisaged in the SHC Scheme, and there is need to strengthen the soil testing service.
- Establishment of modern fully-automated STLs with high output should be considered in place of adding fewer small STLs every year, in order to handle massive soil testing targets without compromising quality of analysis.
- Creation of a state-level service cadre for soil health monitoring would go a long way in improving overall efficiency in the soil testing and fertilizer recommendations.
- Besides revision of existing fertilizer recommendations by the states, there is an urgent need to develop more robust fertilizer prescription approaches that encourage precision nutrient input to achieve maximum economic yields.
- In addition to necessary reforms in fertilizer policies, there is need to promote community level 'waste-to-wealth' model as a small-scale farm industry to enhance availability of quality manure at farmers' doorstep.



## Chapter 2

### Water Management in Agriculture

*Agriculture consumes more than 80 per cent of the total usable water available in the country. Further, this is not equitably available to all crops, all regions and over time of the year. There is increasing demand for the available water for non-agricultural uses and urgent need to achieve high degree of water use efficiency. Water has to be applied in right amounts at the right time in order to achieve the right crop result. At the same time, wastage must be avoided, staying in harmony with the environment. Understanding, measuring and assessing how water flows around the farm, and recognising how farming practices affect flows, will help farmers to manage water efficiently and reduce its loss.*

#### 2.1. Introduction

The Indian agriculture along with allied sector continues to be pivotal to the sustainable growth and development of the country's economy. Water is one of the most critical inputs in a biological production system like agriculture, and is the greatest moderator of vulnerability and climatic variability. It is estimated that about 55 per cent of foodgrain production comes from irrigated agriculture. Paddy and wheat constitute the fulcrum of food security of India; and 74 per cent of these two staples is produced from irrigated areas. But India's water resources are under considerable strain. India accounts for only about 4 per cent of global water resources, but supports 18 per cent of the World's human population and 15 per cent of its livestock.

**Table 2.1 Water Availability Status (billion cubic metres)**

Annual Precipitation (Including snowfall)	4000 BCM
Average Annual Availability	1869 BCM
Estimated Utilizable Water Resources	1123 BCM
(i) Surface Water	690 BCM
(ii) Ground Water	433 BCM

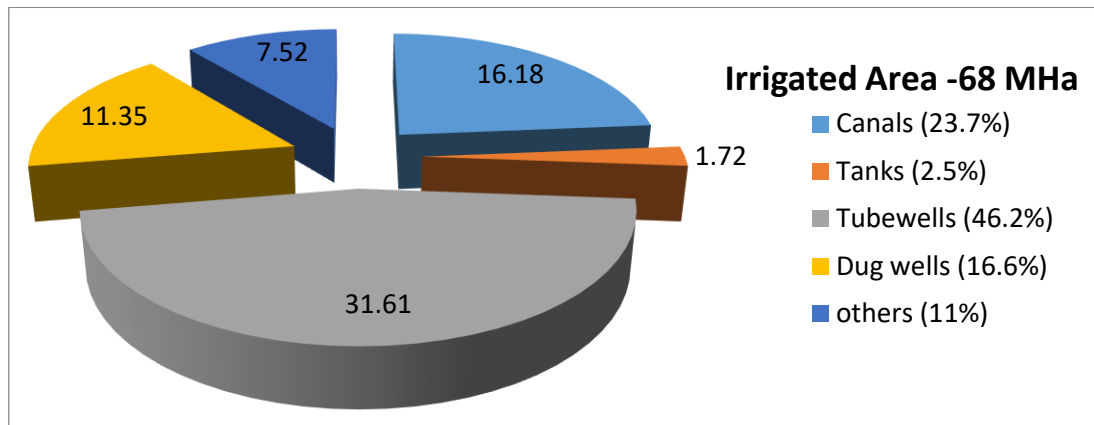
*Source: Ministry of Water Resources*

Over the last few decades, net sown area in the country has stagnated at about 140 million ha; and the possibility of increasing net sown area is minimal. The more probable approach to add to the nation's production kitty through area expansion lies in increasing the cropping intensity. And of course productivity enhancement would be the principle way forward to higher production. Hence producing more from the available land resources remains a priority which is only possible if practised scientifically.

With 52 per cent of its cultivated land being monsoon-dependent, the nation faces substantive challenges in effective management of available water. These rainfed regions of India are characterized by aberrant behaviour of monsoon rainfall, eroded and degraded soils with multiple nutrient and water deficiencies and declining ground water table. These coupled with poor resource base of the farmers are a major reason for low and unstable yields. In addition to these, climate variability including extreme weather events resulting from global climate change pose a serious threat to rainfed agriculture. The rainfed agriculture holds a key position in ensuring food & nutrition security of the country, besides increases in farm incomes and

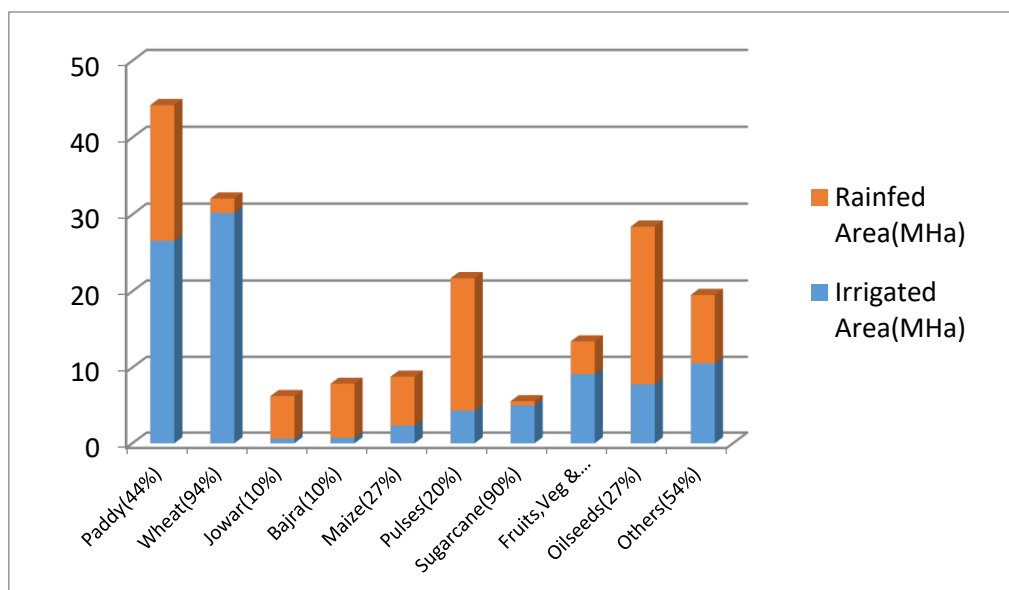
equitability. In India, the average grain yields in rainfed regions is about 1 t ha<sup>-1</sup>, compared to 3 t ha<sup>-1</sup> in irrigated agriculture.

**Figure 2.1 Extent and sources of irrigation in Agriculture**



Rainfed agriculture is prominent in India, accounting for about 52 per cent of the total cropped area and contributes 82 per cent of nutri-cereals, 80 per cent pulses and 82 per cent oilseeds as a ration of the country's production. The rainfed ecosystems are also the one that are prone to the ill-effects of climate change and experience frequent hardships like drought and frequent crop failures. Further, the Indian climate, which is predominantly tropical and subtropical, receives most of its rainfall from the south west monsoons with high intensity resulting in high runoff and degradation of the land mass. In rainfed regions, due to the temporal and spatial variabilities and due to skewed distribution of rainfall, crops invariably suffer from moisture stress at one or the other stage of crop growth.

**Figure 2.2 Crop-wise ratio of rainfed and irrigated area**



Rainwater harvesting is an important solutions to the problems of rainfed farming. The successful production of rainfed crops largely depends on how efficiently soil moisture is

conserved *in-situ* or the surplus runoff is harvested, stored and recycled for supplemental irrigation, and these are inevitable options to sustain rainfed agriculture in climate change scenario.

There is need for a paradigm shift in emphasis towards improving agriculture water management. Marginal changes in management practices will not be enough to increase productivity. One of the important interventions needed to achieve doubling farmers' income is higher productivity of water enhancing the efficiency of the existing irrigation systems. Conservative and efficient use of water will not only help extend its availability to additional area, but also make ways for adoption of modern inputs, practices and technologies. This will increase farming intensity, higher productivity and farm income. However, it has to be ensured that the precious and common resource is equitably distributed among all the sections of the community; across the regions of a hydrological system and required prioritization amongst various uses is achieved.

## **2.2. Current Practices and Challenges**

**Substantial area under rainfed:** About 72 million hectares (Mha) of net sown area (52%) is still completely dependent on rainfall. Further, irrigated area except from reservoir as a source, is also dependent on rainfall. Such irrigated areas are served by ground water, tanks, minor/micro water harvesting structures and account for about 42 Mha. Rainfed agriculture cannot compete with conventional standards and definitions of productive agriculture and requires specific interventions, norms, standards and attention. Rainfed areas constitute about three fourth of land mass under arid, semi arid, and dry humid situations, and are therefore, more vulnerable to weather aberrations and are characterized by low levels of productivity and low input usage. The extent of arid, semi-arid and dry sub humid regions in the country count to 15 M ha, 15 M ha and 42 M ha respectively. Rainfed areas if managed properly have tremendous potential to contribute larger share in foodgrain production and faster agricultural growth compared to irrigated areas that have reached a plateau. The essential pre-requisite is crop alignment with agro-climatic status.

**Regional imbalance:** There exist huge temporal and spatial variations in rainfall and water availability in the country. Most of the water is available during monsoon period and that too, through few spells of intense rainfall, resulting in floods in major rivers. While average annual rainfall of the country is about 1,170 mm, it varies from an average high of 10,000 mm per year in North East and a low of just 100 mm per annum in some parts of Western Rajasthan. It has been estimated, that while the lower rainfall zone (less than 750 mm annual rainfall) accounts for 33 per cent, the medium rainfall zone (750-1,125 mm) accounts for 35 per cent, the high rainfall zone (1,125 to 2,000 mm) covers 24 per cent and very high rainfall zone (more than 2,000 mm) accounts for the remaining 8 per cent of net sown area. The basin- wise availability of water is also quite varied. The Ganga-Brahmaputra river basin contributes to more than 50 per cent of total annual water availability, whereas, Southern and Western basins account for only about 15 per cent each.

**Sub-optimal utilization of created facilities:** One of the major shortcomings in the prevailing irrigation system is the wide gap between irrigation potential created (IPC) and irrigation potential utilized (IPU). The reasons are: inadequate maintenance of canal system, lack of participatory management, changing land use pattern, deviation from the designated cropping pattern, soil degradation and delay in command area development. As against the gross created irrigation potential of about 118 million ha area, the gross irrigated area used is only 96 million ha, resulting in a gap of about 22 million ha. This gap can be bridged to the advantage of agriculture and farmers.

**Poor irrigation efficiency:** Gross irrigated area in the country is about 96 Mha from nearly 650 BCM (billion cubic metre) of water which gives a delta of 0.68 metre (m) per ha. of gross irrigated area. Taking 70 per cent of the average rainfall of 1,170 mm (1.17 m) as effective for crop consumptive use, the gross water use is about 1.48 m per ha. of the gross irrigated area. This is very high as compared to water use in irrigation systems in developed countries, like USA where water allocation is about 90 cm/ha. This overuse in the country reflects low irrigation efficiency of about 35 per cent to 45 per cent in most surface irrigation systems, and about 65 per cent in case of ground water use.

**Improper crop and cropping system:** Presently, high proportion of cultivated area under water guzzling crops like rice, sugarcane etc. is witnessed. Water being the most critical input for agriculture, its judicious use is important to ensure sustainable agricultural development and food security. There is a need for adopting a policy that encourages optimum cropping pattern, that utilises available water resources in an efficient manner. This necessitates a study and analysis of current cropping system. Based on the principle of maximizing annual income returns and efficiency of water use for long term sustainability, crop diversification from rice and sugarcane to low duty crops such as pulses and oilseeds may be a better option. These alternate crops would enable cultivation of larger area benefiting higher number of small and marginal farmers. The additional advantage is greater certainty of water through all stages of crop growth from the same quantum of water. About 2.89 M of ha area is covered under rice crop in 68 districts of India which receive a normal rainfall (50 years average from 1951 to 2000) less than 650 mm. This covers about 6.72 per cent of total rice cultivated area (43 M ha) in India. About 0.721 M ha area is covered under sugarcane cultivation in 91 districts of India, which receive normal rainfall (50 year average from 1951 to 2000) less than 700 mm. This covers about 12.9 per cent of total sugarcane cultivated area (5.6 M ha) in the country. Crops like rice, sugarcane and such other water guzzlers need to be discouraged particularly in over-exploited ground water regions, allowing only surface water resources for rice cultivation. This may facilitate diversification of rice to other low duty crops by the farmers in a phased manner. Suitable low duty crops for diversification include maize, pulses & oilseeds.

**Imbalanced use of ground water:** Ground water has emerged as the main source of growth in irrigated area and it now accounts for over 63 per cent of the country's irrigated area. Power for irrigation in many states is provided either free or at highly subsidized tariff, and this has incentivized use of ground water for agriculture. Apart from wasteful energy consumption,



subsidized or free power has also encouraged farmers to overdraw water from deep aquifers, causing substantial depletion of water table and water quality deterioration in many cases. There has been unprecedented crop diversification to heavy water duty crops due to unregulated ground water use. The preference for high water duty crops like rice, sugarcane, banana, cotton etc. is common in regions, which does not fit into the rainfall pattern or ground water availability status. Notwithstanding the huge significance of ground water in agricultural growth, it is in need of urgent understanding and attention from the perspective of sustainability.

Recent assessment report of Central Ground Water Board (CGWB) shows that 1,034 of the 6,584 assessed Community Development Blocks are over-exploited (referred to as 'dark zones'). Besides, 253 are critical, 681 are semi-critical and 96 blocks are completely saline. The number of over-exploited and critical administrative units is significantly higher in Delhi, Haryana, Himachal Pradesh, Karnataka, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh.

**Competing demand:** The demand for water for various purposes is increasing due to population growth, urbanization and industrialization. Presently agriculture sector is using about 80 per cent of the total available water resources. Let alone there being any further scope for higher water allocation for agriculture, there is in fact increasing demand from competing domains like industries, urban centres and infrastructure. Hence water availability for agriculture may decline to 68 per cent by 2050. Water requirement for various sectors as assessed by "Standing Sub-Committee for Assessment of Availability and Requirement of Water" and by NCIWRD are given in Table 2.2.

**Table 2.2 Sector-wise demand for water**

Sector	Water Demand in BCM			
	Standing sub-committee of MoWR		NCIWRD	
	2025	2050	2025	2050
Irrigation	910	1072	611	807
Drinking Water	73	102	62	111
Industry	23	63	67	81
Energy	15	130	33	70
Others	72	80	70	111
<b>Total</b>	<b>1093</b>	<b>1447</b>	<b>843</b>	<b>1180</b>

**Water logging and soil salinity:** Another challenge relates to over-use of surface water that has resulted in drainage problems causing water logging in some areas. Problem of water logging is very often observed in canal irrigation system and also in areas with poor drainage leading to accumulation of water.

**Climate change:** Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of the high population depending on

agriculture, excessive pressure on natural resources and poor coping mechanisms. Agriculture is particularly vulnerable to climate change. Higher temperatures tend to reduce yields of many crops; and encourage weed and pest proliferation. Climate change will have negative effects on irrigated crop yields across regions, including in India both due to temperature rise and changes in water availability, while rainfed agriculture will be primarily impacted due to rainfall variability and reduction in number of rainy days. Long term data indicates that rainfed areas witness 3-4 drought years in every 10-year period. Of these, 2-3 are of moderate and one may be of severe intensity. Parts of western Rajasthan, southern Gujarat, Madhya Pradesh, Maharashtra, northern Karnataka, northern Andhra Pradesh, and southern Bihar are likely to be more vulnerable in terms of extreme events. Irrigation requirements in arid and semi-arid regions are estimated to increase due to rise in temperature. Adverse effects of climate change on freshwater systems will aggravate the impacts of other stresses, such as population growth, changing economic structure, land use change and urbanization. Yield declines are likely to be caused by shortening of growing period; negative impacts on reproduction & grain filling; decrease in water availability and poor vernalization. Climate change is projected to reduce wheat yield by 6-25 per cent towards the end of the century with significant spatio-temporal variations. A one degree Celsius rise in mean maximum and minimum temperatures during vegetative and grain filling period is likely to cause a yield reduction of 360 and 265 kg/ha, respectively.

### **2.3. Contours of Water Management**

As brought out in the preceding sections, Indian agriculture is divided between:

- i. Irrigated cultivation
- ii. Rainfed cultivation

Both systems are in need of suitable interventions for realizing efficient and sustainable water management practices. The needed measures are discussed below.

#### **2.3.1. Irrigated areas**

In section 2.1, the current practices of water use and management and the challenges involved have been discussed. The broad approach may consist of:

- Bridging the existing wide gap between irrigation potential created (IPC) and irrigation potential utilized (IPU).
- Crop alignment in command areas by promoting low water duty crops and in synchrony with local agro-climatic conditions.
- Efficiency in management of irrigation systems, to reduce water leakage and waste due to poor maintenance of water distribution systems.
- Creating a stake for the water users and making them responsible for water management through Water Users Association (WUA).
- Expanding the area under dependable source of irrigation, by identifying new sources

and completing the ongoing projects in a time bound manner.

- Enhancing water use efficiency by a blend of agronomic practices and deployment of technologies (eg., micro-irrigation).
- Adoption of ground water recharge practices, through various water conservation practices including integrated water management.
- Close attention to management of water budget based on measuring availability of water and its use / demand for alternate purposes.
- Research and Development (R&D) focus for water use efficient varieties & technologies.

### **2.3.2. Rainfed areas**

As emphasized in the previous sections, rainfed cultivation systems account for much higher area than under irrigation, but are yet to be paid necessary attention for realizing their full potential. Both, agriculture as an activity and farmer as a stakeholder are in need of priority attention. Water being a necessary and sufficient input for farming rainfed systems pose a major challenge to optimal growth and development. Some specific approaches suggested.

- Creation of water sources through different categories of irrigation projects – major, medium and minor. The harvesting of potential irrigation potential must get priority attention.
- Considering, that even harvesting of the full potential will leave vast area under rainfed agriculture, water conservation in association with soil conservation practices should become the core of development package.
- A bouquet of water harvesting structures including tanks, ponds, diversion weirs etc should be emphasized.
- The limited water available in water harvesting structures can be most effectively used for protective irrigation during critical periods for a larger coverage with extended period adopting precision irrigation practices (Drips/Sprinkler systems)
- Adoption of water use efficient cropping system and diversified agriculture.
- Adoption of Integrated Farming System (IFS), watershed management, conservation agriculture (CA) etc.
- Adoption of technology – agronomic, engineering and system, that are appropriate in rainfed areas.

### **2.4. Government Initiatives**

In recognition of the need for end to end solution to address water management in agriculture, government has launched a comprehensive flagship scheme called “Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)”. The Rural Employment Guarantee scheme, MGNREGA has

also been supporting agriculture, by enabling use of its funds for creating infrastructure in agriculture like small irrigation structures. Convergence of resources and synchronization of efforts would yield synergistic results.

**Pradhan Mantri Krishi Sinchayee Yojana (PMKSY):** Substantial dependency on rainfall makes cultivation in un-irrigated areas a high risk and less productive profession. Empirical evidence suggest that assured or protective irrigation encourages farmers to invest more in farming technology and inputs leading to productivity enhancement and increased farm income. The Pradhan Mantri Krishi Sinchayee Yojana was launched on 1<sup>st</sup> July, 2015 with the motto of '*Har Khet Ko Paani*' for providing end-to end solutions in irrigation supply chain, viz.

- water sources;
- distribution network: and
- farm level applications.

PMKSY not only focuses on creating sources for assured irrigation, but also creating protective irrigation by harnessing rain water at micro level through '*Jal Sanchay*' and '*Jal Sinchan*'. Micro-irrigation gets due attention to ensure '*Per drop-More crop*'. PMKSY adopts State level planning and projectised execution that allows the states to draw up their own irrigation development plans based on District Irrigation Plans (DIPs) and State Irrigation Plans (SIPs). The components of the scheme are:

- ***Accelerated Irrigation Benefit Programme (AIBP):*** To focus on faster completion of ongoing major and medium irrigation projects, including national projects. (Implemented by MOWR, RD&GR).

This is a progressive step taken by the Government in 2016, by creating an initial corpus fund of the size of Rs. 20,000 crore, which was increased to Rs. 40,000 crore in the year 2017-18 and there stands a commitment to provide the total requirement of more than Rs. 70,000 crore, targeting to complete 99 number of long pending irrigation projects. When completed (target timeline being December 2019), an additional cultivable land to an extent of 7.6 million ha would benefit from dependable source of irrigation.

What is now important is to focus on command area development works in time, so that the water that reaches the final distribution network is used optimally by the farmers. There has to be a time bound work execution plan to this effect.

Further, emphasis is needed on crop alignment in the command area. As seen from the experience in irrigation command areas, there is total deviation from the certified crops. Farmers tend to adopt heavy water duty crops in place of those that can grow using less water. Such deviation results in depriving the tail and farmers of their right to water use. It is, therefore, important to plan for a comprehensive crop plan by involving the farmers themselves, and make them responsible for total adherence.

- **PMKSY (*Har Khet ko Pani*):** Source augmentation, distribution, ground water development, lift irrigation, diversion of water from water plenty to water scarce areas, supplementing rain water harvesting beyond IWMP & MGNREGA, repair, restoration, renovation of traditional water bodies, (implemented by MoWRRD&GR).
- **PMKSY(*Per Drop More Crop*):** Micro level storage structures, efficient water conveyance & application, precision irrigation systems, topping up of input cost beyond MGNREGA permissible limits, secondary storage, water lifting devices, extension activities, coordination & management (implemented by DAC&FW).

The most important intervention of this component is micro-irrigation system, comprising sprinkler and drip irrigation. These irrigation systems promote precision farming by making available water in a targetted manner, thereby achieving water use efficiency. Unlike in flood system of irrigation, where more water is lost in conveyance and by evapo-transpiration, micro-irrigation systems result in water saving. Further, they also aid in soil health management.

Of the 6.4 million ha of net cultivated area under irrigation in the country, the coverage under micro-irrigation (MI) by end of 2016-17 stood at about 9.5 million ha. Since the launch of PMKSY, the coverage has accelerated and the year 2016-17 recorded a high of 8.5 lakh ha of coverage. In terms of area under MI system, though India is bracketed among the top at global level, there is much to be done given low per capita water availability in the country.

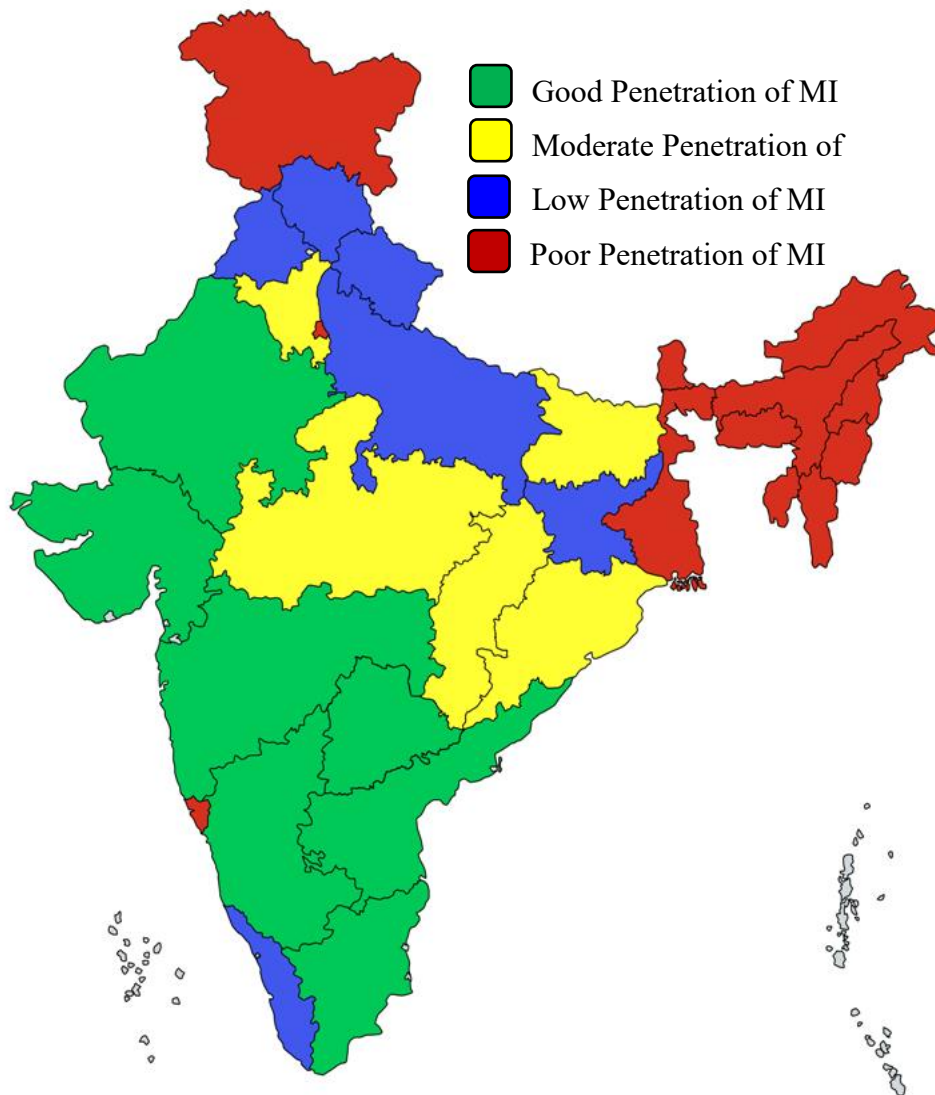
The Group of Secretaries (Govt. of India) has in its recommendations for the year 2017, rightly suggested an annual target of 2 million ha, to add an extent of 10 million ha over the 5 year period of 2017-18 to 2021-22. It is possible to achieve this target given the increasing budgetary allocation under PMKSY. The component 'Per Drop More Crop' got an allocation of Rs. 3,450 crore for the year 2017-18 and a supplement of Rs. 5,000 crore as an 'Extra Budgetary Resource (EBR)'. The Corpus Fund to be created by NABARD, with interest different responsibility to be met by DACFW, would help in increasing the annual coverage.

Given the developing situation of water stress, in the opinion of the DFI Committee, the annual target should be raised to 3 million ha by pooling budgetary and non-budgetary resources. Further, through convergence of resources from large budgeted schemes like MGNREGA, additional funding can be mobilized.

An important issue that needs to be addressed is wide inter-state variations in utilization of funds under micro-irrigation (both Budgetary and MI Corpus Fund sources).

The lead in this regard rests with the western & southern states; and recent initiative seen in central Indian states like that of Madhya Pradesh. The rest of India, particularly in north and north-east seems to be complacent about the efficiency of micro-irrigation. The map below brings out in stark contrast the state variations.

Figure 2.3 Coverage of micro-irrigation



Water table is depleting in the Indo-Gangetic Plain states due to over-extraction, and as a water saving device, micro-irrigation would be an optimal technology; and likewise in the heavy rainfall states of eastern and north eastern region too, it is the answer. Hence, these regions need special attention to promote micro-irrigation.

**Sensor based technology:** Precision farming through micro-irrigation systems can be further strengthened by deploying a combination of sensors, data analytics and drones. This technology is expected to become more robust and cost effective in due course. It would be useful to launch pilot projects to validate and scale up after addressing the constraints and glitches.

- **PMKSY (Watershed):** Ridge area treatment, drainage line treatment, soil and moisture conservation, water harvesting structure, livelihood support activities and other watershed works. (implemented by DoLR)

The Union Cabinet in its meeting held on 27<sup>th</sup> July, 2016 approved implementation of PMKSY in a mission mode. The mission objective is to complete 99 major and medium irrigation projects having potential of 76.03 lakh ha in phases by Dec., 2019, including command area development. For completion of these projects in a mission mode, innovative funding mechanism through NABARD is envisaged.

**Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS):** About 70 per cent of the resources of MGNREGS are used for soil and water conservation activities in rural areas. The Department of Rural Development (DoRD) has been prioritizing construction of farm ponds and de-siltation of water bodies under the scheme. During the year 2016-17, more than 5 lakh farm ponds were constructed which have proved beneficial by providing protective irrigation during dry spells. It is saving irrigation at the critical stage of crop, that is important to de-risk crop cultivation. This approach is highly relevant in rainfed areas, and the efficiency can be improved by integrating conveyor pipeline and drip / sprinkler.

**Rashtriya Krishi Vikas Yojana (RKVY):** RKVY empowers states to take up activities related to infrastructure development in agriculture sector. Many states have been accessing this resource for water conservation and management activities. RKVY funds can be best utilized if water management activities are taken up based on comprehensive work plan and involvement of community. Besides, RKVY, water harvesting and management activities are also supported in most of the agriculture development programmes as package of practices.

## **2.5. Policy Recommendations**

Identification of comprehensive set of problems based on systematic and scientific approach would help in designing and adopting the needed solutions, and achieving efficiency in effectiveness. In the following sub-sections, some strategies are suggested for:

- irrigated area; and
- rainfed area.

Some of the suggestions under the two broad heads would *mutatis mutandis* also apply to the other too. Further, a third category of suggestions is also made which would be common to both the systems listed above.

### **2.5.1. Suggestions for irrigated areas**

#### **(i) Addressing the problems of over-exploitation of ground water**

The states like Punjab, Haryana, Uttar Pradesh, Rajasthan, Tamil Nadu etc. are witnessing serious concern relating to ground water depletion. Sustainable groundwater development and management initiatives in the over-exploited region are needed by incorporating artificial recharge of groundwater and rainwater harvesting, conjunctive use of surface water and groundwater, management of poor/marginal quality groundwater, water conservation (by increasing water use efficiency), regulation of groundwater development, etc. Separation of power feeders for domestic consumption and agricultural use and its timely but controlled

supply for irrigation could help regulate groundwater use. Ways must be explored to empower and entrust village communities with the right and responsibility to collect electricity charges and to undertake rainwater harvesting and groundwater recharge. A gradual withdrawal of cultivation of rice, sugarcane and other water guzzling crops from the over-exploited western region of the country is the call of the day. Substitution of rice has to be a cautious approach, and has to be carried out simultaneously with increases in substitute cereals like millets, so that food security is not compromised.

The CGWB (Central Ground Water Board) report shows that Punjab, Haryana, Rajasthan, Delhi and Tamil Nadu have significant assessed units under over exploited category as the ground water consumption is more than the annual ground water recharge. Though Tamil Nadu has maximum number of 'dark zones' (358 out of 1139 assessed units), Punjab is the worst in percentage term with 105 (76%) of 138 assessed units. Similarly, 164 of 248 assessed blocks in Rajasthan are overexploited (66%), followed by Delhi where 15 (56%) out of 27 blocks are in 'dark zones'. Haryana has 64 (54%) over-exploited blocks out of 119 assessed units. Government is in the process of launching Atal Bhujal Yojana to focus on development of 30 per cent of the assessed blocks (fast depleting ground water) adopting efficient water management and strengthening of recharge through community participation. There is urgent need to expedite activities for better community driven water management, crop alignment and ground water recharge including artificial recharge to save these critical blocks from further depletion and sustaining the agriculture operations.

**(ii) Creating secondary storages in tail end of canal commands**

During peak monsoon periods, the reservoirs are at peak storage level. The availability of water in canal system is unrestricted and water is available in plenty even at the tail end of the system. There is however minimum need for irrigation at such times, and if this water is stored in secondary storage structures constructed at feasible locations of the tail end of canal system, it will not only help in making water available during dry spells when it is scarce, but also reduce impact of flood to a certain extent. This network of secondary storage can also be taken up by accessing water from streams during rainy season, particularly in hilly terrains, for use during critical periods.

**(iii) Irrigation development in eastern and north eastern region**

In East and North East India ground water resources are under-utilized to the tune of 55-99 per cent, while also being blessed with high rainfall. Rice is a staple diet in major parts of India and food security at the country level may be ensured by enhancing its productivity and production in these regions. Care may however be taken to avoid paddy cultivation in uplands, which are common in this region. In Eastern, North Eastern and Coastal pockets of India, the abundantly availability of ground water may be used rationally and sustainably for good agricultural practices. In Assam, Bihar, Chhattisgarh, Orissa, parts of Jharkhand, Eastern Uttar Pradesh and West Bengal, other coastal regions and pockets, a battery of shallow and deep tube-wells can be installed for *Rabi* season cultivation, which will also act as sink for subsequent floods. Small and marginal farmers in Eastern States will benefit from community



tube-wells and mobile pump-sets for use by a group of farmers. FPOs may be promoted for this purpose. Create of such ground water irrigation potential in the Eastern and North Eastern States will also require attention to stable power supply by energizing new tube wells and soft credit for farmers to install tube-wells and pump-sets.

**(iv) Completion of irrigation projects**

As per available information, 149 major and medium irrigation projects are at various stages of implementation and have been pending completion for long. Of these Government has already identified 99 projects for completion on mission mode approach to bring about 7.6 million ha of cultivated land under irrigation by December, 2019. Thus, there will be about 50 remaining major and medium irrigation projects still requiring completion with scope to bring additional area under irrigation. Some of these projects are being taken up expeditiously by the State Governments for early completion. However, rest of the projects are either delayed due to challenges of land acquisition, fund constraints or lack of priority given by the states. These projects also need to be reviewed and feasible projects taken up for completion on mission mode approach in the line of 99 AIBP projects already taken up. This will take forward the component of 'har khet ko pani'.

**(v) To improve on-farm water management**

On-farm water management can reduce wasteful use of water and, at the same time lead to increases in productivity. As irrigation water rates are generally low and also unrelated to the quantity of water use, farmers find no incentive to economize on its use. In cases of improper levelling of fields, farmers are found to apply excess quantity of water to ensure that enough water reaches plants situated on higher grounds. Farmers also resort to submergence of rice fields to check weed growth. These are all wasteful water use practices. Planting wheat on raised beds improves yields, increases fertilizer efficiency, reduces herbicide use, saves seeds, saves water on an average by 30 per cent and can reduce production costs by 25-35 per cent compared to permanent beds. This is just one example of positive effect of on-farm management in water conservation and lowering of production costs without compromising the yield levels.

The results of other All India Coordinated Research Programmes of the Indian Council of Agricultural Research (ICAR) in water management network centres have successfully demonstrated, that there is a great scope for ensuring water economy, increasing crop productivity and improving water use efficiency, if available irrigation and other agro-technologies are transferred to farmers in irrigation commands.

Laser levelling of land also is effective in water saving to an extent of 25-30 per cent.

**(vi) Participatory Water Management**

Farmers are the first and prime stakeholders in water management. Farmers have been managing land and water resources for generations as they are much familiar of the surrounding environment, time of irrigation and overall demand in the neighborhood. Water is best used

when a proper water budget is developed for a particular village / group of farmers assessing the demand and supply positions. However, farmers do not show the same level of collective responsibility and social concern when it comes to publicity.

Organised water users associations (WUAs) would not only help in efficient crop planning and equitable distribution of water, but also would serve as channels for feedback and inputs to improve the performance and services provided by Government. WUAs need to ensure voluntary and active participation in water allocation and management activities. They can also take over the task of Operation and Management (O and M), of the tertiary system including field channels (now with the State Departments of Water Resources); and of collecting water rates (now mostly with State Revenue Department). Since, water user association adopts the process of group dynamics and represents the collective decision of the community to tackle their own problems, probability of acceptance of the decision is likely to be high and success of implementation can also be expected to be high.

**(vii) Water pricing and regulatory mechanism**

A commodity which is free and available in abundance is often misused. So is the case with irrigation water also. It is, therefore, necessary to supply metered water and charged accordingly at a reasonable rate to economize its use.

Alternately, a system that involves release of water on payment to be compensated by the targetted / entitled subsidy on water subsequently may be adopted, as in the case of DBT based LPG distribution. This will discipline water use, while helping farmers with water rate concession.

**(viii) Measures to control water logging & soil salinity**

Water logging leads to soil salinity. Problem of water logging is very often observed under surface irrigation system and also in the areas of poor drainage resulting in accumulation of water. Apart from lining of canals, wherever required there is a need for drainage development either through surface/sub surface/bio drainage or a combined approach followed by appropriate agronomic measures.

**(ix) Emphasis on recycling of water**

Currently, reuse and recycling of waste water are not practised on a large scale in India, and there is considerable scope to adopt this water source for irrigation after appropriate treatment. This has particular role in urban and peri-urban areas, as agriculture / horticulture production that meets the urban demand for fresh produce can be met.

**(x) Water footprint**

Water budgeting i.e, a balanced water use plan taking into consideration the demand & supply and equitable distribution through participatory management is the key to achieving potential use of water. All agriculture commodities should indicate the water foot print and a definite range be prescribed for each commodity for being considered eligible for export and even for

government procurement.

### **2.5.2. Suggestions for rainfed areas**

#### **(i) Conservation Agriculture**

The water stored in the soil and root zone that is available for plant growth is called green water (GW). The green water use techniques improve the soil physical properties, increase the infiltration and convert rainwater to available soil moisture for crops. The green water use techniques are also known as in-situ moisture conservation measures. The in-situ water harvesting techniques can be implemented on any piece of land, and are affordable to most smallholder farmers.

Green water techniques have significant impact on natural resource conservation and crop yield. In low rainfall regions, the land levelling and field bunding increase the crop (particularly crops like castor and cotton) yield upto 61 per cent. The conservation furrows in crop fields increase the crop yields in the range of 8-40 per cent. In medium rainfall regions, the broad bed and furrow (BBF) system increases the crop yields (particularly soybean yields in vertisols) upto 83 per cent. The ridge and furrow system and compartmental bunding perform well in medium rainfall areas. This system increases the crop yields upto 55 per cent. The sub-soiling with chisel plough in alfisols of medium rainfall region improves productivity upto 24 per cent.

The rainfed regions in general, arid and semi arid regions in particular suffer from huge loss of water through evapo-transpiration. The options available to reduce soil evaporation include dry planting/ sowing, mulching, zero tillage, inter-cropping, cover crops, wind-breaks, agro-forestry, vegetative bunds etc. Mulching reduces soil moisture loss caused by evaporation and insulates the soil, thereby protecting roots from adverse effect of extreme summer and winter temperatures.

Artificial mulching is practised using both plastic and biological (crop-residue) mulching. The plant residue mulches increase crop yields up to 31 per cent and increase the soil organic carbon (SOC) content and improve soil carbon build up. The crop residue mulch does not require much investment. Plastic mulch is being successfully practised by several farmers which help reduce the weed infestation & soil moisture evaporation, and effect an yield increase by about 40 per cent. In gravelly & stony soils gravel/ lithic mulching is the best option for evaporation control. In Bijapur (now Vijayapura) District of Karnataka, the gravel mulching was able to increase the yields upto 125 per cent. In rainfed regions, with a view to conserving natural resources, organic/crop residue mulches need to be promoted. Plastic mulches can be promoted in areas with instances of higher weed infestation and soil temperature.

In India, rice is predominantly cultivated adopting transplantation. Transplanting requires at least 25 ha-cm of water. The System of Rice Intensification (SRI) and direct seeded rice (dry seeded rice) technologies have shown the potential of improving water productivity (as puddling requires significant quantity of water and is lost by more seepage and evaporation losses); and reduced use of labour, usage of energy and cost of cultivation; reduced the methane

emissions; and increase in system profitability by 10–15 per cent.

The crops such as sunhemp, greengram, cucumber and ridge gourd quickly cover the ground surface within 45 days. These crops reduce runoff and splash erosion and non-productive evaporation from the ground surface. With cover cropping in kharif, there are yield advantages in various rabi crops and substantial gain in overall system profitability.

**Table 2.3 Green water management interventions and implementation strategies in different rainfed regions**

<b>Rainfed region</b>	<b>Rainwater management techniques</b>	<b>Increase in yield</b>	<b>Implementation strategy</b>
Rainfed regions having average annual rainfall of < 500 mm	Land leveling, bunding, conservation furrow system, mulching	Increase in crop yields upto 80 per cent	Demonstrations and skill enhancement of farmers through KVKS and upscaling through State Agricultural Departments and convergence with the other development schemes like MGNREGS and PMKSY.
Rainfed regions having average annual rainfall of 500-1000 mm	Land leveling, bunding, ridge and furrow, furrow irrigated raised beds, sub-soiling, broad bed and furrow, mulching, direct seeded paddy and wheat cultivation	Increase in crop yields upto 85 per cent	
Rainfed regions having average annual rainfall of >1000 mm	Bunding, ridge and furrow and raised bed furrow systems, mulching direct seeded paddy and wheat cultivation	Increase in crop yields upto 85 per cent	
Rainfed regions having average annual rainfall of < 500 mm	Dug out and embankment type farm ponds/ percolation ponds / silt removal of tanks Earthen / stone / bori bund checkdams, and artificial groundwater recharge structures	Water level in open wells increased significantly by 3 m; Crop yield increased by 3.0q/ha (45 %) and higher income of Rs. 12,000/ha realized. Cropping intensity increased by 125 per cent.	
Rainfed regions having average annual rainfall of 500-1000 mm	Dug out and embankment type farm ponds/ percolation ponds /tanks and silt removal of tanks stone / bori bund checkdams, and artificial groundwater recharge structures	Water level in open wells increased significantly by 4.5 m. Crop yields were increased by 50 per cent cropping intensity increased by 150 per cent.	
Rainfed regions	Dug out and embankment	Water level in open wells	

Rainfed region	Rainwater management techniques	Increase in yield	Implementation strategy
having average annual rainfall of >1000 mm	type farm ponds/tank silt removal Permanent masonry concrete checkdams, and artificial groundwater recharge structures	increased significantly by 4.5 m; Crop yields increased by 50 per cent, and an additional net return of Rs. 15,000 to 22,000/ ha; Rabi cropped area increased by 2 times	

**(ii) Rain water harvesting**

The construction of low cost check dams with available local materials, masonry check dams, and renovation of non-functional water bodies can significantly contribute in storing the rainwater, improving ground water recharge, bringing areas under protective irrigation and increasing cropping intensity in rainfed regions. The construction of low cost check dams at upper reaches and new check dams or renovation of non-functional old structures in the streams of lower reaches can be gainfully implemented under various Central schemes such as PMKSY, MGNREGS, and RKVY. In hilly areas, cost-intensive harvesting structures may not be sustainable and economical due to difficult terrain, slope, high rainfall and excessive run-off. Considering this, small water harvesting structures may be more effective. It is seen that one farm pond of a capacity of 1 to 2 TMC (thousand million cubic) can provide protective irrigation to about 6 to 8 ha of cultivable area.

Check dams play a major role in catching run-off and storing rainwater. A check dam holds an irrigation potential of about 4 to 5 ha directly or / and indirectly when surrounding wells gets recharged. Big check dams can even irrigate upto 50 ha in good locations with larger catchment area. Encouraging trends of funds utilisation under various programmes in recent decades for small-scale harvesting structures in rainfed region reiterates the relevance of this technology. It is observed that various natural water bodies, ancient / traditional water harvesting structures, farm ponds, nalas etc. have been silted up losing water holding capacity. The desiltation of these structures would not only provide economic gains by making water available for crop production and silt for the field.

**(iii) Water budgeting**

Water is most efficiently used, if a proper water budget is developed for a particular village/watershed based on systematic analysis of demand and supply positions. There is need for awareness campaign, skill development and capacity building of farmers for most effective use of the precious water resources. Role of village level institutions becomes more significant towards this end. Panchayats need to take the responsibility in managing water resources through water budgeting, accounting and allocating water to specific farmers/ household. Various examples like Hivere Bazar, Penagram etc. are successful examples of drought proofing through efficient demand and supply management involving village level institutions. A mission mode approach for involving Panchayats in water budgeting is the call of the day.

**(iv) Organic farming**

Extensive promotion of organic farming and compost would help in higher moisture conservation. It has been observed that organic content in the soil improves water retention capacity by upto 80 per cent. More the water available in the soil profile less will be the demand for application of water from external sources for crop production. There is plenty of scope for converting rural and urban organic waste to compost for improving soil health as well as water retention capacity.

**(v) Artificial recharge**

Ground water recharge depends on soil, hydrologic and hydro-geologic conditions, besides being governed by many local conditions. Various soil and water conservation structures under watershed treatment including farm ponds, check dams, percolation tanks, in-situ and ex-situ moisture conservation measures make significant contribution to ground water recharge. However, natural recharge is not sufficient to cater to the needs of groundwater aquifer at all locations. In such case, artificial recharging of aquifer is a basic necessity. Recharge filter is designed to deliver a substantial quantum of sediment-free water to open / tube wells through a buried pipe line. Artificial recharge structures reinforced by surface storage structures showed significant water table rise to about 14 m (pre-monsoon) and 22 m (post-monsoon) in Antisar watershed of Gujarat between 2002-2007. The natural and artificial ground water recharge techniques and participatory groundwater sharing system in rainfed areas is an important subject to be addressed for enhancing productivity and income.

**(vi) Crop alignment**

A farming system involving higher water use which is not compatible with the water availability status of the ecosystem is unfortunately common in many rainfed areas, rendering it drought vulnerable. Crop and land use planning based on land and agro-ecological capability is one of the priority concerns. Crop alignment and crop diversification from high water consuming to low water consuming crops based on agro ecological condition, is useful. Specific incentives for promoting crop alignment to transfer economic gains to the farmers are required. Besides, dis-incentivizing activities not compatible to the agro-ecology, through programme and schemes of various ministries/department may be useful. A reorientation of research on rainfed farming, and rainfed oriented livestock systems, small ruminants in particular, is the need of the hour.

**2.5.3. Suggestions common to both irrigated and rainfed area**

**(i) Promotion of micro-irrigation**

Precision irrigation techniques not only help the farmer in water saving, but also in reducing fertilizer usage, labour expenses, and other inputs, resulting in reduced input costs. Micro-irrigation systems deliver water savings of upto 40 per cent over conventional flood irrigation methods, along with appreciable crop productivity enhancement by about 47 per cent and income enhancement by about 48 per cent.

Piped water facility connecting dams and micro-irrigation system in fields can help reduce water losses; they can ensure roughly 70 per cent conveyance-efficiency and 90 per cent overall water-use efficiency. It is estimated, that with the adoption of micro-irrigation system in irrigated area for conventional cropping system, it will bring additional area of about 15 per cent in kharif and 23 per cent in rabi under irrigation, at adoption level of 50 per cent. And at adoption level of 25 per cent, the estimated additional coverage is 8 per cent in kharif and 12 per cent in rabi. The protective irrigation source may not yield optimal result without linkage to micro-irrigation, since these sources can't support the conventional irrigation but are meant to provide live saving irrigation.

The energy used for lifting water from bore wells/tube wells can be best used if this is linked with micro-irrigation system. This will not only lead to saving water and energy, but also in enhancing productivity and income. A drive for shifting all areas irrigated by water lifting pumps from flood irrigation to micro-irrigation would bring about a huge efficiency in total water availability in agriculture.

**(ii) Micro irrigation for water guzzling crops**

Irrigation management in heavy water duty crops like sugarcane, banana, cotton etc. needs to be gradually shifted from flood irrigation to micro-irrigation by adopting a well-designed roadmap. Industries / stakeholders dealing with these commodities should also encourage farmers to opt for precision irrigation with special incentives from their side. The decision of Government of Maharashtra in the year 2017 to make it compulsory for all sugarcane cultivation in the state to be done under micro-irrigation is worthy of emulation by other states too. That, the state has decided to utilise the borrowings under micro-irrigation corpus fund of the union government for promoting micro-irrigation in sugarcane is a positive example of leveraging various schemes for addressing priority concerns of the states.

**(iii) Use of renewable energy**

It is observed, that the recurring cost incurred by farmers on operating cost of lifting devices has a big impact on the overall economic gain from the farm. Non-renewable energy like solar, wind etc. will have to be popularised in a big way to meet the farm energy requirement. This will also help in accessing the untapped ground water in eastern regions as the availability of energy support for such activities is either not available to the desired extent or not economical to the farmers.

Additionally, the sun energy harvestable throughout the year in most parts of India is not needed on the farm during non-cultivation season. If this surplus power can be mainstreamed into the grid for public use, it will mean an additional non-farm income to the farmers.

**(iv) Convergence of programmes**

Looking at the increasing frequency of droughts in the recent past, many states have taken innovative steps to integrate all water related programmes and schemes of central and state for

cohesive and focused approach towards water conservation and management. Some of the examples like Jalayukt Shivar in Maharashtra, 'Krishi Bhagya Scheme in Karnataka', 'Mission Kakatiya in Telengana', 'Neeru Chetu programme in Andhra Pradesh', 'Jala Swabhalaban Abhiyan in Rajasthan' etc. have been proving useful in minimizing the impact of drought.

**(v) Emphasis on awareness generation & training**

Training and awareness of farmers on proper use of irrigation water at critical stages of crop growth under different soil and environment conditions is very much essential. Training should be an integral part of water resource development and management. It should cover all aspects like information systems, sectoral planning, project planning and formulation, project management, operation of projects and their physical structures and systems and the management of the water distribution systems. The training should extend to all categories of personnel involved in these activities, including farmers. There is need for improving the knowledge delivery system at state and national levels by using innovative approaches. High quality, updated and authenticated information is a useful tool for programme implementation. A dedicated extension service offering end to end solutions right from water augmentation to on-farm water management, will help in effective knowledge dissemination.

**(vi) Need for a strong coordination & convergence mechanism:**

Efficient water management can be achieved through the convergence of resources/programmes of various Ministries/Departments. For instance, water conservation, groundwater re-charge and rainwater harvesting practices have to be undertaken in and outside watershed development projects, with the resources of Ministries of Rural Development, Agriculture, Water Resources, Urban Development and Power etc. Enhancing the productivity of water using micro-irrigation, supplemental and deficit irrigation is possible only through combined efforts of the Ministries of Agriculture, Water Resources and Power. Effective development and management water resources calls for coordinated action plan and collaborative efforts of all concerned Ministries at central and state levels.

## **2.6. Annotation**

Amongst various inputs deployed in raising of crops, water emerges as the most critical one. Of the total water available in the country, more than 80 per cent is being used in agriculture. With increasing population density, the per capita per day availability has declined sharply from more than 5100 cu.mtr in 1951 to 1474 cu.mtr in 2015 and is estimated to further decline 1341 cu.mtr by 2025.

Climate change is likely to bring in negative impact on rainfall and temperature, both to the disadvantage of cultivation practices.

Even now, the major parcels of India's arable land remain under rainfed cultivation. While the strategy calls for increasing the area coverage under irrigation by completing all long pending medium and major irrigation projects, greater emphasis will be needed on minor and micro-irrigation structures to offer protective irrigation to rainfed crops. Soil and water conservation



technologies have to be widely deployed.

Considering the water stress in India, promoting water use efficiency by adopting crop alignment and precision irrigation is very critical. Precision irrigation powered by drip and sprinkler systems, is needed in case of all forms of irrigation – surface, lift and ground water. In fact, ground water based irrigation accounts for 60 per cent of irrigation system in India, and on account of over-exploitation, large number of blocks have turned into dark zones.

Priority attention, is therefore, needed to achieving water use efficiency to realise higher production and reduction in cost of cultivation. This can be achieved only when farmers become active participants in water management.

It is equally important, that the quality of water used in cultivation is good. Poor quality of water can dissolve organic carbon in soil and make it unavailable. Hence both soil health and water quality are important in promoting sustainable cultivation practices.

#### **Key extracts**

- With increasing density of population, the per capita availability of water / person / day has declined from more than 5,100 cu.mtrs in 1951 to 1,474 cu.mtrs in 2015 and is estimated to drop further down to 1,341 cu.mtrs by 2025 and 1,140 cu.mtrs by 2050.
- Of the total available water in the country, more than 80 per cent is being used in agriculture sector, with no further scope for additional diversion.
- Notwithstanding huge investments in irrigation infrastructure in the country, as high as 54 per cent of the cultivated area continues to depend on monsoons.
- The current water management practices are not adequate and appropriate. Knowing that water is a critical input in agriculture and India facing water stress, the emphasis should be on deployment of suitable technology (water irrigation) farm management (eg., crop alignment etc.) practices and infrastructure (eg., command area development) to achieve water use efficiency.
- The quality of water is as important as soil health in practising sustainable agriculture.



## **Chapter 3**

### **Seed**

*Seed is the most important input, and if availability of quality material and accessibility to farmers at affordable price are taken care of, productivity of various agricultural and horticultural crops will grow substantively. This chapter deals with the challenges and solutions.*

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#### **3.1. Seed - A Critical Input**

Seed is a critical input for enhancing productivity of all agricultural and horticultural crops and plays a vital role in improving the income status of farmers. Quality seeds are a key to development, without which the investment in all other inputs can come to a naught. Seeds can serve as a vehicle of production, protection and quality enhancement technologies in a single entity and in a cost effective way. Use of quality seeds alone can increase productivity by 15-20 per cent, showcasing its importance in agriculture. In a way, seeds define the maximum yield, that can be achieved, if the genetic potential is allowed to be expressed by the growth environment that other inputs like water, fertilizers (soil health/soil organic content) and cultivation practices create. The response of all other inputs is conditional upon quality of seeds to a large extent, and productivity can be further raised upto 45 per cent with efficient management of these non-seed inputs. Therefore, any attempt to enhance crop productivity will largely depend on higher replacement rate of quality seeds of high yielding varieties/hybrids of agricultural and horticultural crops.

The conventional breeding is about a hundred years old while the youngest, yet more powerful of all, bio-technology including, molecular marker assisted selection etc. is about three decade old. Improved varieties have made significant impact on output.

Sustained increase in agricultural production and productivity necessarily requires continuous development of new and improved varieties as well as hybrids, suitable for 128 agro-climatic zones of the country. This also necessitates an efficient seed multiplication system integrating plant breeding (comprising developing new varieties, production of nucleus seeds, production of breeder seed, production of foundation seed, production of certified/quality seeds), trade and distribution, and finally the farmer using the seeds. There are many stages along the seed supply chain, where things could go wrong, from breeding to testing and releasing of new varieties, seed production and distribution to farmers. The nature of services available for seed producers, the applicable legal and regulatory requirements and the business climate can also hamper the smooth operation of the seed sector.

Integrated seed sector development approach has gained maturity in Indian seed sector, and there exists a fairly robust distribution platform to reach out the seeds to the farmers. Genetic yield enhancement is the single most significant technological intervention introduced and supported by the National Agriculture Research System (NARS), consisting of ICAR institutions and State Agriculture Universities (SAUs). From the 1960s, the NARS has been continuously developing new varieties suitable for different agro-climatic regions and changing production conditions. Further the country is often affected by natural calamities of

different types viz. drought, floods, cyclone, short window of soil moisture to grow crops etc. This is getting further exacerbated by climate change. Therefore, developing climate resilient – stress tolerant varieties (drought, flood, & salt tolerant), short and medium duration varieties as also heat tolerant varieties is needed to be done continuously. Effectiveness of this requires pro-active participation of the farmers.

Some important issues relating to seed production, are discussed in the following sections, with a view to draw needed policy attention.

### **3.1.1. Quality of breeder seed**

It is very important to maintain the genetic purity of the developed varieties over generations. The variety should be maintained by a group of breeders characterised by varying ages, so that breeder seed is maintained effectively even in the absence of originating breeder. The variety will benefit better, when released in the name of group instead of an individual breeder.

Molecular markers are of high precision in identifying plant genotypes, and hold considerable promise as a reliable tool of intellectual property protection of crop varieties and germplasm. The breeding of new varieties should be encouraged, particularly of those which can replace the very old, though popular varieties like paddy (Uma, Jyothi) in Kerala and wheat (Lok-1) in MP, Maharashtra etc. Similarly the best performing varieties with low input requirement should be developed to optimize the income of farmers.

The variety released by a breeder must find farmers' acceptability in his growing environment/ conditions, particularly in the context of climate change. The relevance of the new variety must be judged by this parameter, as adoption of a number of varieties released year after year is below normal among the farmers. It is also desirable that the new variety is named in a series, as introducing new name makes it difficult for the farmers. Introduction of Swarna Sub I or IR 64 drought are such an example.

### **3.1.2. Millets and Wheat Over Rice and Wheat**

A shift to wheat, millets and maize from polished rice; and chicken and legumes along with leafy vegetables and coconut could reduce India's micro-nutrient deficiencies.

A team of researchers from Austria, the U.S. and India, headed by Narasimha D. Rao from the International Institute for Applied Systems Analysis. Austria, used the data generated by National Sample Survey Organizations (NSSO) on consumption expenditure in India (2011-12) and the National Nutrition Monitoring Bureau to examine Indian diets. The team found that, while nearly three quarters of Indians consume less than the ideal number of calories a day, and more than half have protein deficiency, the deficiencies of micro-nutrients were more prevalent. The research showed, that nine in 10 Indian are iron-deficient, 85 per cent do not meet the required intake of vitamin A and two-thirds have zinc deficiency.

The cost was clearly a concern as deficiencies were found to decrease as household incomes

increased. Surprisingly though, urban households had increased deficiencies compared to their rural counterparts (apart from vitamin A), which the researchers attribute, to greater diversity of cereals in rural areas. Having identified 32 representational diets each for northern, southern, eastern and western India, the researchers found that the rice-based diets of southern and eastern India make the people in these areas more vulnerable to micro-nutrient deficiencies than people elsewhere.

The researchers also found that while those above the poverty line can make up for this nutritional inadequacy without their food budgets being affected much, nearly 160 million people below the poverty line cannot do so without exceeding their food budgets.

They suggest that the required micro-nutrients can be met by reducing the intake of rice (from 61% to around 40% of calorie share) and meat and replacing them with nutri-cereals such as bajra, ragi, sorghum, foxtail millet etc. and maize along with legumes including groundnut, dark, leafy vegetables, and coconut.

Seed production system must bring focus on these nutri-rich crops.

### **3.1.3. Changing climate puts India at risk**

Researchers led by the University of Exeter in the U.K. after examining the nature of impact of climate change on vulnerability of different countries to food insecurity, indicate that India could be one among the more sensitive countries.

The study, published in the journal *Philosophical Transactions of the Royal Society*, looked at 122 developing and least-developed countries, mostly in Asia, Africa and South America. As per this study, the countries most vulnerability to food insecurity caused by temperature spike of 2 degrees celsius are Oman, India, Bangladesh, Saudi Arabia and Brazil, researcher said.

Climate change is expected to lead to more extremes of both heavy rainfall and drought, with different effects in different parts of the world, reports Richard Betts, Professor of the University of Exeter, in the study referred above.

Seed production system beginning with research and release of variety should address these issues relating to climate change with a view to introducing effective coping and mitigation measures.

## **3.2. Seed Delivery System**

Seed delivery in India is represented by both informal and formal systems. In spite of huge investments in infrastructure by both public and private seed sectors and supportive seed development policies of the Government, even today, as high as around 60-65 percent of the seed in use is either farm saved or un-labelled. Certified/labelled seed availability is only around 35-40 percent, which while depicting the tardiness of progress, also suggests the scope that exists for growth and development. Resolution of this lacuna in the seed system is the

critical need for achieving higher productivity. An effective and farmer-friendly model should be developed to make available to the farmers, quality seeds of improved varieties/hybrids at affordable price. In tribal and agro- biodiversity rich hilly regions of the country, farmers' varieties are still popular and this may be on account of excellent quality associated with therapeutic/medicinal value, resistance to biotic and abiotic stresses, climate resilience and some special attributes associated with these varieties. These varieties are however not in the seed chain, and efforts should therefore be made to integrate them into informal seed chain with some amount of genetic purity, by adopting special maintenance breeding methods. These farmers' varieties are important for future breeding programs, as they possess useful gene/gene blocks for certain traits. It is worth appreciating, that these varieties are the products of a dynamic evolution that has occurred naturally in the eco-system and are well adapted to the region.

An effective and farmer-friendly model through Seed Village Programme (SVP) to upgrade the quality of farm saved seeds has been in operation. Under this programme foundation/certified seed is provided at 50 per cent subsidy on cereals and 60 per cent subsidy on pulses, oilseeds, green manure seeds and fodder crops limiting to 1 acre/farmers. The farmers are also trained on seed production and seed technology at the stages of sowing, flower initiation and harvest. The quality seed produced by these farmers are used for the following three years and excess quantity is sold/shared/bartered to other farmers locally and in nearby villages. This is a useful system and can be further strengthened.

Community Seed Banks (CSBs) for promotion of local varieties and Community Nursery Banks (CNBs) for promotion of planting material in case of tree species are the best options to promote farmers' varieties. Enabling the resource-poor farmers with quality seed and suitable production technology for sustainable livelihood is a critical challenge, that should be gainfully addressed on priority. Since 86 per cent of the farmers in India are small and marginal, providing quality seeds at affordable price is also a challenge, as seeds produced by using varieties/hybrids with bio-tech traits are costly. The critical need today is cost rationalisation of certified seeds.

Forage crops are the most neglected ones and efforts should be made to integrate them into effective seed chain to support dairy and livestock sector having huge growth potential. This sector has been identified as an engine of growth in this Report. What is also needed in order to maintain high standards of seed quality is to undertake restructuring of quality assurance and quality enhancement system.

### **3.3. Assessing Seed Requirement**

Accuracy in estimating the seed requirement, would avoid undesired situations of over-production or under-production, both of which can cause serious implications. Over-production can result in non-use and sale of costly seed variety as normal seed leading to financial loss, and when under-produced farmers are deprived of quality seeds, affecting output and income. Hence, the critical importance of assessing seed requirement accurately and well in time.

It is important, that a robust seed rolling plan for successive five years based on adaptability and performance of the variety is made at district and block levels by district level and block level committees.

### 3.3.1. District level committee

The Committee in preparing the rolling plan should be guided by the recommendations of the block level committee. Other factors that should be considered are current crop coverage in different seasons (kharif, rabi and summer), productivity, seed replacement rate (SRR), varietal replacement rate (VRR), status of seed production, distribution etc.

**Table 3.1 Seed assessment committee**

1	Representative of the State Dept. of Agriculture	Joint Director / Dy. Director/ Distt. Agri Officer
2	Representative of KVK/University/ICAR Institute	Seed Technologist and subject matter specialist of major crops grown
3	Representative from seed industry(both public/ private)	Managerial Level
4	Progressive Farmer cum Seed Growers having long experience in seed production including FPOs/Cooperatives.	Two or more

### 3.3.2. State level consolidation of the requirement

A Committee headed by the Director of Agriculture can compile and consolidate total seed requirement for the State and assign the target for production to different seed producing agencies.

**Table 3.2 Compensation of the state level committee**

1	Director of Agriculture	
2	Representative of SSC/private sector	General Manager Production/Production Incharge
3	Representative of NSC	Regional Manager or Production Manager
4	Representative of Seed certification Agency	Director
5	Representative from State agriculture universities/ ICAR institutes of respective state.	Seed Technologist/Subject Matter Specialist
6	Progressive Farmers cum Seed Growers having long experience in seed production	Two or more

### 3.3.3. Block level committee

An appropriate committee may be constituted at the block level too for bottom – up seed assessment plan. This committee should also be guided by various factors suggested above in

preparing block level rolling plan.

It is important that, the State Department of Agriculture executes MoUs with reliable Seed Producing Organisations (SPOs) for assured supply of seed. The selection of these organisations can be based on following norms.

- Organizations with own seed production and seed processing facilities.
- Adequate infrastructure for quality control (laboratory, GOT facilities etc.).
- Adequate technical manpower at field level to produce required quantity.

#### **3.3.4. Basis of assessing seed requirement**

The following are suggested:

- Dynamic Seed Rolling Plan be prepared based on the existing crop-wise area in kharif, rabi and summer seasons, seed rate per hectare used, desired/targeted seed replacement rate, total crop-wise quantity of seed required etc. It should also take into account the national and state strategy on agri-commodities (eg, the nation may target to achieve self sufficiency in pulses or reduce import of edible oils etc), climate change etc.
- For each crop, variety-wise quantity of seed required be worked out based on the existing/previous year's variety-wise seed production and distribution, plus new varieties released & notified during the last year and its likely expected/anticipated potential area coverage. Also, identify the poor performing varieties & area (yield, pest & disease, quality, duration etc.) which can be replaced by alternate varieties or new varieties, based on pre-season deliberation.
- Target variety-wise quantity of certified/quality seed to be produced and distributed. For each variety, quantity of seed production and distribution targets be given to all the seed producers in both public and private sectors.
- Place the breeder seed indent of Central varieties with the Seeds Division, Department of Agriculture, Cooperation and Farmers' Welfare (DAC&FW) and State varieties with State SAUs.
- Arrange and produce variety-wise required quantities of foundation seeds for organizing certified seed production.
- Monitor variety-wise breeder seed indent, allocation & lifting; foundation seed production; and certified/quality seed production at the state level.
- Map the cultivable area in the country to maximum crop productivity.
- Identify recently released and better performing varieties that meet the specific needs of the locations.



### **3.4. Seed Production and Supply Chain**

All the seed producing agencies should target at least 25 per cent more than the demand assessed by State Committee to safeguard against possible production losses due to unforeseen situation. This will secure supply of seed quantity as projected under dynamic Seed Rolling Plan (MoU), even under unfavourable conditions. Selection of right seed growers is also very important in seed production. Training of seed grower in good agronomic seed production practices and certification requirements and practices like isolation distance, moisture content at the time of harvesting etc., will help in production of quality seeds. It is also desirable, that the list of seed growers is uploaded on the website by Seed Certification Agencies and Seed Producing Companies for each of monitoring. In case of truthfully labelled (T/L) seeds also, the information should be submitted to the State Agriculture Department and Enforcement Agencies.

A robust seed reserve scheme is needed to compensate for quantity of seeds converted into non-seed use, and to account for cost variations in procurement etc. To ensure procurement of quality seeds, all the procurement costs must be paid into the account of seed growers.

The country is often affected by natural calamities of different types. While, planning/preparing for seed rolling plan, the seed requirement for contingency plan should also be included in the seed production target based on the previous years' occurrences/experiences. The drought prone, flood prone, cyclone prone and other calamities prone districts/states need to be more vigilant in advance planning & execution and producing the required crop variety seeds through various seed producing agencies. The states must create 'Seed Reserve' based on past trends of natural calamities to meet situations of contingency. There is some hesitancy on this score, as the states may incur financial loss when the reserve is not put to use when no contingent arises. The Central Government may offer to compensate a certain percentage of loss in this context as an incentive.

### **3.5. Breeder Seed Production and Varietal Status in Seed Chain**

Breeder seed is the basic seed needed to initiate effective seed chain for ensuring production of desired quantity of certified/quality seed at the farm level. The Indian Council of Agricultural Research (ICAR) and State Agril Universities (SAUs) are mandated to produce breeder seeds of varieties released and notified for more than one state in pursuance of Section 5 of the Seed Act 1966, as per the indent of the Department of Agriculture and Co-operation and Farmers Welfare (DAC&FW), Government of India. The breeder seed indent for varieties notified for specific state is directly submitted to the concerned State Agricultural Universities (SAUs)/Organizations by the State Director of Agriculture, State Seed Corporations, Seed Cooperatives, NSC, NAFED, KRIBHCO, IFFCO, HIL, NFL and other Private Producers.

The Seed Division of the Ministry/Department of Agriculture collects breeder seed indents of about 38 general crops (paddy, wheat, maize, bajra, sorghum, ragi, barley, kodo, kulthi, foxtail millet, arhar, urd, moong, cowpea, moth bean, horsegram, gram, lentil, peas, rajmash, soyabean, groundnut, til, sunflower, safflower, niger, castor, rape seed & mustard, toria, cotton,

jute, sunhemp, fodder jowar fodder, bajra fodder, maize, oats, cowpea, lucerne, berseem etc.) of kharif, rabi & summer seasons consisting of about 1352 varieties (as of date) from various seed producing states / agencies (public and private) and forwards it to ICAR after screening and compilation to organize breeder seed production. Similarly, the indents of vegetable crops are collected and forwarded to ICAR.

ICAR finalizes the production programme in respective All India Crop Workshops and organizes production through State Agricultural Universities and its Research Centres. Project Directors / Project Coordinators of ICAR Centres thereafter send the breeder seed production report, and Seed Division makes the allocation of breeder seed based on indents and production reported by ICAR for downstream activities. In order to ensure proper utilization of precious breeder seed, Seed Division, regularly reviews the lifting and its multiplication into foundation-certified seed at Zonal Seed Review Meetings. What is now needed is a more granular level of review, wherein crop and varietal alignment with the varied agro-climatic conditions of the country is addressed.

Assessment of the total quantum of breeder seeds required as per crops, varieties and seasons, and production form the basis of producing the final requirement of certified seeds at farmers' level. Hence, this stage is the most critical one in the seed chain. ICT based assessment and review is needed. Also, coordination among the 3 main organisations, namely, the States/UTs, DACFW and ICAR is of utmost importance.

### **3.6. Impact of Climate**

#### **Impact on seed quality and quantity**

Seed quality comprises several parameters, viz. physical and genetic purity germination, viability, vigour, health and appearance (size, shape, weight and colour) of the seed. Each of these parameters depends on climatic variables prevailing during the entire period of crop growth, and the subsequent seed processing environment. If climatic factors are adverse during crop growth period, seed production is affected. For example, water stress during grain filling stage will result in poor quality of seed, as also the yield level. Further, climatic vagaries such as cyclones, untimely rains, hailstorms severely affect quality of seed produced. To meet the shortfall in production, compensator seed production in Rabi-Summer/Zaid seasons must be pressed into service. In such cases, provision for reimbursement charges will also have to be made, besides ensuring crop insurance to cover such risks. This will incentivise the state governments and seed producers, since likely loss is covered in varying degrees.

#### **3.6.1. Production of abiotic & biotic stress tolerant varieties**

The implication of climate change like change in temperature and rainfall distribution can result in poor performance of existing varieties. Research and development will now need to focus on developing varieties which can perform well under situations of biotic and abiotic stresses. Further, they need to be integrated into the seed production chain.

### 3.7. Improving the SRR, VRR and SMR

#### 3.7.1. Present status vs future prospects

Keeping in mind the genetic purity of seed the following seed replacement rate (SRR) has been proposed.

- i. Self pollinated crop – 33 per cent of seed is to be replaced after every three years, as in case of self pollinated crops the seed will remain pure in two successive generations, provided further, that proper care is taken by the farmers.
- ii. Cross pollinated crops – 50 per cent of seed is replaced in alternate years. Due to cross-pollination, chances of admixture are high. Alternate year replacement will help in harvesting the full genetic potential.
- iii. Hybrids – 100 per cent of seed is to be replaced every year, degeneration of FI vigour happens in successive generations.

**Table 3.3 Seed Replacement Rate (SRR) – Projection as per current and future requirements**

Crop	2016-17		Projected by 2022	
	Present SRR	Requirement	Project SRR	Requirement
Wheat	40.3	117.5	41(50)	123(145.78)
Paddy	39.8	87.74	40(50)	88.18(110.23)
Barley	30.2	2.44	33	2.67
Maize	64.6	12.47	100	19.3
Sorghum	38.2	2.82	45(100)	3.32(7.38)
Bajra	57	2.36	60(100)	2.48(4.14)
Moong	33.5	2.68	35(50)	2.8(4)
Urd	37.9	2.67	40(50)	2.82(3.52)
Arhar	33.5	2.71	40(50)	3.23(4.04)
Gram	31.8	17.65	33	18.32
Soyabean	38.1	29	40(50)	30.45(38.06)
Grounut	25.2	23.48	33	30.74
Mustard	68	2.49	80(100)	2.93(3.66)
<b>Total</b>		<b>306.01</b>		<b>329.24(391.78)</b>

The seed replacement rate has been proposed on higher side keeping in view the importance of replacing old varieties in case of some self-pollinated crops which have continued to rule beyond the threshold limits of prescribed age. If the export potential can be harvested, the projected requirement will go up further. India can become a robust exporter of various crop seeds to countries that are similar to India's climatic conditions.

#### 3.7.2. Varietal Replacement Rate (VRR)

Over the last few years, SRR has improved across crops and regions. Yet, the levels of yield enhancement are not impressive. The strategy for higher production and finally higher farm incomes is dependent on achieving higher per ac/ha yields. As discussed in the preceding section, the crop is vulnerable to a number of biotic and abiotic stresses. Hence, varieties that

can negotiate these stress situations and also are genetically designed to yield more will have to be promoted.

It is seen that in many states and in case of several crops old varieties are continuing to rule. Globally, seed life is 5 years, and in India 10 years is the norm. In reality, however, requests for continuation of varieties beyond the threshold norms is acceded to for coverage under Crop Development Programmes (CDPs) of the governments. This is indicative of the failure of acceptance of new varieties notified by the NARS. The reason for failure could be, that research claims are not true or/and the extension machinery has not succeeded in popularizing the new varieties.

It must be recognised, that SRR and VRR need to march as a couple, if the low yield averages across the crop cafeteria are to improve.

Alongside denying permission for coverage of beyond age norm varieties under Seed Production and CDP, suitable replacements must be demonstrated to the farmers for appropriateness and popularise them.

Seed Multiplication Ratio (SMR) holds the final key in reaching out desired varieties and targeted quantities of the crop cafeteria to the farmers across the country. The ratios of multiplication of the seed variety down the seed chain between 'Breeder Seed' and 'Certified Seed', at each of the stages should be ensured.

### **3.7.3. Production of certified seeds**

- All the State Seed Committees should prepare rolling seed plan for specific season(s) and crop(s) depicting targeted SRR and variety-wise requirement of certified seeds, for production under both normal as well as contingent situations like drought, flood, cyclone etc.
- The states should share their seed production will in time all the seed producers, viz, State Department of Agriculture, NSC, SSCs, SAUs, Co-operatives, KRIBHCO, NAFED, NFL, HIL, FPOs, and private seed industries etc. This will help these agencies to plan and execute their production strategy.
- States should execute MOUs (Memoranda of Understanding) with seed producers for production and supply of the required quantities of certified seeds crop, season-wise and year-wise, so as to ensure their timely availability. During the last six years (2012-13 to 2017-18), certified/quality seed production has increased from 328.58 qtls. to 419.41 lakh qtls. but there are a lot of mismatches in varieties. This can be rectified through advance and diligent planning.
- Seed producers and states should chalk out the requirement of breeder seed and foundation seed as per the seed plan and place requisitions with the DAC&FW and concerned organization respectively.
- States should ensure that the seed produced under the MOUs is distributed through DBT (Direct Benefit Transfer) by the seed producers subject to fulfillment of quality standards.
- All the states should monitor and review seed production at the field level, by taking note of actual rainfall received, water stress, and production estimates etc.

- States must review objectively contingent situations arising and accordingly plan seed requirements for inclusion in the seed plan and National Seed Reserve. Due cognizance may be given to fodder and green manure crops in both seed plan and contingent planning.
- All states must make efforts to produce seed or to get the seed produced within the state through all credible seed producers having technical competence, sufficient seed infrastructure facilities, experience and efficiency in seed production. It is not advisable to depend on one or two agencies and it would help to promote more FPOs, SHG, CIG etc. for seed production.
- States must ensure increase in SRR (Seed Replacement Rate) and VRR (Varietal Seed Replacement). Close coordination with ICAR-SAUs is necessary for bringing newly developed varieties into seed production chain.
- States which do not take up seed production as per the seed plan and which do not purchase the contracted quantity of seed from the seed producers as per MoU, must be held accountable in some way.
- States should take up certified seed production of the latest varieties/hybrids, as and when released and notified.
- All Seed Producing Agencies must arrange to procure seeds immediately after harvest of the crop to avoid non-supply by the producing farmers/organizations, which is probable in the event of increase in the prices of the crop in the market.
- The strength of the certification staff has not been increased over the years in proportion to the increase of seed production requirement. One way of adding staff strength to do this is by hiring final year agriculture science graduates from the Universities, for which course calendar may be modified to enable their participation.
- States to also focus on crops, whose production may have been impacted during the current year due to deficiency in rainfall. Demand for seeds of such crop in the succeeding year could be high.
- Seed Certification Agencies should not extend procurement period and should stick to the scheduled timeline.
- States which are not generally availing the facilities under Seed Village Program may be motivated to do so.

### **3.8. Strategies for Energising Seed Production and Supply Chain**

A systematic, strong and vibrant seed production system is essential for food security of the country. It also serves as a driver of growth in agriculture. Enabling the resource-poor farmers with quality seed and its production technology is still a challenge, that needs to be focused upon. Seed production chain involves several stakeholders, primarily the NARS (National Agricultural Research System) i.e. ICAR-SAUs, DAC&FW of GoI, Departments of Agriculture in different States, State Seed Corporations, National Seeds Corporation, NAFED,

KRIBHCO, HIL, NFL etc. A networked and work flow based operation is required among these stakeholders. Due attention is needed for production of breeder seed and its conversion into downstream classes i.e. foundation and certified seeds under assured irrigation and good agronomic practices.

The State Seed Committees may prepare seed rolling plan upto 2022-23 by identifying region-wise varieties, assessing yearly seed requirement, ideal seed replacement rate and gradual annual increase. Appropriate MoUs should be entered into among different stakeholders for firm commitments of procuring the seed, thus mitigating the problem its non-lifting. Then realistic indents for breeder seed along with token advance should be placed with the concerned organization responsible for developing/sponsoring a variety, at least one year in advance. In recent years, the climate change has been adversely impacting agricultural production in the country and the seed production programme is not an exception. Therefore, there is an urgent need to identify non-traditional season/areas for compensatory seed production. Attendant technologies and agronomic practices needed for such non-convention production plan must also be taken care of.

### **3.8.1. Effective input management in seed sector**

- Input management with respect to quality and cost is critical to regulate the cost of cultivation.
- Seed is the true carrier of technology. In India, three sets of institutions produce seeds: research institutions and agricultural universities; public sector seed producing corporations; and private sector firms including multinationals.
- One of the serious factors responsible for low use of quality seed is sale of spurious seed in the market. In order to raise productivity, there is a need to supply and promote use of quality seed among the farmers. The seed supplying agencies have a prime responsibility of assuring the farmers of seed quality. Hence, the need for a strong and effective enforcement.
- Some important initiatives have been taken under the recently amended New Policy on Seed Development. The policy permits 100 per cent foreign direct investment (FDI) under the automatic route and simplifies the procedure for inclusion of new varieties in the Organization for Economic Cooperation and Development (OECD) Seeds Scheme. The thrust is also on creating a National Seed Reserve. Since 2013-14, a Seed Rolling Plan has been in place for all the States for identification of good seed varieties and agencies responsible for production of seeds. This needs to be pursued for effectiveness.
- Several steps need to be taken to improve the quality of seeds used by farmers: Sometimes prices of good quality seeds, especially hybrids, are high and farmers are unable to afford them. ICAR & SAUs should own responsibility to produce hybrids in collaboration with Farmers Seed Producing Organization (FSPO) on large scale and supply them to farmers at affordable price.
- Creating Community Seed Banks through FSPO in producing areas can reduce

dependence on market for seeds. The seed banks not only can protect the existing crop varieties but also ensure supply of seeds to the farmer to meet contingency.

- Proper storage of seeds is essential to get satisfactory germination. All SAUs/CAUs and ICAR Institutes should set up seed storage structures for various agricultural and vegetable seeds and offer cost effective services to the farmers. They may also work on upgrading the indigenous storage systems in the rural areas.
- Huge demand-supply gap exists in case of forage seed. This is a major cause of concern for development of dairy sector in the country. ICAR, SAUs, State Animal Husbandry Department and Public Sector Seed Agencies should come forward to produce the forage crop seed varieties bred in the public sector in collaboration with FSPO and Dairy Cooperatives/Dairy Federation on large scale and supply to the farmers at affordable price.
- Regulatory measures for quality seed production have to be tightened so as to discourage sale of spurious seeds to farmers. The seed companies should be made responsible for poor performance of seed supplied by them. The details of seed traits should be displayed on seed packages and agency website. The seed companies should provide adequate compensation package for farmers in case of general failure of their seeds. Research institutions must develop rapid testing kits for seed hybridity to allow quick seed testing, thus, enabling the detection of spurious seeds at the time of sale.
- By and large enforcement in the states is weak. A robust enforcement system for various inputs including seeds, fertilizers, pesticides etc calls for well trained and adequately staffed manpower, laboratories for testing of standards, deployment of I.T Apps for track and trace etc. It is suggested that a separate Directorate of Enforcement is established by all the States/UTs with a mandate to cover all inputs, letting the Directorate of Agriculture, Horticulture, Animal Husbandry, Fishery etc to concentrate on development and extension.
- In order to improve the quality of farm saved seeds (60-65%), Seed Village Programme being implemented from year 2005-06 onwards needs to be upgraded for better monitoring. The targeted 500 number of Seed Processing and Godown at the Gram Panchayat level by 2022 will strengthen seed production system. This target can further be enhanced by another 500.
- To reduce the seed cost and get maximum seed yield per unit area, all the seed producers in both public & private sectors may adopt scientific agronomic practices including subsoil drip, raised bed planting, ridge and furrow method sowing, precision farming, micro-irrigation etc.
- By following improved irrigation methods, one can double the irrigated area with the existing water availability. Further, seed producer may also adopt SRI, SWI, DSR in seed production of paddy, wheat, ragi, bajra, jowar, maize, pulses & oilseeds etc.
- Seed subsidy for high yielding variety/hybrid seeds under various crop development programmes of GOI and States may be provided to the farmers only once in 3 years a

particular variety, so that maximum number of farmers gain access to newly developed seeds. Further, subsidy may be transferred through DBT.

- At the time of supply of breeder seed, crop specific proven package of practices for each variety may be provided to the seed producers, so as to enable them adopt the same in seed production. This information may also be hosted on the portals of all the stake holders.
- At the time of release of new crop varieties seeds with specific recommendation on top screen aperture size and bottom screen aperture size should be mandatorily shared, so that all the seed producers and farmers can follow appropriate screen size for grading their produced seed.
- Crop variety-specific hand sieve/spiral grader may be provided to farmers for grading their farm saved seed and preserve/store it, till next sowing season. This will empower the farmers to be self-reliant relating to seed requirement.
- More number of varieties tolerant to drought, flood & salt, initial heat, midterm heat, and terminal heat need to be developed. Further, develop varieties that are short & medium in duration and are photo-insensitive.
- Adequate production of forgotten crops (like millets), horticultural crops (like vegetables & flowers) must gain due attention.

### **3.8.2. Seed vision**

- Enhance seed replacement rate of all self pollinated crops like paddy, wheat, ragi, barley, kodo kutki, foxtail millets, urd, moong, cowpea, gram, lentil, rajmash, peas, lab-lab (averai), groundnut, sesamum , safflower, niger, to 33 per cent by 2022-23.
- Enhance seed replacement rate of all cross pollinated crops like jowar, bajra, sunflower, arhar, castor and cotton to 50 per cent by 2022-23.
- Enhance seed replacement rate of hybrid maize and hybrid cotton to 100 per cent by 2022-23.
- Increase the use of new varieties and chase a targeted varietal replacement rate.
- Establish a robust seed production systems encompassing the spectrum of crops across agriculture and horticulture sub-sectors.
- Empower the farmers to produce & store quality seed and improve the quality of farm saved seeds.
- Weed out all old varieties with suitable new releases as substitutes.
- Promote seed production activity as an enterprise for youth and identify hubs across the country based on agro-climate and crop suitability. All needed backward and forward linkage infrastructure may be provided at these hubs.
- Seed production should be undertaken for both domestic and export markets.



### 3.8.3. Strategy

- **To increase the use of new varieties**

Under All India Coordinated Research Projects on-farm field trials of varieties should be undertaken simultaneously from the 3<sup>rd</sup> year to assess suitability for cultivation use, farmer's acceptance of the new varieties as discussed in below:

The Breeder gives the potential seed material for multi-locational field trials under All India Coordinated Research Project (AICRP). The process then involves:

Year 1:	Initial Evaluation Trial (IET)
Year 2:	Advanced Varietal Trial (AVT) – 1 (multi-locational trials happen at the same place as in IET)
Year 3:	AVT - 2 (multi-locational trials happen at the same place as in AVT – 1)

In order to save on time, it is suggested that parallel to AVT-2, NARS may undertake on-farm varietal trials. This will help in expediting the process of acceptance of the new variety to be release among the farmers.

Further, acceptance can be brought about by undertaking frontline demonstrations, supporting farmers through seed mini kit distribution etc.

- **To increase SRR – strategy for timely availability of seeds**

At the time of release and notification of the varieties, minimum prescribed quantities of breeder seed availability be ensured by the breeder. This should be followed by a systematic seed production plan, large number of frontline demonstrations (FLDs) and intensive extension for popularizing the new varieties among the farmers.

Ensure systematic seed plan for new varieties.

### 3.9. Seed Processing and Storage

The seed processing should be done at processing plant. Establishment and up-gradation of seed processing and storage plants is required with advanced equipments / tools with scientific support. Agriculture system is such, that seeds produced in one season or year will need to be stored for short period of time until next sowing/use. Adequate and appropriate storage infrastructure will therefore have to be made available. Other infrastructure like creation of scientific threshing floors and mobile seed processing plants can be established. For high value crops and left over seed, cold storage facility is to be created and new technology of storage is to be introduced.

In addition to static seed processing plants, mobile processing facilitates may also be promoted. This will benefit small & marginal farmers.

### **3.10. Seed Distribution**

The farmers are to be made aware about latest technologies like new planting equipments and new varieties suitable for their area by the State Extension Machinery. The extension activities need to be strengthened for popularisation of new varieties. All the seed producing agencies under public and private sectors be encouraged to the location-specified HYV seeds/Hybrids to the farmers. The seed subsidy available under various crop development programmes be used effectively and should be provided to the farmers only through DBT. The seed subsidy for the same variety be provided to the farmer once in three year only, so that maximum number of farmers gain access to newly developed HYV seeds. For popularization of newly developed varieties, seed mini kits demonstration be organized by all the seed producing agencies themselves for assessing their performance, getting feedback of farmers and estimating potential.

### **3.11. Focus on Seed Chain of Vegetable/ other Horticulture Crops**

#### **3.11.1. Monitoring of horticultural crop seeds by Seed Division**

Presently zonal seed review meetings are being organised by Seed Division of the DACFW with state governments to assess seed requirements of foodgrain, pulses, oilseeds and fibre etc. There is no such monitoring of production & distribution of vegetable seeds. There is total dependence on private sector seed. It will be desirable that all the public sector seed corporations are mandated to produce vegetable and flower seeds, that are bred and released through NARS comprising ICAR and SAUs.

#### **3.11.2. Supply of breeder/foundation seed of vegetable crops**

Like breeder/foundation seed of foodgrains, pulses, oilseeds and fibre etc. the seeds of vegetable crops varieties/hybrids should be provided to NSC, State Seed Corporation, NAFED, KRIBHCO, NFL, HIL, IFFDC and private sector for production & distribution. Presently, the varieties/hybrids developed by ICAR-SAUs system are being given to private sector seed companies by charging nominal rates of royalty. The breeder seeds are not being given to public sector seed producers as per para 2.3 & 2.4 of NSP 2002 creating in result a monopoly situation in vegetable seed production and distribution dominated by private sector, the farmers are not getting vegetable seeds at reasonable price. Having charged royalty on the private parties, ICAR loses its control over the prices of seeds produced from such breeder/foundation seed. These seeds are being sold by private seed companies in their brand name at high prices. By providing breeder seeds on cost basis to public sector seed organisations, they may be able to produce vegetable seeds in large scale and provide to farmers at reasonable price. ICAR-SAUs should also provide variety-wise package of practices for vegetable seed production and technology, alongwith breeder seed to all the seed producers.

### **3.12. Focus on Nutri-cereals**

Millets which have been native to India since centuries have lost their prominence over the last few decades yielding space to paddy and wheat. Since millets are climate resilient and nutrition rich, it is necessary to promote them. The key to millet promotion lies in building a strong seed production chain.

### **3.13. Pilot Model Seed Platform:**

Of all the seeds, 35-40 per cent are purchased annually from the organized sector, while 60-65 per cent is produced by the farmers themselves including under the seed village programme and is exchanged or traded with neighbours or in local markets.

In addition to the existing seed dealers and retailers, the quality seeds produced annually in the seed village programme is about 100 lakh qtls. An additional target of 25 lakh qtls. has been planned by promoting 500 GP level Seed processing-cum-godown facilities. This is expected to be achieved by 2020-21 and FPOs will be expected to own responsibility. This is a good initiative and can be further strengthened, bringing particular focus on weaker crop segments.

In the private sector, there are 624 number of seed companies, who have received backended subsidy. Their processing capacity is 168.18 lakh qtls. and seed storage capacity stands at 54.34 lakh qtls. With the Government's commitment to developing number of retail agriculture markets, there would be a good platform to sell quality seeds to the farmers.

### **3.14. Scope for Seed Export**

#### **3.14.1. Production potential**

India is bestowed with tropical, sub-tropical and temperate climates, that enable production of all kinds of crops for seed purpose. This is a unique advantage. For seed quality assurance, fairly a good network of 25 State Seed Certification Agencies and 126 notified seed testing laboratories exist in the country. In both public and private sectors, ISTA accredited labs exist which can issue ISTA-Orange International Certificate to facilitate export of seeds. Since October 2008, India is a member of OECD (Organisation of Economic Cooperation and Development) which provides an international framework for the certification of agriculture seed in international trade under its umbrella. India has enlisted over 160 varieties in 37 crop species of five (5) OECD schemes. There exists scope for export of several of these seed varieties. India is also a member of ISTA which supports the export of seeds to neighbouring countries and Africa. Simplification of export procedure will encourage farmers to take up seed production for export, and earn good foreign exchange for the country. More importantly, this avenue will create job opportunities in the rural areas and additional income for the farmers. Seed production hubs may be created as discussed in see 3.8.2.1.

#### **3.14.2. Potential areas for seed export**

Africa majorly imports seeds from U.S. & Europe, but they do not perform well because of prevailing tropical climate in African countries, which varies violently from the temperate climate of these exporting countries. Indian seed industry should explore opportunities for exporting various crop seeds to African countries as both the continents experience similar tropical and sub-tropical climates, and Indian seeds are more likely to be accepted. The potential export destinations are Kenya, Zambia, South Africa, Zimbabwe, Tanzania, Ethiopia & some East African and West African countries (sorghum, bajra, paddy, maize, cotton, sunflower, pulses and all vegetables seeds). The SAARC-region has huge potential market, for example, varieties that are suitable in Punjab, West Bengal southern, northern and eastern India

are found well adaptable in Afghanistan/Pakistan, Bangladesh, Sri Lanka and Nepal/Bhutan respectively. Similarly other Asian countries like Indonesia, Cambodia, Vietnam and Thailand are also potential export destination countries from India may also be explored.

### **3.14.3. Export promotion of seeds & other agriculture product**

It is suggested, that an Export Promotion Wing may be set in Indian Embassies of export destination countries manned by a professional with domain knowledge, so as to promote Indian seed varieties in these countries. Seeds can go along with other material components, that can be offered to African and SAARC countries as an aid in kind or as part of trade. This can become integral to establishing good country to country relationships.

### **3.15. Use of ICT- Real Time Data**

The use of Information and Communication Technology (ICT) can be fruitfully deployed in seed production across nucleus seed, breeder seed, foundation seed, certified seed, labelled seed to trace real time data on the whole seed chain, and also to trace the quality of seed that is made available to the farmer. This will also give the available status of these seeds upto retailer level. There are many stages along the seed supply chain, where things could go wrong. ICT will be helpful in tracking all the activities and identifying the problems in good time for required interventions.

### **3.16. Annotation**

Seed is the seed of growth in agriculture. With its ability to integrate production - protection - and quality-centric technologies by way of genetic capability, it is the single most potential source of achieving sustainable productivity. Hence, at both research and policy levels, seed sector should get the highest attention. While Indian seed sector has been well supported by a legal framework and seed production has evolved robustly, there is much that as yet needs to be done.

There is an urgent need to take note of various challenges, that have emerged in the form of biotic and abiotic stresses. Greater certainty of climate change with its implications on seasonality and cropping system that describe Indian agriculture has compounded the already existing challenges. Hence, the need for appropriate R and D for releasing suitable varieties.

Further, the Green Revolution technology has not been secular across crops, sub-sectors and geographies. The seed production system has concomitantly suffered bias too. It is time to correct and bring universal character by greater emphasis on forgotten crops (eg. Millets) and horticultural crops (eg. vegetables, flowers).

It is time to adopt a robust seed production plan based on 'Rolling Seed Plan', influenced by SRR (Seed Replacement Rate), VRR (Varietal Replacement Rate) and SMR (Seed Multiplication Ratio). It is also necessary to decentralise and broadbase the seed production platform by roping in SHGs, FPOs, VPOs, youth-entrepreneurs, contract-farming etc.

Quality of seed and affordable price are another set of requirement and an institutional system needs to be put in place. Exports should become an integral component of seed production system considering India's capabilities and potential.



## Chapter 4

### Pest Management

*Pests and diseases affect crop yields and output and pest management to protect crops, adds to the farmers costs. To minimise cost of cultivation and ensure pesticide residues below threshold norms, pest management needs to be carried out in efficient and effective manner, having selected the treatment judiciously. In this context, alternate methods to manage pests including early warning system & preventive measures are important considerations. Regulations also impact on availability, choice, cost competitiveness and quality of pest control systems offered to the farmers.*

#### 4.1. Introduction

The Agriculture sector is prone to various risks or threats, and pests represent one of them. These pests can be plants or animals that can carry/cause disease and destroy crops. They can be insects, virus, bacteria, rodents, etc. that are detrimental not only to agricultural produce but also to other living beings. Based on the degree of damage they cause, the frequency of their occurrence and their behavioural characteristics, they can be segregated into key/occasional/migratory/potential pests.

The level of infestation can be influenced by ecological, economic and cultural changes. The damaging effects of insects on cultivated plants could be both direct and indirect. The direct effects consist of physical damage from chewing, piercing and sucking; whereas, the indirect effects lead to lowering the quality and quantity of plant products, besides transmitting disease. The loss due to pests can be broadly classified into two groups i.e. pre-harvest and post-harvest. The cumulative effect thus is the cost involved in preventing the potential crop damage and the consequential monetary loss.

#### Changes that influence level of infestation

##### 1. Ecological changes:

- Large scale agriculture which provides abundant supply of food
- Planting of highly nutritious crop varieties
- Planting of yield crops
- Water irrigation, etc.

##### 2. Economic and cultural changes:

- Change in cropping system eg. mono-cropping
- Change in value of crop can make a pest that is of insignificant important to be highly important

In the light of above, plant protection strategies become indispensable for a good crop production. These strategies consist of both chemical and non-chemical alternatives. In India, the farmer's crop yield losses range from 15 to 25 per cent owing to the presence of weeds, pests, diseases and rodents. Even though pesticides could be inevitable for protecting crop yields, per hectare pesticide use is much lower in India in comparison with other countries. India uses a low average of 0.5 kg per ha of pesticide compared to 7.0 kg per ha in the USA, 2.5 kg in Europe, 12 kg in Japan and 6.6 kg in Korea. However, averages by themselves do not give a true picture of the field. Within India, there exist wide variations between regions, crops and across irrigated-rainfed status. The intensity of pesticide usage is high in case of certain crops, particularly when raised in irrigated systems. Further, among the varied inputs, such as pesticides, seeds, fertilisers, etc., pesticides alone account for a large share of the expenditure for all major vegetables, oilseeds, major pulses, flowers, paddy, cotton, and many other crops. It is also noteworthy, that pests are a major reason for crop losses, next only to weather vagaries,

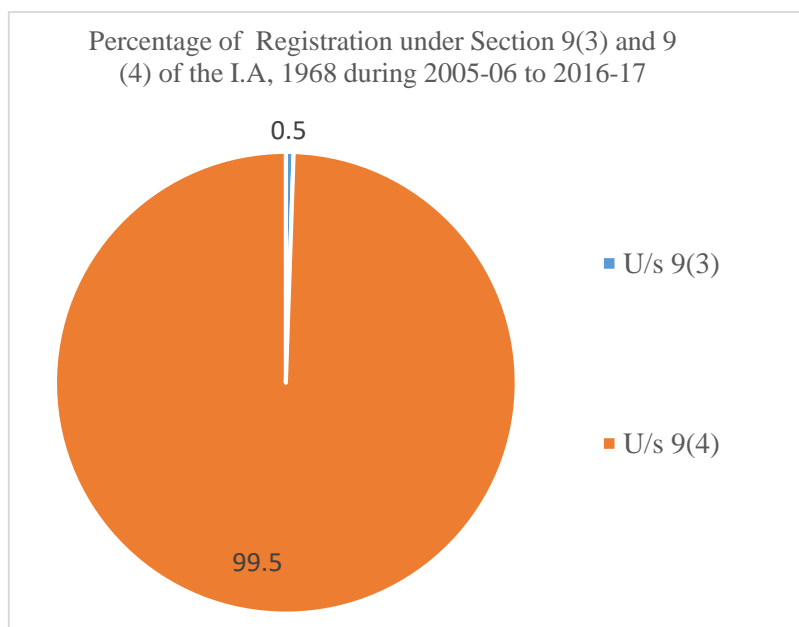
making it an extremely important component to be addressed in developing strategies for increasing farmers' incomes.

The impact of climate change on pest behaviour is another aspect to be taken into account. In order to counter such new challenges, new technologies may be introduced that may prove effective in the short run but care should be taken to assess long term solutions for sustainability over a substantial period. A short term answer may lead to a new problem e.g. some GM (Genetically Modified) crops may intend to solve a particular type of pest or category of pests, but can give rise to secondary pests which may prove more detrimental to the crop. Chemicals and non-chemical systems used, can also impact on health and safety of other flora and fauna, including humans. It is, therefore, important that any technology offered as a solution is comprehensively examined before it is introduced. Certain regulation is deemed necessary in regard to pest management systems.

The Government enacted Insecticides Act (I.A.), 1968 regulates import, manufacture, sale, transport, distribution and use of pesticides so as to prevent risks to human beings, animals and matters connected therewith. The Act is supported by Insecticides Rules, 1971.

**Insecticides Act (I.A), 1968:** Under I.A, 1968, insecticides are mainly registered under sec 9(3) and sec 9(4). Under sec 9(3) new molecule and formulation are being registered whereas under sec 9(4) registrations are granted for already registered insecticides (also known as 'Me Too').

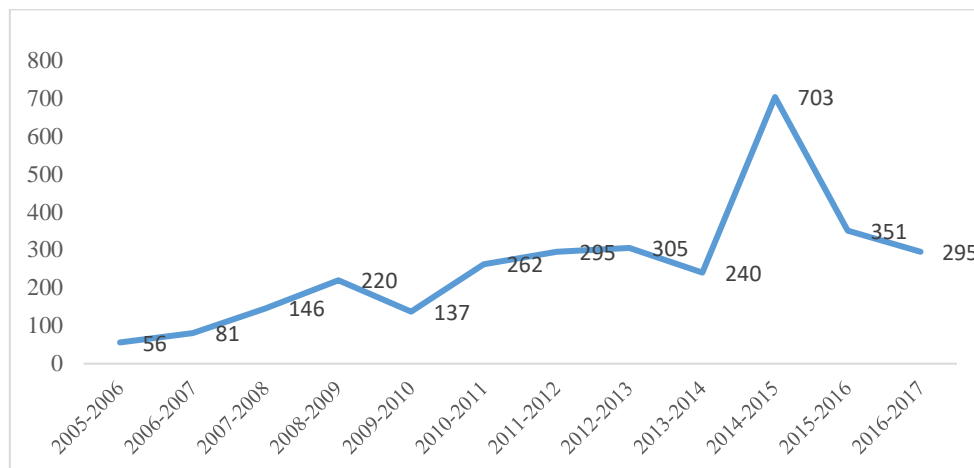
**Figure 4.1 Registration of Pesticides (2005-06 to 2016-17)**



The above figures, indicate negligible registration of new molecules, inferring that there exists a lack of domestic R&D activity. The number of Bio-pesticides registration during the same period is as follows:



**Figure 4.2 Total number of Bio-pesticides Registered (2005-06 to 2016-17)**



Implementation of the provisions of the Act is the responsibility of both, central and state governments. The central government is responsible for registration of insecticides, whereas, the state governments are responsible for licensing, and enforcement of the provisions relating to manufacture, sale, transport, distribution and use of pesticides. Both central and state governments are jointly responsible for quality control.

## 4.2. Challenges

As mentioned above, the share of pesticide costs in the total cost of production is high. Therefore, any attempt to increase farmer's income must also dwell upon interventions required to reduce expenditure incurred on pesticide. It is pertinent to highlight the challenges to be negotiated, if expenditure on pesticides is to be checked. These are:

- i. Quality of pesticide
- ii. Optimum application of pesticide
- iii. Popularising IPM techniques
- iv. Price of generic pesticides & monopolistic practices

### 4.2.1. Quality of pesticides

The sale of spurious and misbranded pesticides is one of the biggest challenges faced by the agriculture community. The spurious pesticides are inefficient in treating the concerned pests, leading the farmers to apply them in proportions greater than prescribed by the Registration Committee (RC). This not only increases the expenditure but also engenders repercussions detrimental to the crop, human health and environment. As per the Insecticide Act, 1968, the quality control of pesticides is a shared responsibility between the Centre and the State, and therefore, both must coordinate their efforts for efficiency and effectiveness.

At present, there exists one Central Insecticide Laboratory (CIL), and two Regional Pesticide Testing Laboratories (RPTLs) in the country with an annual testing capacity of 4,700 samples. In addition, there are 68 State Pesticide Testing Laboratories (SPTLs) with an annual test capacity of 73,547 samples. There exist wide inter-state variations in the number of SPTLs. Tamil Nadu (15) has the highest no. of SPTLs followed by Rajasthan (6), Karnataka (6), Andhra Pradesh (5), Maharashtra (4), Uttar Pradesh (4), Haryana (4) and so on, whereas, States like Bihar, West Bengal, Chhattisgarh, Assam, Madhya Pradesh and Odisha have only one

## SPTL.

A comparison of the annual test capacity of all the state laboratories with the total number of registered pesticide dealers, throws up a very disquieting picture. As of 2016-17, there were 2,17,407 number of registered pesticide dealers, whereas the annual test capacity was just 73,547 samples. Therefore, it can be inferred that annual capacity is highly inadequate. Ironically, even these lesser than required number of SPTLs are under-utilized, with only around 70-80 per cent of the total capacity utilized.

The utilisation too exhibits inter-state variations, which is hundred per cent in Gujarat and Maharashtra, 75-100 per cent in the States of Andhra Pradesh, Punjab, Tamil Nadu, Telangana and West Bengal, and less than 50 per cent in case of Chhattisgarh, Himachal Pradesh, Kerala, Odisha, Tripura and Uttarakhand. Under the provision of the Insecticides Act, 1968, the state governments have notified 13,403 number of Insecticides Inspectors which is less than required numbers.

Hence, the geographical reach vis-a-vis quality control is limited. Induction of non-qualified analysts in the SPTLs has only compounded the problem. In addition, majority of these Inspectors are saddled with other functions limiting their ability to collect samples for quality analysis. Some additional issues vis-a-vis the SPTLs are as follows:

- Some states have not established even one SPTL.
- Most of the SPTLs have limited capability of analyzing all the 279 pesticides with 542 formulations that are registered under section 9 (3) of the Insecticide Act, 1968 as of now. The reasons are insufficient infrastructure, analytical capabilities, trained analysts, availability of certified reference materials and analytical methods.
- All the SPTLs and RPTLs are not networked for knowledge sharing, to analyze and discuss the challenges in analysis of pesticides and their formulations.
- The total number of misbranded pesticides range around 5 per cent of the total samples collected by the Inspectors and analysed by the Analysts. Many a time, the methodology followed for collection is not adhered to, and tantamount to fulfilling a formality. Further, as the analysis of newer molecules and newer formulations is challenging, it is observed that most of the Inspectors are collecting such pesticides / formulations which are easily analysed by SPTLs. Hence, capacity building programs need to be regularly

### **Factors effecting adoption of pesticides**

- i. Quality of pesticides
  - Inadequate quality monitoring infrastructure (physical and human)
  - Mismatch between number of registered pesticide dealers and annual capacity of the States
  - Underutilization of existing capacity
  - Lack of comprehensive data on dealers and pesticides being sold in the market
- ii. Optimum application of pesticide
  - Lack of trained extension officers
  - Inadequate sensitization of farmers
  - Sale of pesticide by unqualified Retailers
  - Delay in dissemination of required information to the farmers
- iii. Limited reach of IPM techniques
  - Lack of effective pest surveillance mechanism
  - Availability of IPM inputs like bio-control agents, bio-pesticides, light traps, rodent traps, pheromone traps, sticky traps, seed treatment drums etc.
  - Lack of trust on modern IPM techniques among the farmers
- iv. Price of generic pesticides

conducted, and the same can be entrusted to NIPHM (National Institute of Plant Health Management), Hyderabad.

The central government has been supplementing the resources of state/UT governments in quality control testing of pesticides. For this purpose, two Regional Pesticides Testing Laboratories have been established at Chandigarh and Kanpur (earlier there were 4 RPTLs, of which two, namely, Bombay and Madras RPTLs closed in 1980s) under the Directorate of Plant Protection, Quarantine & Storage (DPPQ&S), Faridabad (Haryana).

#### **4.2.2. Optimum application of pesticides**

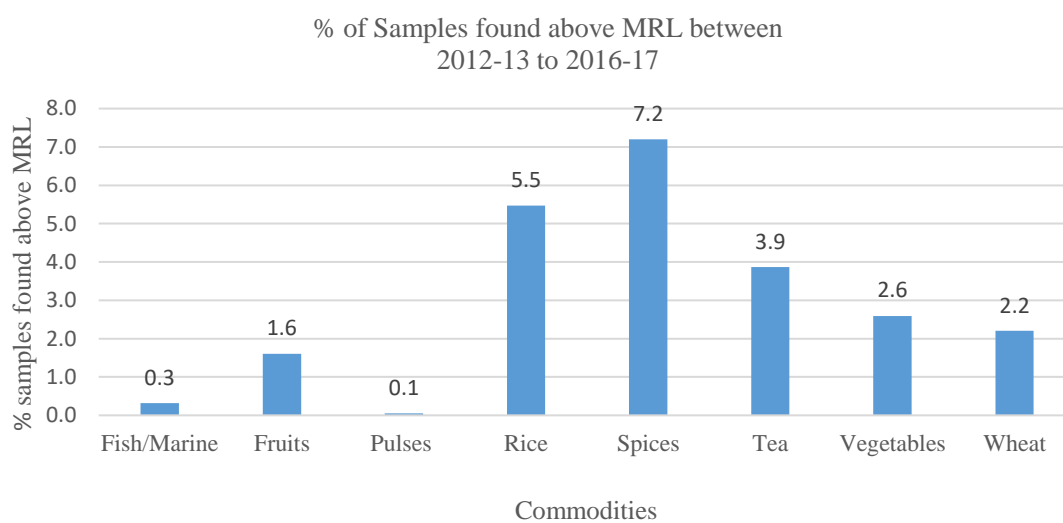
One of the factors for increased intensity of white fly in cotton (Punjab) in the year 2015-16 was unscientific application of pesticides with respect to both manner and usage. Pesticide poisoning in Yavatmal region of Maharashtra during 2017 is yet another bad experience linked to unscientific application of practices and non-use of personal protection equipments (PPE). Therefore, the application of pesticide as per 3 R's (i.e. right manner, right dosage and at right time) acquires significant importance in agriculture and for the farmers. The 3 R's will help in reducing the consumption of pesticide to an optimum level, and result in reduced pesticide expenditure and higher net income to farmers.

The extension officers are the most important functionaries as they help in effective implementation of the policies, by undertaking training/sensitisation of the farmers on various aspects of agricultural production, and also by disseminating required information to the farmers at the right time. The 3R approach to application of pesticide is constrained by many factors, and one of them is absence of refresher training programme and extension material for updation of knowledge of the extension officers. When the extension machinery is found to be inadequate, the farmers tend to rely on the local pesticide dealers for pest management advice, who serve as their 'First Contact Point', and advise them on pesticide selection, dosage, methods and timing etc. Since majority of these pesticide dealers lack relevant qualification, their advice suffers from scientific rigour. Apart from this, conflict of interest also comes into play, compromising the objectivity of advice given. In this context, the following are suggested:

- The local dealers should be made aware of registered uses / recommended uses of pesticides through the concept of the "Read the Label First", which not only minimizes the secondary effects but also issues of pesticide residues and food safety, as the label reading makes dealers and also farmers to understand about the target pest and crop on which the pesticide is registered for use, and also perfect dose and pre-harvest intervals (PHIs).
- As the dealers are "first contact persons", their knowledge can be upgraded through capacity building programs as para extension workers, for effective pesticide management.
- The phenomenon of pesticide spraying has changed in the recent years, due to engagement of persons for pesticide spraying on per tank / acre basis. Hence it is very essential to conduct special short trainings for such persons on maintenance of spray

equipment, good spraying practices and use of personal protection equipment, for not only protecting health of such people but also for obtaining effective control of pests.

**Monitoring of Pesticide Residues at National Level (MPRNL)** is a central sector scheme being implemented by DAC&FW, since 2005-06 to determine the levels of pesticide residues in food commodities and environmental samples with the participation of various laboratories. During 2012-13 to 2016-17, a total of 98,276 samples have been collected and analyzed for the presence of pesticide residues, out of which 2355 (2.4 %) number of samples have been found with residues exceeding above Food Safety and Standard Authority of India (FSSAI) Maximum residue Limit (MRL). Commodity-wise, 7.2 % samples of the Spices are found to be above MRL, followed by Rice (5.5%), Tea (3.9%), Vegetables (2.6%) and Wheat (2.2%)



#### 4.2.3. Limited reach of IPM techniques

Integrated Pest Management (IPM) is an eco-friendly approach and aims at keeping pest population below economic threshold levels by employing all available alternate pest control methods and techniques. These include cultural, mechanical and biological techniques and practices with emphasis on use of bio-pesticides and pesticides of plant-origin like neem formulations. The use of chemical pesticide is advised as a measure of last resort, if pest population crosses economic threshold levels (ETL).

The use of pesticides can effectively be minimised, by adoption of IPM approach, and realise higher income of the farmers. IPM not only reduces the input costs, but also helps in minimizing pollution in soil, water and air; reducing occupational health hazards; conserving ecological equilibrium; and reducing pesticide residue loads in food. Though the IPM approach has been accepted by researchers, agriculture extension functionaries and farmers, and has proved its effectiveness in management of pests, there are many constraints in its implementation.

Some of the inadequacies are poor pest surveillance mechanism and availability of IPM inputs (bio-control agents, bio-pesticides, light traps, rodent traps, pheromone traps, sticky traps, seed

treatment drums). Further, quality of IPM inputs is also important to build and sustain confidence in IPM practices. There is inadequacy in respect of this.

Over the years, the governmental effort has sensitized the farming community on use of IPM tools, who now are aware about the tools and techniques. However, due to non-availability of biological control agents in the market, the use of bio-agents is not prevalent. The states should encourage on-farm production and mass multiplication of bio-agents through SHGs, FPOs, Cooperatives, Mahila Sanghs etc. and the inputs should be made available at village level either at the office of Panchayats / Kisan Bhawans, etc. The quality control of bio-agents is also very pivotal for sustainable use of such products and creation of confidence among the farming community. Capacity building programs are organized at NIPHM, but the implementation of production of inputs by trained persons is very shallow.

#### **4.2.4. Price of generic pesticides**

The price of pesticides (both branded and generic) is uncontrolled and is determined by the market forces i.e. inter-play of demand and supply. However, of late, prices of generic pesticides are seen to be increasing for unknown reason. As a result, the farmers' expenditure on pesticides has increased, thereby affecting their net incomes. Before attempting to bring in Price Control System, it is advised that large number of alternates should be promoted so that competition among them will bring in a rational price.

### **4.3. Interventions**

The interventions aimed at bringing down the expenditure on pesticide represents a collation of institutional, capacity building, procedural, policy and research strategies. These interventions have been segregated into three broad-based domains i.e. Central, State and Research Organisations.

The basis of this segregation is to bring clarity for functionality and should not be treated as water tight compartments. The efficacious implementation of these interventions is predicated upon a concerted and coordinated synergy among all the stakeholders.

#### **4.3.1. Interventions by central government**

- i. Establishment of RPTLs in all major states (8 or 9) where the pesticides are used extensively. The RPTLs should be sufficient in terms of infrastructure, analytical equipment and trained manpower where all registered pesticides in all registered formulations can be analysed. They should be such as to serve as a Model to the SPTLs.
- ii. The RPTLs should be able to analyze all the pesticides in the schedule for identification of spurious pesticides.
- iii. All RPTLs and CIL should be GLP and ISO 17025 complaint.
- iv. The RPTLs should create a kind of networking with all SPTLs for knowledge sharing and to meet the challenges in analysis of pesticides for quality control purposes.
- v. One may prepare and share documents, namely, "Requirements for establishment of

RPTLs” and “Requirements for establishment of SPTLs” for promoting adherence to quality standards vis-a-vis GLP (Good Laboratory Practices) and ISO 17025.

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| <p>vi. As the Certified Reference Materials (CRMs) and Technical Materials (TMs) required are very elaborate and expensive, an inventory of these may be maintained by CIL and supplied to RPTLs and SPTLs.</p> <p>vii. Since, BIS methods are not published for all pesticides and formulations, all laboratories may not be capable of undertaking all types of analyses. The manufacturing methods should therefore be made available to all SPTLs through CIBRC / CIL.</p> <p>viii. A portal may be created for the Analysts, whereby they can learn about CRMs and methods of analysis and can exchange information among themselves.</p> <p>ix. National data/inventory of pesticides registered in the country be maintained.</p> <p>x. Strong enforcement of quality control to ensure supply of quality pesticides.</p> <p>xi. Creation and dissemination of Standard Operating Procedure (SOP) to states for establishment of State Pesticide Testing Laboratories and Pack Houses for bolstering backward and forward linkages.</p> <p>xii. Establishment of new Central Integrated Pest Management Centres (CIPMCs) and strengthening of existing CIPMCs for vigorous monitoring and surveillance of agriculture fields and encouraging farmers to adopt IPM. Farmers Field Schools (FFSs) can be used for this purpose. Proper understanding of location based agriculture &amp; concerns, therein is important too.</p> <p>xiii. Strengthening the Ministry sponsored Central Sector Scheme on “Monitoring of Pesticide Residues at National Level (MPRNL)” being implemented at ICAR-IARI, New Delhi and its 25 NABL accredited centres in the State Agricultural Universities and national research centres. The project identifies crops and regions having preponderance of residues in India in order to focus on extension efforts for IPM and food safety (MRL fixation).</p> <p>xiv. Expedite registration procedure with a view to grant registration swiftly &amp; transparently. In this way, enhance competition among the manufacturers, which may balance the prices. There is an urgent need to squeeze the current time frame of 4 years needed for a registration. In fact, much more than 4 years is the time required in reality to get a pesticide registered. In addition, simplification of the registration procedure for</p> | <p><b>Central Government Interventions</b></p> <ul style="list-style-type: none"> <li>• Introduction of GMP &amp; GLP norms</li> <li>• Establishment of new RPTLs</li> <li>• Strengthening of Techo-legal Cell</li> <li>• Creating SOP for SPTLs and Pack Houses and sharing the same with States</li> <li>• Establishment of new CIPMCs</li> <li>• Strengthening of existing CIPMCs</li> <li>• Strengthening of DAC sponsored Central Sector Scheme on “Monitoring of Pesticide Residues at National Level (MPRNL)” Expedite registration procedure</li> <li>• Encouraging indigenous manufacturing of active ingredient</li> <li>• Regular training of enforcement officials and laboratory analyst</li> <li>• Electronic platform for pest surveillance</li> <li>• Creation of Portal providing information on various aspects of pesticide</li> <li>• Comprehensive policy on products in the name of “organics”.</li> <li>• Sensitisation of farmers through Media, T.V, etc.</li> </ul> |
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- bio-pesticides/ botanicals is also essential. Expansion of label claims of already registered pesticides on other crops should also become the norm. Implementation of the long pending Crop Grouping & Minor Change Concepts of Regulation be expedited.
- xv. Most of the new molecules with patents are imported, which adds to the cost per unit. Special encouragement should be given for discovery and manufacture of the active ingredients in India. The local manufactures should also be encouraged to export, so that they can afford to sell at lower price in the domestic market.
  - xvi. Ensure regular training of enforcement officials/officers on pesticide quality control and prosecution procedure and training of laboratory analysts at periodic intervals to update their skill. Enforcement intensity needs to improve.
  - xvii. Electronic platform for pest surveillance can be developed and rolled out in coordination with state governments. This will help in real time dissemination of pest management information techniques to the farmers. The data generated through the electronic pest surveillance will also help in creation of Centralised Prescription Repository (CPR). The current system is largely manual, limiting the quality and utility of surveillance and its outcome.
  - xviii. Important to create a Portal in collaboration with states and Pesticide Associations which will provide information on all registered pesticide dealers along with their education qualification. The portal should also include information on pesticides produced and sold by the companies along with their prices.
  - xix. There is a need for a comprehensive policy on products sold as 'organics', 'bio-stimulants' etc. which are neither tested by a competent body nor registered at CIB-RC. These are presently not recommended by any scientific body for pest management. Active ingredients in these products are not disclosed, keeping both the user and the subject experts in dark. Many a time, these organic products are used along with the other synthetic insecticides in a single application resulting in significant increase in the cost of plant protection. Further, as the nature of the molecule is not known, it also puts the consumer at serious risk on account of pesticide residues. It would be useful to establish registration procedures for organics / natural products / concoctions / mixtures of natural products / products based on traditional knowledge for encouraging them in accordance with desired norms.
  - xx. As the 'deemed to be registered' pesticides exhibit minimal label claims, but are recommended traditionally by Universities on various crops based on research trials, it is very essential to expand the labels with MRLs and PHIs to avoid compromise of GAPs.
  - xxi. The registration is usually for major crops, but expansion of labels to minor crops / related crops is very essential and is possible through crop grouping. A policy be evolved by CIBRC on crop grouping and label expansion through data on field trials and also risk assessment for fixing MRLs and recommendation of PHIs.
  - xxii. Sensitisation of farmers through media, T.V, trainings, Farmers Field Schools etc. about

use of recommended pesticides as per label prescription, at right dose against right pests & in right time will help.

- xxiii. Strengthening of techno-legal Cell of the Directorate of Plant Protection, Quarantine and Storage (DPPQ&S) for facilitating swift action in cases of misbranded/spurious instances of pesticides.

#### **4.3.2. State government interventions**

- i. Establishment of additional SPTLs in sync with the number of registered pesticide dealers and strengthening of existing SPTLs. In this regard, the central government may share SOPs with the States, which, inter alia, may include best practices, optimum no. of pesticide testing laboratories needed, list of equipments, information about accreditation etc.
- ii. Creation of a dedicated and independent Enforcement Cell in the State Agriculture Department for collection of pesticide samples for their analysis.
- iii. Establishment of 'Pack Houses' for bolstering backward linkages. In this regard, the central government may share SOPs with the States.
- iv. Ensure regular training of enforcement officials/officers on pesticide quality control and prosecution procedure; training of laboratory analysts at periodic intervals to update their skill; and placement of trained analyst to ensure qualitative and quantitative progress.
- v. Sensitisation of farmers through media, T.V, trainings, Farmers Field Schools etc. about use of recommended pesticides as per label prescription, in right dose against right pests & at right time.
- vi. Regular training of extension officers on pest management including IPM. State Agriculture Department to undertake vigorous monitoring and surveillance of agriculture fields and encouraging farmers to adopt IPM strategies for controlling pests.
- vii. Collation and compilation of comprehensive data on the consumption of pesticide/bio-pesticide, no. of pesticide dealers, their education qualification etc. and to provide the same to Central Government for creating a dedicated portal for the same.
- viii. "Prescription-based sales" of pest management inputs may be considered, as done in Kerala (spices), Maharashtra (pomegranate, grapes, sugarcane).
- ix. Lay down protocols for establishment of SPTLs", so that quality standards vis-a-vis GLP and ISO 17025 are met.
- x. Every state should establish at least one SPTL.
- xi. All major states should designate one SPTL as lead laboratory, where all facilities as

##### **State Government Interventions**

- Establishment of additional SPTLs
- Creation of dedicated enforcement cell
- Establishment of Pack Houses
- Regular training of enforcement officials and laboratory analyst
- Sensitisation of farmers through Media, T.V, etc.
- Regular Training of extension officers
- Collation and compilation of comprehensive data
- Prescription-based sales



available in RPTLs should exist and also help in analysis of other state samples for second verification purposes and for Inter-Laboratory Comparisons (ILCs).

- xii. All analysts should undergo training (induction and refresher) at NIPHM on Pesticide formulation analysis.
- xiii. All SPTLs should be GLP and ISO 17025 compliant.
- xiv. A dedicated “Coding Cell” be established at Directorate of the State, where the inspector samples are received, coded and sent to SPTLs for tamper proof analysis.

#### **4.3.3. Interventions by research organizations (ICAR/SAUs)**

- i. Institutions (both ICAR and SAUs/CAUs) should adopt region-wise model clusters with a view to reach farmers by providing them timely advisory on plant protection measures to bring down unnecessary expenditure. This will help farmers to take appropriate decisions with respect to plant protection chemicals.
- ii. The region-wise and crop-wise usage of plant protection molecules may be recorded religiously. Regular statistics of these, similar to yield estimates will help to plan appropriate region-wise measures to check abuse of plant protection molecules.
- iii. Collaborative institutional projects with a time frame of 3-5 years should be proposed by scientists in Plant Health (Entomology, Pathology, Soil science) along with the Divisions of Agricultural Extension and Agricultural Economics in all ICAR and SAU systems, taking district as unit of study, by providing all necessary and timely advisory support to cover target farmers across different crops. Pilot study should be initiated wherever vulnerability is higher.
- iv. Research on analysis of pesticide residues is necessary in agricultural commodities, soil, water etc. through supervised field trials to generate data on persistence and dissipation of newer and existing molecules for fixation of safe waiting periods, MRLs, and approval of label claims. Presently ICAR-All India Network Project on Pesticide residues (AINP-PR) at IARI, New Delhi conducts such studies through its 15 NABL accredited coordinated centres located throughout the country.
- v. Research on enhancement of pesticide efficacy and stability through use of adjuvants (synergists, potentiators, stabilizers) and employing proper dispensing mechanism (spray technologies) to reduce sizeable quantity of pesticide consumption should be strengthened. Availability of new molecules, that are less labour intensive, less harmful to environment and that facilitate less for more coverage needs to be ensured.
- vi. Research should be targeted for elevating the level of pest resistance to major invaders rather than developing resistant cultivars, which is an uncertain and time consuming task. Cost reduction in pesticide use is on pro-rata basis with resistance level. Stability of such varieties is greater than those with resistance.
- vii. Development of fore-warning system with suitable precision in respect of key pests. This will enable timely pest management interventions to reduce the pesticide load in the environment.

- viii. Creation of field diagnosis protocols that serve as a step-by-step guide for diagnosis of field problems. A protocol should encompass all the known problems of a crop and include various diagnostic approaches like visual, chemical, digital, etc. These protocols should be revised from time-to-time as new technologies, new problems, new research findings, etc., come to light.
- ix. Creation of a Centralised Prescription Repository (CPR), that caters to all the diverse cropping situations and preferences. The CPR should contain all the authentic prescriptions to tackle pest situations at different crop stages and at varying intensities of damage for different regions of the country. Further, the CPR should include the entire range of preferences such as biological, organic, conventional, mechanical, cultural, etc., for each specific agro-climatic zone. The CPR should be continuously updated with inputs based on latest research findings, changing pest scenarios, policies and other regulations, technologies developed, etc. This should be backed by suitable policies that is binding for all to adopt from the prescriptions listed in the CPR.
- x. Big data analytics of pest situations being reported from across the country: As digital extension systems are continuously expanding in the country, there is a need for establishing a big data analytics and interpretation centre. This centre should be able to provide all the necessary alerts across every district of the nation for each of the cultivated crops. Lack of such data systems has led to delayed administrative and policy-level decisions. Effective data analytics can help in interpretation of data and drawing of messages for containing pests within certain limits of their occurrences. Large scale pest occurrences and server damages can such data analytics would be of vital importance for predicting pest occurrences and for pest quarantine.

**Research Organizations  
(ICAR/SAU) Interventions**

- Adoption region wise model clusters
- Recording of region wise and crop wise usage of plant protection molecules
- Collaborative institute project staking district as unit of study
- Research to develop pest resistant varieties
- Creations of field diagnosis protocols
- Creation of a Centralised Prescription Repository (CPR)
- Big data analyses of pest situations
- Timely Dissemination of IPM recommendations

#### **4.4. Reducing Pesticide Consumption in Indian Agriculture**

Pesticides play a sensitive role in food systems. They are applied in order to protect crops, but they are now the center of attention known to have negative impacts on the environment and human health. A significant number of the chemicals applied have proven to be excessive, uneconomic or unnecessary. It is time to gradually reduce pesticide use to a level where negative impacts – externalities like health hazards, bio-diversity loss or water pollution at the minimum, do not outweigh the value added in terms of yields or cost savings in production.

Today there is a consensus among a wide range of stakeholders, that pesticide use needs to be gradually reduced to a level that is minimally required to ensure effective crop production, and that risks of pesticide application need to be reduced as far as possible. Experience across the

world shows, that pesticide use can be reduced considerably without unduly reducing yields or increasing costs of production. A reduction of pesticide use is feasible already within the current production systems. New knowledge, technologies and alternatives available now, clubbed with traditional practice of cultivation can also be introduced to minimize or optimize the use of pesticide. In case of exports in particular, strict adherence to 'Maximum Residue Levels' (MRL) as laid down by the importing countries becomes essential.

The problems of excessive pesticide usage can be addressed through multi-stakeholder participation. In addition to farmers, pesticide producers and sellers, middleman of vegetable trade and consumers should also be involved in diagnosis of the problems and designing of approaches. A proper understanding of the concerns may help in reducing the magnitude of use of pesticides in agriculture. Some suggestions are made below:

- All stake holders should be sensitized on “*Read the Label First*” for correct use of pesticides, which reduces the cost of cultivation.
- CIBRC may make amendments, that lets notifying *leaflets* only in two languages, but by using bold letters and pictorial representation of target pest and crop for easy understanding of recommend use by farmers.
- The availability of bio-pesticides, mass trapping methods and mating disruptors is very important for use of environmental friendly tools.
- The traditional chemical pesticides which are required to be used at higher doses be eliminated in phases through regular reviews by Registration Committee.
- Pest life-cycle and behavior based management practices be popularized for effective management of the critical pests such as pink boll worm, army worms, fruit borers, mealy bugs, wilt fungus, vertebrates etc.
- Agro-Ecosystem Analysis, Ecological Engineering methods and Pest-Defender Analysis be popularized among all extension staff for effective crop protection practices.
- Discourage use of pesticides-mixtures / cocktails etc.
- The pesticide packages be made in such a way, that the packing is sufficient for one acre (packing for acre – crop wise), so that farmers do not have to purchase more than required. Considering that majority of the land holdings are small & marginal, smaller packages will be cost-effective.
- Government may approve only calibrated and suitable sprayers / pesticide application / plant protection equipments.
- Continuous extension visits and on-farm demonstration on good spraying practices and recommended use of pesticides and their efficacies in case of areas of pest severity / epidemics.

- All Research Stations / Institutes should conduct model farm / crop demonstrations at village level for promoting methods for reducing the use of pesticides and cost of cultivation. At every farm demo site, the budget balance sheet should be displayed.

Reduction of pesticides in agriculture is necessary to ensure a more resource efficient approach. This reduction can be achieved primarily by a combination of:

- Use of advanced technology in conventional agriculture
- Introduction of climate inductive organic crop production leading to allied organic sectors; cultures of agriculture e.g. sericulture, apiculture, aquaculture, including livestock and animal husbandry
- Overall plant protection policy changes at the central level and stringent compliance at the state level.

This paradigm shift of adopting pest management strategy in preference to the approach of killing of pests enables application of a combined approach of mechanical, chemical, thermal, or biological combat of pests without harming the bio-diversity. The importance of 'Threshold Limits' (THLs) needs to be re-worked and re-emphasized. Farmers should be made aware of such approaches, and also encouraged to take advantage of innovative technologies like:

- **Use of injection syringes:** Injection syringes can help the farmer minimize pesticide use. Typically, pesticide and water are mixed to the full capacity of the sprayer. On the contrary injection syringes allow the farmer/operator to change the concentration of the single pesticide or select different mixtures of pesticides as needed.

**Agro-chemical application for orchards without spraying:** Agro-chemicals are applied to trees for many reasons. For example, insecticides control insect pests, fungicides control fungal diseases, nutrients and plant growth regulators affect growth, and herbicides control unwanted plants or weeds or prevent sprouting after tree removal. Spraying is the most typical methodology of application of such products. It is fast, convenient and uses readily available equipment, and is understood to a certain level of utilization.

The down side, however of spraying is that much of the chemical being applied is wasted, either due to drift, run-off, or because it cannot be applied precisely to the location where it is needed on the trees. In certain cases, pesticides are more effective when placed inside the tree/s or orchards, and this is difficult with spraying. Some alternative methods of applying chemicals on trees that can be more efficient and targeted include i) trunk implantation; ii) trunk injection; iii) soil injection/drenching; and iv) trunk basal spray.

- Injection and implantation methods probably are most useful where soil access is limited or extensive root damage may have occurred. Even in such cases, a trunk basal spray would more likely work, assuming the product is labeled for the pest in question and for the intended type of application.
- Use of GPS: GPS can reduce pesticide consumption by approximately 10 per cent, as it prevents double treatments in wedges and while turning. It can be used to calculate

the needed amount of pesticides and can be connected to sowing/ planting machines allowing the seeds or the plants to be placed in a pattern, which subsequently allow to hoe the plants across the rows and to hoe closer to the rows than what is possible without GPS.

- Quadcopters/Drone based fertilizer and pesticide spraying system: Fertilizers and pesticides (biological & chemical) are primarily required for the growth of crops & control of pests, respectively. World Health Organization (WHO) estimates that there occur more than 1 million pesticide poisoning cases every year, out of which more than 100,000 deaths are of spray operators in developing countries. UAVs (Unmanned Aerial Vehicles) can be deployed to avoid poisoning incidents linked to application of pesticides & fertilizers. Such applications can be localised, restricted or specific in nature to avoid exposure of spray operators during application. Multiple uses of such UAVs can also relay remote sensing images that may be analysed by appropriate available software.
- GPS targeted spray application, or other chemical application through electronic control technology: Electronically-controlled or managed chemical spray application technologies can be more precisely used for application of agricultural pesticides at intended targets. Reduced chemical drift will improve water quality by minimizing the delivery of chemical compounds through the air to water bodies. Such application systems require the use of GPS data loggers (i.e., devices that record the track, time and location of field trips for download to maps) in order to document site-specific compliance with all label requirements for drift mitigation.
- Computer-assisted information gathering and application: Information technology can be used to gather information about the health status of crops and compare conditions with a computer model. The resulting management information can be used to develop a turf spraying program based on observations of soil type, weed and disease status, along with response to pesticides.
- A hand-held data logger can be used with a global position indicator, so that weed or diseased patches can be identified and located for spot treatment. Smart cards and disc systems allow information to be downloaded from the office computer into the sprayer controller.
- Satellite positioning would indicate the grid reference. The 'smart card' contains information on the level of infestation, allowing the pesticide to be applied at varying levels according to the degree of infestation. As the injection sprayer drives towards a patch of weeds or diseased area, the vehicle position indicator informs the sprayer controller and switches on a particular injection pump. A patch of weeds or disease can be spot treated with pesticide as sprayer passes. As the weed infestation is passed, the sprayer can be switched off.
- The potential for using all forms of sophisticated electronics as an aid to both management and practical application of pesticides needs to be encouraged. While in order to overcome concerns of the degree of sophistication, particularly in regard to reliability in a harsh environment, maintenance, fault finding and longevity, training in

the correct use of such devices is of paramount importance.

To summarize, one or more of the following techniques can be utilized for GPS and computer aided pest control:

- i. Precision guidance systems that reduce ground or aerial spray overlap to less than 12 inches.
- ii. Smart sprayers that utilize automatic sensors and computer controlled nozzles to turn individual nozzles on and off.
- iii. Computer guided application systems that integrate real time meteorological data and computer model guidance to reduce pesticide drift from aerial application
- iv. Electrostatic spray and re-circulating spray technologies that capture and reuse overspray to reduce overall pesticide application rate and off-site spray drift
- v. GPS, plant recognition systems, direct injection sprayers, and hot water/steam sprayers may enable applicators to rationalize their pesticide use, reduce environmental pollution and reduce operator contamination.
- vi. Variable rate application of pesticides along with GPS will result in more appropriate use of pesticides with an overall reduction in application rates, thereby satisfying environmentalists, legislators and applicators.
- vii. Information technology systems already exist, that allow development of computer aided pesticide application technology. The new systems will enable better informed pesticide application strategy and improved decision-making skills.

Some of the methodologies that may be considered to target reduced usage of pesticides in agriculture are:

- i. Assessing the external costs of pesticide use
- ii. Re-designing farming systems based on agro-ecology
- iii. Breeding robust varieties with resistance to pests
- iv. Advancing alternative crop protection methods, including sustainable farming systems
- v. Adequately funding research and development activities; as also capacity building
- vi. Strengthening know-how on alternatives and on safe use
- vii. Applying agro-ecology for designing resilient farming systems
- viii. Education, training and information for efficient pest management
- ix. Capacity building on safe use
- x. Increasing the demand for low-/no-pesticide agri-produce
- xi. Applying restrictions on hazardous pesticides
- xii. Raising awareness about pesticide issues among consumer, policy & decision makers, and other stakeholders

- xiii. Revisiting the regulatory practices, and related policies and legislation
- xiv. Assessing the risks of pesticides and monitoring progress
- xv. New sprayer technology to reduce pesticide use
- xvi. Nano-technological interventions to reduce pesticide use in crop protection

#### **4.5. Some Strategic Interventions**

##### **Availability of molecules:**

- i. All molecules for which registration applications are filed with the regulator for use in the country for the first time should be registered as done earlier by clubbing section 9(3) along with 9(3B) of the Insecticide Act, 1968. This implies, that the Registration Committee needs to register a formulation after the fixation of its Maximum Residue Limit (MRL) u/s 9(3) as recommended by the JPC and set across by FSSAI as mandated. Wherein, the 'technical' needs to be compulsorily registered u/s 9(3B) with a commercialization rider to extend beyond the provisional period of 2 years, and during this period of provisional registration, balance data required to be submitted can be generated and further registered u/s 9(3) within a period not exceeding a total of 3 years from the date of provisional registration.

This will enable introduction of both patented or non-patented molecules in the country, and ensure data protection of minimum of 2 years and maximum of 3 years for companies willing to invest in new molecules being introduced for the first time in the country.

As a result, the subsequent prospective registrants will be encouraged to go in for registration for indigenous manufacture or new import source, thus providing an end to the monopoly of the said molecule registered for the first time for use in the country. This will result in competitive pricing.

- ii. Protective cultivation has become popular and with diversification into high value crops, its adoption is growing. However, there are no formulations registered for use in protective cultivation, wherein fertigation that combines application of water, fertilizer and plant protection can be encouraged. In this regard, molecules that are suited to fertigation need to be registered.  
Another concern related to protective cultivation is the rising infestation nematodes and lack of adequate number of registered nematicides.
- iii. Seed treatment registrations have been accorded priority for registration. However, seed treatment solutions are not available for all seeds of national importance. Bio-pesticides need to be encouraged for seed treatment with a focus on export oriented produce.
- iv. Plant protection products needed for treatment of agri-produce during storage (post-harvest management) need to be given importance in registration.
- v. Pesticide treated plastic wraps for slow ripening of fruits or plant protection products need to be encouraged and evaluated.

#### **4.5.1. Access or Accessibility**

- i. Each state falls under one or more agro-climatic zone(s), which define the region's crop patterns and unique pest scenario. This needs to be studied and analysed from the perspective of Package of Practices (PoPs) issued by the respective states. This will enable to identify the required kind of pesticides and map them to manufacturers & importers of formulated pesticides within the state and / or nearby location.
- ii. Crop Cluster Development Scheme (CCDS) approach may also be considered. This will help in promoting efficient way of pesticide application.
- iii. The rate of pesticide dose in application should be linked to the seed variety in the given crop cluster or agro-climate zone or state, as the case may be.

#### **4.5.2. Cost**

A detailed study is required to identify pesticides registered for use in respect of specific crops, identified pests and available manufacturers & importers for the said product. This will be required to identify and ensure the availability of identified and required pesticides in a particular region of interest.

#### **4.5.3. Awareness & education for effective and safe use**

- i. Basic harmonized training modules be formulated, and translated into all regional languages so that the issues related to safe & effective use of pesticides are addressed holistically. The next step will involve crop specific detailed training based on the generic and not the brand name.
- ii. All websites of the State Agriculture & Horticulture departments need be at least bilingual i.e. English & regional/local language. This will help in connecting with other states for new learnings and adoption of best practices.

Pesticides may be considered as an essential item and price control may be opted for generic pesticides similar to the Drug Price Control.

#### **4.5.4. Early warning and preventive measures**

The risks involved during crop production, can be reduced by preventive practices involving selective use of pesticides based on pest monitoring and forecast technologies. Forecasts based on agro-meteorological data may help reduce the risk involving pest incidence on the strength of the weather dependency of the host and the parasite. Whether, the outbreaks can be forecast accurately and in time to allow suitable response for control remains uncertain. However, pests whose outbreak is influenced by weather or which require long incubation periods, can be reasonably tackled by weather based forecasts. This is particularly helpful in averting epidemics e.g. in case of wheat, paddy etc.

Pest & disease surveillance is today carried out by the Union Department of Agriculture through its 35 number of CIMPCs (Central Integrated Pest Management Centres). The surveillance is largely manual, and therefore the advice is dated. If new technology platform



based on electronic crop & pest status survey, weather data and data analytics is deployed, the surveillance will become more meaningful and advisories more effective and timely. This will enable the farmers to take appropriate and advanced action, that will minimise the outcome of pest attack.

Some tools like PESTWATCH are available providing on-line information for pest monitoring and forecasting. FAO provides satellite-based images of large locust habitat areas supported by rainfall and green vegetation data for the technical staff for purpose of monitoring and intervening to check their population. Such modules may be developed or adopted for pest surveillance for large areas like that of state/district/clusters.

Harmonization of data obtained from different centres is necessary keeping in view the regional variations in farming practices.

Calendar spraying of pesticides as a strategy helps maintain lower risk of crop loss due to pest infestation.

It is advised to adopt IPM as a pest management approach. It is essentially an ecological approach to pest management, requiring the knowledge of the interaction between pests and their environment (abiotic & biotic). Hence, understanding the factors involved affecting population abundance of the pest during the crop season and off season, would guide in formulating strategies of their management.

Nuclear technique, also known as sterile insect technique (SIT) is one of the IPM practices, that can be promoted in managing fruit flies, moths etc. It is a form of sterilization of insects and systematic release of huge number of male insects. The sterile males compete with insects in the wild, and through mating with wild females, contribute to reducing overall pest numbers.

#### **4.5.5. Prophylactic measures**

Promote awareness of IPM, precision farming, cluster farming approach or training of Farmer Produce Organizations (FPO) along with trainings on the safe & judicious use of pesticides and timely availability of advanced technologies.

Promotion of right information, knowledge and skill on pest management and pesticide use is critical to minimal and effective use.

#### **4.5.6. Registration of pesticides**

Time bound registration, particularly of pesticides that are needed on priority is essential. Alternatives should be promoted, so that there is no monopoly practice. Responsible marketing by the pesticide industry through qualified retailers/dealers is important.

The quality of pesticides (both imported and domestically manufactured) in the country can be assured by mandatory implementation of i) Good Manufacturing Practices (GMP); ii) Good Laboratory Practices (GLP) for chemical & biological evaluations; iii) Crop Grouping for

enabling enhanced label approvals; and iv) Minor change regulation for formulations to reduce use of harmful additives/adjuvants by more environmentally friendly ones, etc.

#### **4.6. Annotation**

Pest Management is one of the key aspects of the pre-harvest practices. Pest Management (non-chemical and chemical) entails cost, and therefore, it is pertinent to ensure efficacious and sustainable practices to rationalise cost of production, while minimising pesticide residues and thereby increasing farmers' income. Such gains will come from lower cost of production and higher demand from safe foods. Addressing the challenges in respect of pest management (i.e. quality of pesticides, optimum application of pesticide, popularisation of IPM techniques and price of generic pesticides) requires implementation of multi-faceted strategies/interventions (Policy/ Procedural/Research and Development/ Information Technology/Institutional/Capacity Building) at different levels (i.e. central/state/local government, farmers, pesticide industry, etc.). Further, these strategies/interventions call for synergy and knowledge networking at all levels for efficiency & effectiveness.

While pesticides are used to protect the crops from pest damage, the consequential residues are a cause for concern. Hence, the most minimum of pesticide required to protect the crop should alone be utilised. This warrants deployment of most efficient & effective approach to pest management, which implies integrated management comprising mechanical, biological, agronomic and chemical methods.

Further, in order to make available multiple options to the farmers for accessing pesticides that are of good quality and reasonably priced, the regulation system of registration & licensing should be reformed.

Enforcement system, that will ensure adherence to prescribed quality standards, label claims etc. is critical too. At the basic level, capacity building of farmers in effective pest management is of primary importance.

The unscientific use of chemical pesticides adds to unnecessary cost of production and poses a health risk to the crop. Therefore, emphasis on efficacious and sustainable pest management would reduce the cost of production and ensure a healthy produce, thereby increasing the income of the farmers. The four main challenges that need to be addressed at different levels are pesticide quality, reach of IPM techniques, optimal application and price. Excessive pesticide usage can be contained through multi-stakeholder participation in diagnosis of the problems and designing of approaches. Use of injection syringes, agro-chemical application for orchards without spraying, and GPS and computer assisted tools for targeted pesticide spraying need to be promoted.

### **Key Extracts**

- Special encouragement should be given for discovery and manufacture of the active ingredients. There is also need to simplify the registration procedure, including for organics / natural products / concoctions / mixtures of natural products / products based on traditional knowledge. The system needs to be quick objective and transparent. Attention is needed to developing suitable protocols for registration of biological/natural etc. products, as also their regulation.
- Create a national level portal with data/inventory of all registered pesticides, and to disseminate information on all registered pesticide dealers along with their education qualification is suggested.
- Undertake comprehensive training of extension and enforcement officials/officers on pesticide quality control/prosecution procedure/IPM policy.
- Model clusters be adopted by ICAR and SAUs/CAUs; region-wise and crop-wise usage of plant protection molecules need to be recorded to plan appropriate location-specific measures to check abuse of plant protection molecules
- Collaborative institutional projects with a time frame of 3-5 years, for development of fore-warning system with suitable creation of field diagnosis protocols, & Big data analytics of pest situation need to be rolled out.
- Research and promotion of bio-pesticides, especially those indigenous to the country need to be given greater focus.
- Bio-pesticides need to be encouraged for seed treatment; Package of Practices issued by the respective states may consider agro-climatic zone specificity. Other good initiatives that deserve promotion are crop cluster development (CCD), harmonized training modules etc. that are available in all languages. The websites of the State Agriculture & Horticulture departments need be at least bilingual.
- Promote awareness of IPM, precision farming, cluster farming approach.
- Time bound registration, particularly of pesticides that are needed on priority is essential. The overall system of registration of new molecules and formulations, under sections 9(3) and 9(4) of the Insecticides Act, 1968 needs to be simplified and made facilitative for more transparent and time bound registration.
- Enforcement to ensure adherence to prescribed quality standards is of critical importance. For this purpose, the states must be supported to set up independent 'Enforcement Authority/Body' at the state levels.
- Generic pesticides may be brought under price control mechanism similar to the Drug Price Control.
- To regulate & enforce quality standards, the infrastructure needs to be strengthened with more test labs, accreditation (NABL) & with well-trained manpower.



## Chapter 5

### Agricultural Mechanisation

*Machines in the agricultural sector are an input that help in efficient utilisation of other inputs to increase the productivity of land and labour. Machines also help in reducing the drudgery in agricultural operations. At present, India needs greater application of appropriate and precision and economically viable engineering technology to maximise productivity of different farming systems.*

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#### 5.1. Farm Mechanisation – Meaning and Relevance

Of the various production costs in agriculture, labour counts as a major component. Thanks to various employment generation activities of the Government, more particularly, the guaranteed employment offer under MGNREGA in the last decade (2000s), there has been a wage spiralling in the rural areas. From the welfare perspective of the rural population this is certainly a welcome step. However, agriculture sector which demand extra labour during certain stages of its operation cannot depends on family source alone, warranting engagement of hired labour.

Additionally, the rural economic structure has been undergoing a gradual shift over the last decade and a half in particular, resulting in transition to non-farm jobs. This too is a welcome change in a situation where agriculture is over-populated.

These positive changes have however impacted agriculture, since the terms of trade have not been farmer-favouring. Their income has not been able to keep pace, such as to cater to increasing costs of production including that of rising labour wages. Hence, the need for labour-substituting farm/agriculture machinery. Parallely, it is also important to note, that several activities are highly time-bound and unless executed as per schedule, the farmer is likely to suffer loss. Agriculture mechanisation is an appropriate answer to such a challenge.

Lest it be misunderstood, that higher wages of labour is against the interest of farmers, it is emphasized that wage increases are a must for the welfare of larger society. This is also in the interest of farmers themselves, as an increase in purchasing power of the rural community can be expected to create a higher demand for the farm produce, more particularly the high value crops like fruits, vegetables, pulses, milk, meat, fish etc.

The average earnings of the farmer vis-a-vis the industrial & landless agriculture labour have suffered a relative slide since the 1980s. It hence drives home an emphatic narrative advocating for terms of trade that are advantageous to the farmers. The corollary to this is the need for interventions that will bring down costs of production and enhance per unit output.

Farm mechanisation, more appropriately agriculture mechanisation will also absolve the wage labour as also the farmer of the drudgery involved in manual operations, besides enhancing manpower productivity since skills are integral to machine based operations.

Effective use of agriculture machinery helps to increase productivity & production of output, undertake timely farm operations, and enable the farmers to quickly rotate crops on the same land. By raising a second crop or multi-crops from the same land, there is improvement in the

cropping intensity, and making agricultural land in sequel commercially more viable. Mechanisation also helps in animal husbandry, dairying and fisheries.

Agricultural Mechanisation mitigates drudgery and speeds up tasks, and helps bring judicious use of inputs like seeds, fertilizer & water, contributing to farm productivity, and is, therefore aid in enhancing farmers' income. Estimates indicate that agricultural mechanisation can contribute a cut in cultivation cost by 25 per cent and rise in productivity by 20 per cent, thereby effecting an increase in farm income, to the extent of 25-30 per cent. It is assessed, for example, that laser-levelling machine can fructify a water usage saving of 30 per cent and crop productivity increase by 20 per cent, The need for mechanisation, varies across the agricultural subsectors, and depends on the farming system practised (field crops, horticultural crops, livestock systems, etc.), type of crop, size of farm, skills available, availability of fuel or power, etc. The cost benefit analysis affects the adoption and deployment - cost of operations, cost to maintain, gain in productivity and resulting income. Availability of labour is a key factor that impacts adoption of mechanisation and runs across the aspects such as farming cost, size of farms and ease of farming.

In the dairy and livestock sector, which is largely integrated with an associated industry, the adoption of mechanisation has been more common. Milking machines, fodder handling and feeding machines, harvesting systems in abattoirs, etc. are examples. In the fisheries sector the adoption of mechanisation has been even more, and it has reaped major benefits. Examples here, range from mechanised fishing boats which deploy propulsion and motorised net handling equipment, fish pond management equipment, etc. Factory ships in the fisheries sub-sector are probably the largest format of machines and mechanisation deployed in the agricultural sector. On farm fields, mechanised tilling and harvesting are now most commonly used and India is the largest market for tractors and a variety of harvester machines. Irrigation pumps, fertigation systems and pesticide applicators are other mechanised forms of farm inputs. However, given the scale of India's agricultural sub-sectors, mechanisation is yet to penetrate all across regions and farm types. One of the main limitations to deploying farming machines, is the capacity of a farm to efficiently own such equipment. Small farmers will continue to be the mainstay of Indian agriculture and the concept of custom hiring centres and mechanised services is therefore most apt in this situation.

According to a recent McKinsey Study, the farm mechanisation market in India is worth US \$ 112 billion and is growing year-on-year @ 16 per cent. This can add hugely to the country's agricultural economy.

## **5.2. Defining Agricultural Mechanisation**

It is observed that agricultural mechanisation as an input for farmers is loosely defined. The term is also, at times, used for pre-harvest seed storage, post-harvest product handling, field fencing, packaging, processing lines, grain storage silos and other forms of infrastructure or machines, which are more in the nature of agri-logistics. As such, the focus point on machines as a farm input can get diluted. Hence, the DFI Committee felt the need for a certain rigour in understanding defines agricultural mechanisation as.

*“Agricultural mechanisation is the deployment of engineered machines and motorised tools, in lieu of manual activities to prepare, tend, protect, harvest and handle waste in the cultivation of any agricultural produce. Its efficiency and effectiveness can be further enhance by blending the power, electronic & space technologies.”*

Examples of some of the manual activities benefiting from use of machines are as below:

**Preparatory phase**

- |      |                              |       |                              |
|------|------------------------------|-------|------------------------------|
| i.   | Destoner                     | vi.   | Transplanters, seed drilling |
| ii.  | Ploughing, disking harrowing | vii.  | Manure spreaders             |
| iii. | Power weeders                | viii. | Pond cleaning and dredging   |
| iv.  | Levelling                    | ix.   | Cattle shed cleaning         |
| v.   | Seedbed preparation          | x.    | Etc.                         |

**Tending phase**

- |      |   |       |                                  |
|------|---|-------|----------------------------------|
| i.   | Mulch laying                                | vi.   | Fodder handling and feeding      |
| ii.  | Canopy management                           | vii.  | Aeration and pumping of ponds    |
| iii. | Shade net management                        | viii. | Humidification fans for orchards |
| iv.  | Fertilizer and fertigation pumps            | ix.   | Animal rearing and caring tools  |
| v.   | Irrigation of fields and watering livestock | x.    | Etc.                             |

**Protection phase**

- |      |   |      |                                      |
|------|---|------|--------------------------------------|
| i.   | Pesticide sprayer                           | v.   | Aerial shepherding                   |
| ii.  | Net management equipment for hail and birds | vi.  | Shed/ Stall/Pigsty cleaning machines |
| iii. | Water cleaning and treatment                | vii. | Etc.                                 |
| iv.  | Scarecrow machines                          |      |                                      |

**Harvest phase**

- |      |                            |       |                              |
|------|----------------------------|-------|------------------------------|
| i.   | Combine harvesters         | vii.  | Threshing & bagging machines |
| ii.  | Fruit harvesters           | viii. | Mechanical tree shaker       |
| iii. | Trawlers and fishing boats | ix.   | Haulm toppers                |
| iv.  | Milking machines           | x.    | Transport trailers           |
| v.   | Crate washing and cleaning | xi.   | Etc.                         |
| vi.  | Cotton picker              |       |                              |

**Waste handling**

- |      |  |     |                                      |
|------|--|-----|--------------------------------------|
| i.   | Silage and forage harvester                | iv. | Waste shredder and pulveriser        |
| ii.  | Stubble compacter and baler                | v.  | Waste digester & Composting machines |
| iii. | Cow dung handling, dung log making machine | vi. | Etc.                                 |

**5.3. Agricultural Mechanisation and Sustainability**

Injudicious deployment of mechanisation, can result in great harm to the agricultural sub-sectors in the long run. Past lessons abound, that demand that suitable foresight is applied before promoting mechanisation across the sub-sectors. Some of the major stresses on the

agricultural sector include concerns on sustainability are a result of intensive use of machines, without appropriate guidance and controls. For example, use of heavy machines can lead to soil compaction and affect infiltration and aerobic activities.

Machines can displace physical attendance and human application, and then, diligence and innovation can suffer. Age old skills and traditions also change and can get lost. Most importantly, intensity of deployment can result in acute distress in the basic bio-ecology on farms. Such examples abound in and across the agricultural sector:

- Free electricity and/or solar powered pumps allow for indiscriminate use of water, resulting in ground water depletion.
- Marine fishing, globally, has witnessed a depletion of fish and trawling has damaged sea beds.
- The ease in applying of chemicals can result in over dosing and leave harmful residue of pesticides and fungicides.

A multiplicity of outcomes can result from indiscriminate mechanisation. Here, the example of rice stubble in farms of north-west India is apt. The easy access to irrigation caused a shift into rice-wheat production system. The procurement system supplemented the economic growth and opened access to farm machines in large scale. Combine harvesters took over the task of farm animals, reducing that population. The residue on rice field was no longer usable or useful, leading to burning of stubble and associated pollution. In this case, mechanising the access to water brought a change in the cropping pattern, bringing rice into a zone where the society was not rice eating, and eventually led to the problem of stubble burning and corresponding air pollution.

Therefore, due application of cross-disciplinary inputs, to understand the long term implication of mechanisation, is an important learning to keep in mind. Nevertheless, the fact remains that mechanisation is a vital aspect in modernising agricultural systems.

Agriculture sector requires greater engineering inputs and introduction of high capacity, precision, reliable and energy efficient equipments. The agricultural machinery needs to be adequately supported by automation, GPS, remote sensing, data analysers and the like. Semi-mechanized nursery raising technology has been developed which needs to be popularized. Harvesting of fruits is still mostly manual. Packaging lines and equipment for on- farm processing and value addition of fruit and vegetables are needed. Sugarcane and cotton are another category of important commercial crops. As yet there is no deployment of affordable mechanical harvester for sugarcane and cotton. Likewise there are other crops that need mechanization for which concentrated efforts are required.

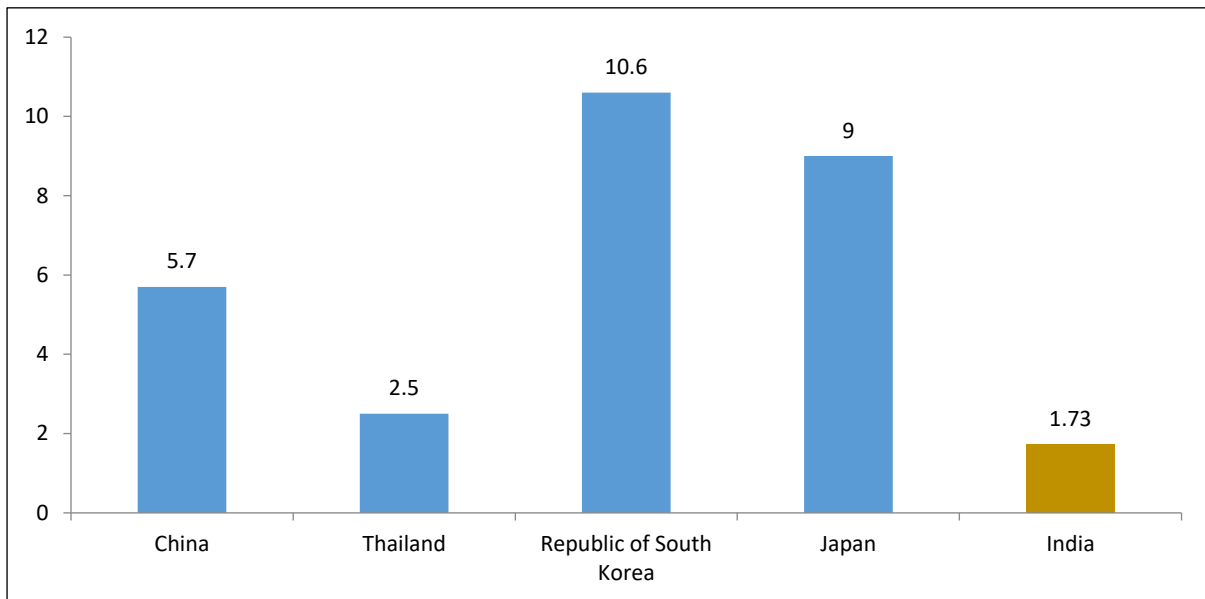
#### **5.4. Status of Farm Mechanisation**

Machines are normally rated by their power, the measure being horse power or kilo watt. The level of farm mechanisation in a country, is therefore, normally assessed on the availability of



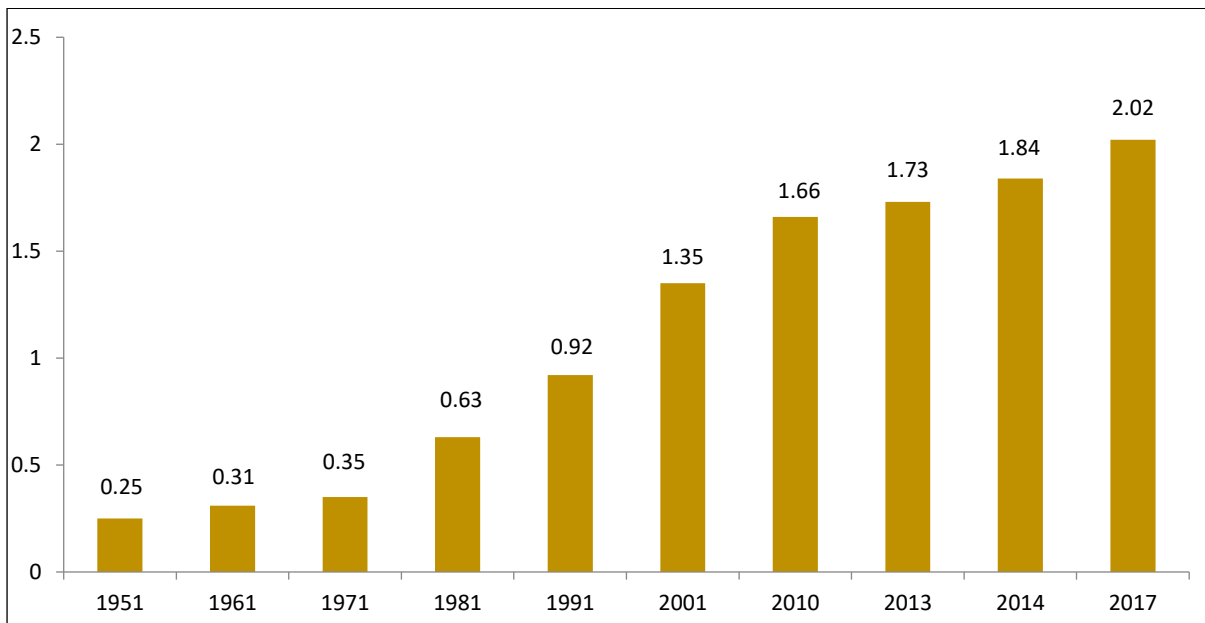
power per hectare. The following figure indicates this measure of power availability at farms across some Asia-Pacific countries.

**Figure 5.1: Farm power availability (kw/ha) (2013-14) in Asia Pacific Countries**



Though, availability of manpower is an important factor to consider when comparing farm power, it is still pertinent to note that India ranks last in the figure above. Since 2013, the farm power availability in India has increased by about 17 per cent to touch 2.02 kW/ha in 2017. The trend since 1951 is represented in the figure below.

**Figure 5.5.1: Trend in farm power availability in India (kw/ha)**



The average farm power availability in India has increased from 0.30 kW/ha in 1960–61 to about 2.02 kW/ha in 2016–17. The Government targets to achieve 3 kW/ha by 2020. The penetration of powered machines in various farm activities is assessed in the range of 40 to 45

per cent, and the share of mechanisation of field activities in 2016-17 is represented in the following table.

**Table 5.5.1: Share of farm mechanisation in farming operations**

<b>Operation</b>	<b>Percentage of operations mechanised</b>
Soil working & seed bed preparation	40
Seeding and planting	29
Plant protection	34
Irrigation	37
Harvesting and Threshing	60-70 % for wheat and rice and <5 % for others

The Government of India is promoting agricultural mechanisation on farms through a Sub Mission on Agricultural Mechanization (SMAM) of Rs. 2000 crore, which started from April 2014 under the umbrella of National Mission on Agricultural Extension and Technology (NMAET). The objectives of this Mission are:

- Increasing the reach of farm mechanisation to small and marginal farmers and regions with low farm power
- Promoting ‘Custom Hiring Centres’
- Creating hubs for hi-tech & high value farm equipments
- Awareness through demonstration and capacity building
- Ensuring performance testing and certification of Machines.

The pace of mechanisation needs to pick up further across the sub-sectors of agriculture, across crops and regions. It is worth chasing a target of 4.0 kw/ha. by 2022-23.

### **5.5. Strategy and Recommendations to suit Indian Agriculture**

Looking at the pattern of land holding in India, about 84 per cent of the holdings are below 4 ha. In this scenario of operational holdings, the individual ownership of agricultural machinery is made uneconomic and operationally unviable. The solution is to set up ‘Agriculture Machine Banks’ (AMBs) and ‘Custom Hiring Centres’ (CHCs) of agricultural machineries to allow small & marginal farmers access to powered machines, without the need to own the asset themselves. These Banks and Centres can be operated by Co-operative Societies, FPOs or VPOs, NGOs, Trusts, as well as private entrepreneurs and as CSR (Corporate Social Responsibility) activities.

The DFI Committee recommends a target of at least one custom hiring centre (CHC) in every large village or Gram Panchayat (GP) in case of small villages. The custom hiring centre should typically house the low order machines needed to suit the crops and production systems in that village. The recommendation does not restrict more than one such centre in a village and multiple such centres can be welcomed, depending upon crop area, cropping intensity and other likewise needs for mechanised support for agricultural works.

An Agricultural Machinery Bank (AMB) should be established at District level. The Bank is expected to house cost intensive machines like combine harvesters etc as well as high level maintenance and repair facilities. The order of investment in these centres would be about Rs.75 lakh to Rs.100 lakh.

As a third tier in the hierarchy of mechanisation, Regional/State level Service Centres may be promoted in the private sector. These can service large geographies and cater to specialised and a package of services. They may imply an investment of about Rs.150 to Rs.200 lakh.

Besides hiring of machines, a natural corollary is that farmers hire mechanised services as per their needs. This will alleviate the need for each farmer to own machinery and learn skills to operate the individual machines. Each Centre that rents machines can also rent out the associated package of service of that machine (the equipment and skilled manpower to deploy the machine efficiently and effectively). Such mechanised service enterprises for farmers, will also create jobs for skilled youth in that region.

The Committee also suggests that the Central government, in formulating a contract farming legal piece, include contracted services as part of the provision. As such, the formulation of a Model Contract Farming and Services Act that caters to various agricultural services including farm machinery is recommended.

The States must undertake district and block level crop/agriculture planning so that most appropriate type of development is carried out. This will ensure better capital use efficiency in farm mechanisation.

To promote and make mechanised tools available to farmers, it is necessary for the government to provide suitable and targeted support to farmers. The establishment of enterprises (CHC) that provide farming tools and machines is presently being supported through provision of subsidy. However, the farmers may also be provided support for the hire of such machines. The subsidy to farmers can be routed through the Aadhaar linked DBT (direct benefit transfer) mechanism to ensure that the support reaches right beneficiary. To prevent misuse or over use, the farmer may be required to pay the rental in full, to the CHC or AMB, and subsequently get relief in the rental through direct beneficiary transfer. The hiring facility would require to upload and confirm the utilisation including the running hours and other details of farmer, the field and type of equipment. This system would also provide granular data to the monitoring departments to assess better the mechanisation in use, and penetration of farm mechanisation in each region.

## **5.6. Aggregation Platform**

A number of professional service providers have emerged in the country catering to agricultural mechanisation on the principle of 'Pay Per Use' (PPU). These service providers offer a range of services on demand from the farmers. Since they serve a large hinterland, they can afford

to make huge investments of about Rs.200 lakh and manage to break even within 2-3 years. Going beyond machinery, they also cater to other facilities like labour etc.

It is possible to use the brand equity of such professional service providers and expand agricultural mechanisation via the franchise route. Such decentralised franchise holders can then improve service efficiency by combining their own machineries and deploying machineries owned by others including individual farmers on rental mode. The concept of aggregation platform already common in city taxi service can be replicated in agriculture machinery sector. City taxi services like Uber, Ola are household names globally. Uberisation of agriculture machinery is a win-win situation. To the individual owner, this helps in finding usage, when he does not need it and to the franchisee, the advantage is that he can expand his business with lower order investment and also increase the platter of services on offer. To the farmer not owning machinery, the advantage lies in availing of services without the bother of procurement, operation & maintenance and acquiring needed skills.

### **5.7. Appropriateness of Machinery**

The Indian agricultural structure engenders unique set of challenges in promoting farm mechanisation and need to be addressed appropriately. Some of these are:

- i. small size of farms;
- ii. hilly and rolling topography;
- iii. mixed cropping and integrated farming;
- iv. poor servicing facilities for proper operation & maintenance of machinery;
- v. poor financial ability of the farmer to invest in farm machinery.

The above context calls for indigenous Research and Development (R&D), so as to roll out farmer-friendly, location-specific and easy-to-manage agricultural machinery. It obviously calls for local designs to suit varying Indian conditions.

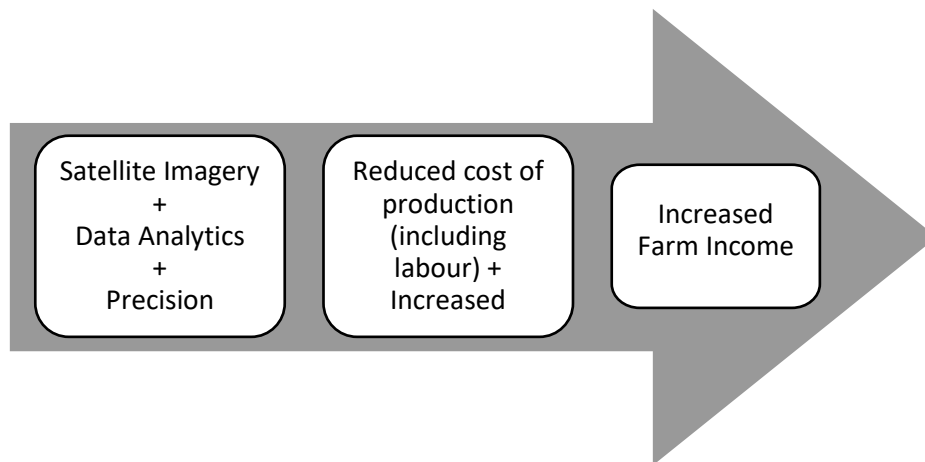
One of the key drivers of change in arriving at a more robust agriculture production system is certainly linked to engineering & technology. The domains of farm machinery, agro-processing, agri-logistics testing and fore-warning systems built on the power of engineering & technology (ICT) contain vast potential of transforming agriculture. These interventions can be expected to improve productivity, enable timeliness, and mitigate both natural and manmade risks that constrain agriculture today.

### **5.8. Going Beyond Mechanical Power**

Agricultural mechanisation based on mechanical power is a great step forward from human and draft power that has been the mainstay of Indian agriculture through millennia. In the recent decades, the dynamics of technology has been subject to break-neck speed and has found

utility in several economic domains.

Indian agriculture now set to transition from production to income-centric profession needs to invite new technology, as well, so as to operate the sector on the principles of enterprise. In the contemporary world, the trisection of three (3) important technologies, namely, satellite imagery, robotics and big data offer a new hope to Indian farming. These technologies combined with soil chemistry, artificial intelligence, sensors and Apps can help in transforming the way agriculture is practised, for they contain the potential of imparting efficiency all along the agricultural value chain, besides enhancing risk negotiation capability. It would not be out of place to enlist the following equation as a part of doubling farmers' income strategy.



**Some illustrations of technology deployment:**

Plant Health Indicator (PHI) – Satellite imaging can help in assessing the plant health. A healthy plant reflects a different colour on the satellite compared to an unhealthy one. Using satellite imagery, it is possible to create NDVI (Normalised Difference Vegetation Index). A low NDVI manifests sickness of the plant, suggesting fertilizer application or pest management. When this Index is used along with precision farming, the input use can be rationalised. This technology is already being tested in several places including in Telangana and Karnataka. Such services can be made available to the farmers on payment.

There are several other illustrations in practice already. Some of these are:

- Monitoring and Forecasting of weather
- Solar-powered phase change enabled materials for irrigation. This intervention is useful in areas with poor/unstable electricity and in case of small & marginal farmers.
- Dairy farm optimisation and monitoring services by leveraging IoT (Internet of Things), big data, cloud and mobility for improving milk production and procurement.

**5.9. Annotation**

Agricultural mechanisation is an important input to achieve higher productivity and mitigate costs in the agricultural sector. Availability of farming labour power is reducing, due to various

factors, including diversion of labour into other employment generation programs of the government. Even when available, it may not be available when needed and at affordable price to the farmer.

Mechanisation of farming/agriculture needs to include past learning, as it can lead to intensive cultivation, and negatively impact on long term sustainability. Research & Development activities on agricultural mechanisation on various farm operations and their possible outcomes is needed. Similarly, to ease the pressure of cost of machinery, local engineering and prototype development needs to be scaled up.

Agricultural mechanisation plans, must include farm waste management machines, so that farming residue is not committed to uneconomic disposal but becomes a viable off take from farming. The cost component of other social and environmental ramifications must be incorporated into such planning.

Access to mechanised tools, to small land parcels, is best promoted through developing common use assets at Custom Hiring Centres and Agriculture Machine Banks. As the demand for such equipments develops, these Centres can also rent out more comprehensive package of services. This will also be a mode of employment to skilled operators in the region. Farmers, who are skilled operators themselves, can find secondary income as operators once their own farm has been serviced.

## Chapter 6

### Credit and Capital Formation in Agriculture

*Finance is an overriding input that makes available the material inputs discussed in previous sections and chapters. Credit is the mechanism that enables access to finance, which commences the initial cycle of input, production and marketing. Credit allows for modernising agricultural practices, inducting new technologies, building risk taking ability, accessing markets and makes farming more productive. In addition to short term credit, which caters to seasonal production requirement of the farmer, he will also need long term investment credit to build infrastructure on his farm. Further, some common infrastructure for the farmers in a region will also be required.*

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#### I - Credit

##### 6.1. Context

Credit is an important component for cultivation, procurement and marketing and access to institutional credit at affordable rates would ease the practice of agriculture at the farmers' level. More importantly, it would wean away farmers from dependence on moneylenders and other informal sources. Empirical evidence suggests that output elasticity of farm credit is significant and positive; roughly every 1 per cent increase in agricultural credit producing 0.29 per cent increase in agricultural GDP and consequently aiding increased income.

Enhancing agricultural productivity requires the right kind of material inputs and their efficient use. These inputs, discussed in the previous chapters, are driven by access to finance. Financial inputs are made through the monetisation of the farmed produce, and by credit, in advance to the marketing of the produce. An efficient agricultural enterprise, should normally generate the necessary revenue for the next cycle of production and marketing. However, all businesses are not perfect and agricultural sector is not only not an exception, but is rather subject to many other random variables. Therefore, access to formal finance is crucial for farmers to upgrade and sanction their enterprise by managing the various inputs needed to achieve higher agricultural productivity.

Credit in the form of loans is used as working capital at the beginning of the growing season, as also at later stages of production & harvesting in order to purchase material inputs, prepare land or invest in farm machinery, as well for the harvest, processing, transport and to market the produce. Access to credit also allows a farmer the leeway to take risk, at every stage of the business including during marketing of the output. A successful business cycle would eventually reduce the need for credit, besides enhancing the farmer's ability to borrow and absorb higher credit.

The latest NSSO 70th round (year 2013) report reveals that among various sources of credit, there was high dependence on non-institutional channels. Nearly 40 per cent of loans came from informal sources and 26 per cent were advanced by moneylenders. Households having marginal landholdings suffer most with only 15 per cent of their credit coming from institutional sources like government, cooperatives and banks while for households in the highest land class (with land more than 10 hectares), the ratio is 79 per cent.

**Table 6.1 Indebtedness status of farmers**

Indebtedness of farmer households	2003	2013
Percentage of farmer households indebted	48.60	52
Average amount of outstanding loan (Rs)	12,585	47,000
Share of loans from institutional sources	57.70	60

*(Source: NSSO - SAS, 59<sup>th</sup> round 70<sup>th</sup> round)*

In 2003, out of 89.35 million farmer households, 48.6 per cent were reported to be indebted, with the average amount of outstanding loan amount per household being Rs 12,585 at the all India level. At the same time, 57.7 per cent of households had loans outstanding from institutional sources.

In 2013, indebtedness in terms of average amount of outstanding loan per agricultural household was about Rs. 47,000, with 52 per cent of the agri-households estimated to be indebted; and 60 per cent of the outstanding loans were from institutional sources, which is a minuscule improvement in terms of institutional coverage. That, the indebtedness among farmer households, as also the quantum of outstanding loan increased by 2013 over the year 2003, need not necessarily be considered as a negative change. While the first change can be attributed to better access to institutional credit, the second increase could be indicative of higher absorption capacity.

## **6.2. Growth in Agricultural Credit**

The recent past has witnessed a healthy growth in the flow of agriculture credit, particularly since the introduction of the policy of doubling of agriculture credit by the Government of India. Agriculture credit grew at an overwhelming rate of 35 per cent per annum during the doubling period (2004-05 to 2006-07). For the period from 2003-04 to 2016-17, compound annual growth rate (CAGR) of agriculture credit was 21.47 per cent. Ground level credit (GLC) increased by 16.41 per cent during 2016-17 over the previous year.

In terms of outreach of credit, during FY 2016-17 around 10.70 crore number of agricultural accounts had been financed as compared to 8.99 crore financed by all agencies taken together during 2015-16, thereby indicating that close to 77 per cent of the operational holdings are covered by institutional credit in the country<sup>3</sup>. However, this will require closer analysis, as it is possible that same farm families, whose members own different parcels of land are availing of the credit, and many others particularly those with outstanding debt are being left out. The Government of India has been setting annual targets for the flow of institutional credit to the agriculture sector, which are being happily surpassed by the banks. Table 6.2 presents a status in this regard.

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<sup>3</sup> Arrived at by dividing the number of accounts by the number of operational holdings (138 million as per Agri Census 2010-11) and assuming that they act as proxy for number of farmers and also assuming that there is no multiple accounts in a single operational holding.



**Table 6.2 Agricultural credit - targets and achievements since 2007-08**

Year	Target (Rs crore)	Achievement (Rs crore)	% Achievement
2007-08	2,25,000	2,54,657	113.18
2008-09	2,80,000	3,01,908	107.82
2009-10	3,25,000	3,84,514	118.31
2010-11	3,75,000	4,68,291	124.88
2011-12	4,75,000	5,11,029	107.58
2012-13	5,75,000	6,07,376	105.63
2013-14	7,00,000	7,30,123	104.30
2014-15	8,00,000	8,45,328	105.67
2015-16 *	8,50,000	9,15,510	107.70
2016-17 #	9,00,000	10,65,755	118.42

\*Data based on information furnished by SLBCs in respect of Commercial Banks and reporting banks in respect of RRBs and Cooperative Banks.

# Data submitted by Banks in ENSURE portal in respect of Cooperative and Regional Rural Banks and data furnished by Banks through mail in respect of Commercial Banks. Data on Term Loan includes disbursement under Agriculture Infrastructure and Ancillary activities.

**Table 6.3 Year 2016-17 – break up of agricultural credit (Rs. in crore)**

Particulars	Target for 2016-17	Achievement	% achievement
Short Term Agr. Loan (Crop Loan)	6,15,000	6,89,457.32	101.25
Agr. Term Loan (Investment Credit)	2,85,000	3,76,298.35	118.29
<b>TOTAL AGRI CREDIT</b>	<b>9,00,000</b>	<b>10,65,755.67</b>	<b>118.42</b>

Source: Data submitted by Banks in ENSURE portal in respect of Cooperative and Regional Rural Banks and data furnished by Banks through mail in respect of Commercial Banks. Data on Term Loan includes disbursement under Agriculture Infrastructure and Ancillary activities.

As seen above, institutional credit has two components,

- Crop loan – short term agricultural loan
- Investment loan – long term agricultural loan

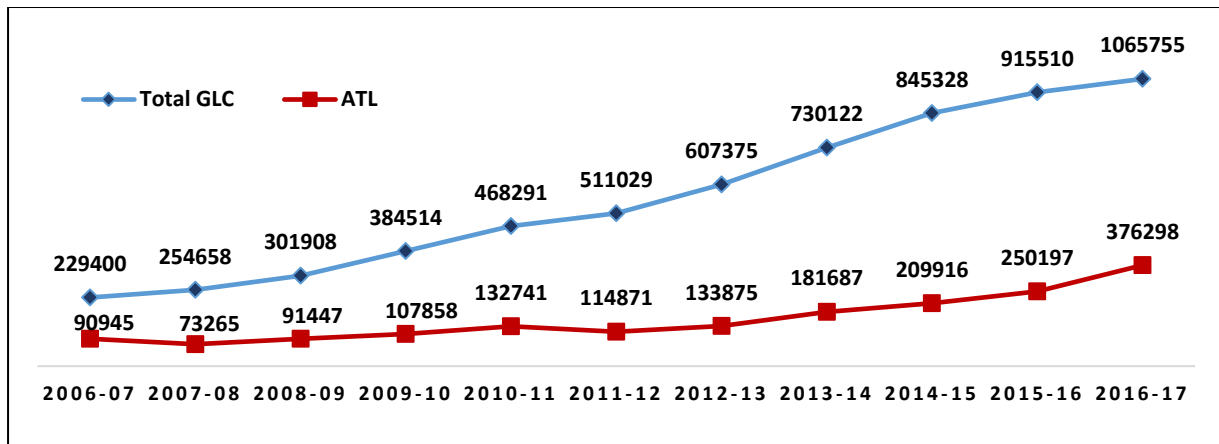
### **6.3. Short Term Credit and Investment Credit (LT)**

While crop loans meet the seasonal production credit demand of the farmer, investment loans contribute to capital formation in agriculture and sustain production in the long run. Both of these loan categories are important for an efficient agricultural enterprise.

As has been well recognised, credit acts as an enabling factor in the agricultural production and post-production processes at the farmers' level. The link is indirect, as it provides command over other inputs (and resources) like seeds, fertiliser, water, machinery etc. Both short term credit and investment credit aid the production process – while crop loan helps by sustaining

it, investment credit helps in generating the capacity to further expand agricultural production through capital formation in agriculture. A disquieting feature of agriculture credit in India, however, has been the poor share of investment credit in the total agriculture credit. In 2003-04, the share of investment credit in total agriculture credit was 37 per cent, which improved to 42 per cent in 2005-06 but declined to 19 per cent in 2013-14. However, with renewed emphasis on Term Loan, the share of investment credit in total agriculture credit has started showing signs of improvement as seen from 35.30 per cent in the year 2016-17.

**Figure 6.1 Trend in GLC and Term loan (Rs. crore)**



*Source: IBA, SLBC, NABARD & NABARD Ensure Portal (from 2016-17 onwards),*

#### Flow of Agri. Term Loan (ATL) (2006-07 to 2016-17) - Highlights

- Share of ATL declined from peak of 42 per cent in 2005-06 to 35 per cent in 2016-17.
- Improvement in ATL during 2015-16(27.33%) and 2016-17 (35.30%), is a positive trend which needs to be sustained.
- Low growth in ATL adversely impact agricultural growth, as it compromises capital formation in agriculture, which is essential to trigger high growth rate.

#### 6.4. Ground Level Credit – Share of Various Agencies

One of the prominent features of the trends in ground level credit (GLC) is the change in share of various agencies. Disaggregated data (Table 6.4) indicates that the share of cooperative banks which was around 40 per cent of GLC in agriculture during 1999-2000, has reduced to an average of 17 per cent since 2009-10. During the corresponding period, the share of commercial banks, which was 53.7 per cent in 1999-2000, increased to settle at an average of 72 per cent from 2009-10 to 2014-15. While, it came down to 70.2 per cent in 2015-16, it improved to 75 per cent in 2016-17.

The share of Regional Rural Banks (RRBs) improved their share from 6.9 per cent in 1999-2000 to 13 per cent by 2015-16. However, both Cooperatives and RRBs have shown a decline

in their share thereafter.

It is interesting to note that the cultivator household's share of outstanding debt in respect of commercial banks fell from 35.2 per cent in 1992 to 30.7 per cent in 2013, hinting at such lending going to non-cultivators households.<sup>4</sup> This is not a good sign from the perspective of agriculture.

**Table 6.4 Share of agencies in total agricultural GLC (Rs. crore)**

Year	Comm. Banks		RRBs		Coop Banks		Total GLC
	Amount	% to total	Amount	% to total	Amount	% to total	
1999-2000	24836	53.7	3172	6.9	18260	39.5	<b>46268</b>
2004-2005	81674	65.2	12404	9.9	31231	24.9	<b>125309</b>
2009-2010	285800	74.3	35217	9.2	63497	16.5	<b>384514</b>
2013-2014	527506	72.0	82653	11.0	119963	16.0	<b>730122</b>
2014-2015	604376	71.5	102483	12.1	138469	16.4	<b>845328</b>
2015-2016 *	642954	70.2	119261	13.0	153295	16.8	<b>915510</b>
2016-2017 #	799781	75.0	123216	11.5	142758	13.5	<b>1065755</b>

\*Data based on information furnished by SLBCs in respect of Commercial Banks and reporting banks in respect of RRBs and Cooperative Banks.

# Data submitted by Banks in ENSURE portal in respect of Cooperative and Regional Rural Banks and data furnished by Banks through mail in respect of Commercial Banks. Data on Term Loan includes disbursement under Agriculture Infrastructure and Ancillary activities

For the period 2007-08 to 2016-17, on an average while the cooperative banks financed around 267 lakh number of agricultural accounts annually, the corresponding figure in case of commercial banks was 329 lakh.

**Table 6.5 Agency-wise number of agricultural GLC account (2007-08 to 2016-17)**

Agency	(No. of Acntts. in lakh)									
	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16 *	2016-17 #
Commercial Banks	175	202	205	234	255	307	385	426	442	664
Cooperatives	202	178	204	242	309	311	321	306	324	269
RRBs	63	75	73	73	82	85	99	121	133	137
<b>Total</b>	<b>440</b>	<b>455</b>	<b>482</b>	<b>549</b>	<b>646</b>	<b>703</b>	<b>805</b>	<b>853</b>	<b>899</b>	<b>1070</b>

\*Data based on information furnished by SLBCs in respect of Commercial Banks and reporting banks in respect of RRBs and Cooperative Banks.

# Data submitted by Banks in ENSURE portal in respect of Cooperative and Regional Rural Banks and data furnished by Banks through mail in respect of Commercial Banks. Data on Term Loan includes disbursement under Agriculture Infrastructure and Ancillary activities

<sup>4</sup> Based on Ramakumar, R. and Chavan, Pallavi (2014), "Bank Credit to Agriculture in India in the 2000s: Dissecting the Revival," Review of Agrarian Studies, vol. 4, no.1

Agency-wise flow of GLC - Highlights

- Share of Cooperatives declined from 39 per cent in 1999-2000 to 13.5 per cent in 2016-17 but that of RRBs improved from 6.9 per cent to 11.5 per cent during the same period.
- Commercial Banks emerged as a major player during this corresponding period.
- There has been improvement in the access of small & marginal farmers (SMF) to institutional credit.

### 6.5. Regional Imbalance in Credit Disbursement

Regional imbalance in the disbursement of agriculture credit has persisted over the years. Despite the healthy growth achieved in agriculture credit, the disbursement discrepancies remained uncorrected. Between the tenth and eleventh plan period the imbalance has accentuated with the major share getting further skewed in favour of the southern region.

Empirical evidence indicates that there is a growing disconnect between the real sector parameters and regional distribution of agriculture credit. For example, the central region of the country accounts for 27 per cent and 32 per cent of the Gross Cropped Area (GCA) and Gross Irrigated Area (GIA) respectively, and with a cropping intensity of 139 per cent accounts for hardly 13 per cent of the agriculture credit disbursed during the 11<sup>th</sup> Five Year Plan period.

Among all the regions in the country, the eastern region has the highest cropping intensity (151 per cent) and with 14.65 per cent share in GCA and 15.25 per cent in GIA accounts for hardly 7.54 per cent of agriculture credit disbursed during the 11<sup>th</sup> plan. The southern region accounts for around 18.68 per cent GCA and 16.35 per cent GIA, respectively but accounted for the highest share (39.9 per cent) of agricultural credit disbursed during the 11<sup>th</sup> plan. The situation has been showing marginal improvement with an increasing share of eastern and north eastern regions in the total GLC, as observed in 2016-17 figures.

**Table 6.6 Regional distribution of agriculture credit and real sector indicators (%)**

Regions	Share in total agri. GLC			Real Sector Indicators				
	10 <sup>th</sup> FYP	11 <sup>th</sup> FYP	2016-17	Share in GCA #	Share in GIA #	Cropping Intensity #	Share in Food grain production	Share in rural/ semi urban branches ^
<b>Northern</b>	28.69	26.01	21.85	20.11	26.32	148	26.58	17.35
<b>N E R</b>	0.38	0.62	0.82	2.83	0.68	128	2.02	3.04
<b>Eastern</b>	6.67	7.54	8.15	14.65	15.25	151	16.37	16.38
<b>Central</b>	15.1	12.58	14.68	27.26	31.66	139	30.55	20.73
<b>Western</b>	14.17	13.33	12.83	16.47	9.74	114	8.31	15.68
<b>Southern</b>	34.99	39.92	41.67	18.68	16.35	124	16.17	26.82

# GCA- Gross Cropped Area, GIA- Gross Irrigated Area. GCA and GIA are averages for the period 2007-08 to 2011-12).  
^Source: RBI DBIE website (for Commercial Banks and RRBs) and NABARD (for Cooperative Banks) – As on 31-03-2017.

**Table 6.7 Region wise GLC flow under agriculture during 2015-16 & 2016-17 & target for 2017-18**

(Rs. in Cr.)

Region	2015-16		2016-17		2017-18	
	Achv.	% to Total	Achv.	% to Total	Target	% to Total
North	216919.14	23.69	232846.88	21.85	229212	22.92
North East	5832.70	0.64	8772.66	0.82	11513	1.15
Eastern	103673.28	11.32	86860.25	8.15	130140	13.01
Central	153289.31	16.74	156475.93	14.68	196330	19.63
Western	107933.83	11.79	136786.56	12.83	129195	12.92
South	327861.66	35.81	444013.39	41.66	303610	30.36
<b>Total</b>	<b>915509.92</b>	<b>100.00</b>	<b>1065755.67</b>	<b>100.00</b>	<b>1000000</b>	<b>100.00</b>

### 6.5.1. The regional trends in agricultural credit flow

i) The Eastern Region with 14.65 per cent share in Gross Cropped Area and 8.63 per cent share in Agri GDP (2015-16 at current prices) accounted for hardly 9.47 per cent and 11.32 per cent of the total agriculture credit disbursed in the country during 2014-15 and 2015-16 respectively. The % share dropped to 8.15 per cent during 2016-17.

ii) The North Eastern (NE) Region with a very small share of 2.83 per cent in Gross Cropped Area and 3.79 per cent share in Agri GDP (2015-16 at current prices) accounted for a meagre 0.53 per cent and 0.64 per cent of the total agriculture credit disbursed in the country during 2014-15 and 2015-16 respectively. However the share improved marginally to 0.82 per cent during 2016-17.

iii) The Central Region with 27.26 per cent share in Gross Cropped Area (2014-15) and 25.04 per cent share in Agri GDP (2015-16 at current prices) accounted for only 15.75 per cent and 16.74 per cent of the total agriculture credit disbursed pan-country during 2014-15 and 2015-16 respectively, which declined to 14.68 per cent during 2016-17.

iv) This disparity is in spite of the fact that the Central, Eastern and NE Regions have reasonable banking infrastructure in term of rural and semi-urban branch network.

### 6.6. Inclusiveness of Agriculture Credit System

**Coverage of Small and Marginal Farmers (SMF)** - Land holding pattern in the country is dominated by small and marginal farmers (SMF) category. Roughly 85 per cent of the total operational holdings in the country (about 43 per cent of the gross cropped area) are in the SMF category.

Providing timely and affordable credit to this resource constrained group is the key to attaining

inclusive growth. For the system as a whole, on an average (2007-08 to 2016-17) 60.60 per cent of the agriculture accounts belong to SMF category; whereas, in terms of amount disbursed the share of SMF is 40.46 per cent. However, agency-wise differences are observed.

**Table 6.8 Agency-wise share of SMF in total Agriculture credit (average for 2007-08 to 2016-17)**

SN	Agency	Share (%) of SMF	
		Number of accounts	Amount Disbursed
1	Comm. Banks	54.17	33.90
2	Coop. Banks	64.93	54.66
3	RRBs	68.67	63.07
4	Total	60.60	40.46

*Source: GOI, IBA & SLBC*

Of the total agriculture credit disbursed by 3 categories of lenders, namely commercial banks, cooperative banks and RRBs during the period of 2007-08 to 2016-17, the credit share of small and marginal farmers (SMF) is observed to be 33.90, 63.07 and 68.67 per cents respectively. In terms of average number of accounts, the share of SMF was 54.17, 64.93 and 68.67 per cents for commercial banks, cooperative banks and RRBs, respectively for the same period. This demonstrates that the cooperatives and RRBs fared better than commercial banks, so far as serving the interests of small and marginal farmers is concerned, with respect to both physical and financial terms.

The latest data shows that share of SMF accounts in total number financed by all agencies grew from 60.07 per cent in 2015-16 to 72.06 per cent in 2016-17. More importantly, in terms of amount disbursed, the share of SMF grew from 41.51 per cent (in 2015-16) to 50.14 per cent (in 2016-17).

**Table 6.9 Ground level credit flow to Agriculture – share of SMF**

Year	Agency	No of accounts (Rs. lakh)			Loan disbursed(Rs. crore)			Avg loan to SMF (Rs.)
		Total	SMF	SMF Share (%)	Total	SMF	SMF Share (%)	
2013-14	Com. Banks	385.26	232.52	60.35	527506	201296	38.16	86572
	Coop. Banks	321.37	206.05	64.12	119964	69352	57.81	33658
	RRBs	99.27	66.62	67.11	82653	51359	62.14	77092
	<b>Total</b>	<b>805.90</b>	<b>505.19</b>	<b>62.69</b>	<b>730123</b>	<b>322007</b>	<b>44.10</b>	<b>63740</b>
2014-15	Com. Banks	426.19	195.44	45.86	604376	197540	32.69	101075
	Coop. Banks	306.86	202.77	66.08	138470	78736	56.86	38830
	RRBs	120.5	87.82	72.88	102483	70390	68.68	80153
	<b>Total</b>	<b>853.55</b>	<b>486.03</b>	<b>56.94</b>	<b>845328</b>	<b>346666</b>	<b>41.01</b>	<b>71326</b>

Year	Agency	No of accounts (Rs. lakh)			Loan disbursed(Rs. crore)			Avg loan to SMF (Rs.)
		Total	SMF	SMF Share (%)	Total	SMF	SMF Share (%)	
2015-16*	Com Banks <sup>^</sup>	441.62	210.15	47.59	642954	200346	31.16	95335
	Coop. Banks	324.20	232.90	71.84	153295	97999	63.93	42078
	RRBs	133.24	96.99	72.79	119261	81653	68.47	84187
	<b>Total</b>	<b>899.06</b>	<b>540.04</b>	<b>60.07</b>	<b>915510</b>	<b>379998</b>	<b>41.51</b>	<b>70365</b>
2016-17#	Com. Banks	664.16	482.47	72.64	7,99,781	3,62,675	45.35	69783
	Coop. Banks	269.54	190.10	70.53	1,42,758	89,178	62.47	46207
	RRBs	136.98	98.98	72.26	1,23,216	82,496	66.95	80504
	<b>Total</b>	<b>1070.68</b>	<b>771.55</b>	<b>72.06</b>	<b>10,65,755</b>	<b>5,34,351</b>	<b>50.14</b>	<b>69256</b>

Source:

\*Data based on information furnished by SLBCs in respect of Commercial Banks and reporting banks in respect of RRBs and Cooperative Banks.

# Data submitted by Banks in ENSURE portal in respect of Cooperative and Regional Rural Banks and data furnished by Banks through mail in respect of Commercial Banks. Data on Term Loan includes disbursement under Agriculture Infrastructure and Ancillary activities

## 6.7. Constraints in Financing Small and Marginal Farmers

### 6.7.1. Declining size of land holding

Division and fragmentation of land ownership has limited the credit absorption capacity of SMF and slowed down GLC in agriculture. Banks are also reluctant to finance SMFs on account of high transaction and monitoring costs. The share of small-sized and mid-sized accounts (loans up to Rs. 2 lakh) in direct financing to agriculture (outstanding), has declined from 47 per cent of total agricultural finance as at the end of March 2009 to almost 42 per cent by the end of March 2013. At the same time, the share of loans disbursed under the Rs. 2 lakh – Rs. 10 lakh category increased from 23 per cent to almost 30 per cent during the same period. It should be ensured that lending to small and mid-size accounts, which normally corresponds with small & marginal farmers does not suffer. Capital formation is necessary on all sizes of farms.

### 6.7.2. Lack of proper Record of Right

In a security-oriented system of lending (especially in case of agriculture credit), followed in India, the inadequate availability of collateral was considered as the major reason for low penetration of institutional credit (particularly investment credit) amongst SMF and landless farmers. Often small holders are not able to use their holdings as collateral due to the absence of proper titles or Record of Rights (ROR). This needs priority attention.

### **6.7.3. Increased share of tenant farmers/share croppers**

Ever-increasing urbanisation and migration from rural areas, along with fragmentation of land holdings, has accelerated the proliferation of tenant farming in the country. As per National Sample Survey reports, the leased-in area as percentage of operated area at the all India level was 10.88 per cent in 2012-13, an increase of 4.38 percentage points over a decade from 6.5 per cent recorded in 2002–03 (GoI, 2014).

### **6.7.4. Notion of high NPAs**

Besides higher transaction costs, another reason often cited for the tepid response to agriculture loans, especially to small farms, is the high prevalence of non-performing assets (NPAs) in the sector. However, such an argument is not supported by any data as NPAs in agriculture are almost comparable with other sectors under priority sector lending (PSL). As on March 2014, RBI (2014) reported that the overall NPA has been increasing across sectors and that the phenomenon is not confined to agriculture alone.

## **6.8. Coercive action for repayment**

A recent study by Institute of Social & Economic Change (ISEC), commissioned by the Ministry of Agriculture shows that one of the reasons reported in instances of farm suicides was the pressure to repay. Among causes related to farming were unmet expectations of more credit, in some states. What is worth noting is that in states such as Kerala, Tamil Nadu, Uttar Pradesh and Haryana, victim families were under greater pressure from banks to repay loans compared to non-institutional sources like moneylenders.

## **6.9. Anomalies in the Priority Sector Lending (PSL) in Agriculture**

There has been a sharp increase in the share of large-sized loans (Rs. 10 crore and above) in agricultural credit (R. Ramkumar, Tata Institute of Social Sciences). Similarly, there is a substantial increase in the share of agricultural credit outstanding from urban and metropolitan branches of banks. Further, a concentration of disbursement of agricultural credit from January to March is perplexing given that this is not the normal borrowing period for farming operations by farmers.

Loan size or credit limit per borrower being allowed to be large with norms that are constantly increasing the limit is said to be taking away agriculture credit meant for farmers, that too smallholder farmers to non-farmer borrowers. Input dealers, State Electricity Boards, Agri Clinics, Rural Electrification Corporations, NBFCs, food processing units etc., are all part of such borrowings. While the RBI directed that banks should try to meet at least 13.5 per cent to direct credit and ensure that the credit flow to non-corporate borrowers should not fall below the three-year system wide average, the distinction between direct and indirect lending has been removed, and needs to be made explicit with distinct allocations. With loan limits increasing, it is apparent that other borrowers end up occupying larger space in agriculture PSL.



## **6.10. The Way Forward: Strategies for Financing SMF**

### **6.10.1. Strict adherence of target group stipulations**

Latest PSL guidelines by RBI stipulate that within the 18 per cent target outlined for agriculture, 8 per cent of Adjusted Net Bank Credit (ANBC) or credit equivalent amount of off balance sheet exposure, whichever is higher, be prescribed for small and marginal farmers. This is to be achieved in a phased manner i.e., 7 per cent by March 2016 and 8 per cent by March 2017.<sup>5</sup> As on 31 March 2017, the share of SMF in disbursements to agriculture stands at 50.14 per cent. All the agencies also achieved the target for the year 2016-17. This performance should be maintained by the banks in the coming years as well to achieve the stipulation set by RBI. In addition, there is need to place a sub-limit in reference to loans to tenant farmers and share croppers, and appropriate credit targets could be fixed for tenant farmers and sharecroppers to make this mechanism more inclusive.

### **6.10.2. Farmers' mobilisation**

Farmers' Producer Organisations (FPOs) help in overcoming the challenges of high transaction costs, security stipulations of loans and also support smallholders in gaining access to markets, public services, better price etc., through collective action.

Producer Organisations Development Fund (PODF) set up in NABARD in 2011–12, supports producers' organisations (POs) to spearhead promotional, credit-plus activities, aggregation, processing and marketing activities to ensure better income realisation to its members.

Producers Organisation Development and Upliftment Corpus Fund (PRODUCE) was set up in NABARD with a corpus of Rs 200 crore for promotion and nurturing of 2,000 FPOs through financial and non-financial support. As on 31 March 2017, 2157 FPOs comprising about 7 lakh farmers, spread over 29 states, have been formed, of which 1922 FPOs have been registered. Grant assistance of Rs. 193.15 crore sanctioned for three years of which Rs. 63.58 crore disbursed as on 31 March 2017.

SFAC also has been promoting FPOs. NABARD and SFAC with active support from state governments needs to ramp up farmers' mobilisation. With income tax exemption now available to FPOs registered under the Indian Companies Act, for a period of 5 years upto an annual turnover of Rs. 100 crore the scope for mobilisation of farmers is higher.

### **6.10.3. Joint Liability Groups (JLGs)**

JLGs have proved to be the best medium for financing landless farmers, tenant farmers, sharecroppers and oral lessees and the success of the programme had led to the declaration of GoI a plan to finance 5 lakh tenant farmers in 2015–16. NABARD's support towards awareness creation and capacity building of the stakeholders and members of JLGs, promoted and financed by banks, stood at 17.52 lakh and 24.53 lakh at the end of March 2016 and March

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<sup>5</sup> Master Circular No. FIDD.Co.Plan.BC.04/04.09.01/2015-16 dated July 1, 2015, RBI

2017 respectively.

There is a need to look at JLGs as potential stable institutions of farmers and not look at them only as institutions for a limited credit period time window. For this, the investments in promoting and strengthening JLGs and system-building within JLGs is important. Such investments has happened with the women's SHGs in the country which translated into significant SHG-Bank Linkage that led to inclusion of the left-out. Experience shows clearly that this model of financial inclusion was clearly beneficial to the banks too.

#### **6.10.4. Land lease markets**

Land lease markets need to be reformed to ensure availability of land for cultivation to marginal and small farmers. There is a need to have a legal framework that secures operational freedom of tenure for tenants during the period of contract as also the right of the land owners to resume use of land after the period of contract is over. Here, the experience of Andhra Pradesh with its statute called Licensed Cultivators Act which gives a Loan Eligibility Card (LEC) to lessees, while protecting the land ownership right of the lessor is worth looking into and improving upon. A Model Act on similar lines for the country is required.

#### **6.10.5. Land records and digitisation**

Computerisation of land records is primarily a facilitative process with a much broader objective. Access to computerised RORs has reportedly reduced the time taken for submitting copy of RoR to banks, which in turn, has helped the farmers in availing bank loans quickly. Banks are also able to access information on property rights by viewing/checking records, including abstracts of past transactions i.e. Encumbrance Certificates (ECs) and RORs online.

At present, many farmers are not able to avail agriculture loan for want of Record of Rights or non-issue of ROR for sub-divided land holdings. State Governments may issue Land Pattas/Record of Rights to all farmers who have inherited land through subdivision of their family property, irrespective of the size of the landholding inherited by them. This will help farmers who wish to avail loan for agriculture (ST/LT) to do so without any administrative hurdles.

#### **6.10.6. Infrastructure and common assets**

Access to common resources is crucial in reducing the cost of cultivation and accelerating private investment; thereby, provide better and stable net income. There is a need to fine-tune the current subsidy purveying system so that the vulnerable sections are benefitted the most in comparison to the current system of larger share being cornered by bigger farmers. Channelling incentives (in the form of subsidies), to SMF groups for custom hiring centres, will generate more externalities, lead to improvement of productivity per unit of crucial inputs and improve net income of small farms.

### **6.11. Other Bank related Concerns**

The following are some other issues which the banks need to take note of and take corrective

steps:

- i. Standardization of MIS (Management information system) as per RBI guidelines
- ii. Review in SLBC/DCC – Interventions for doubling of farmers' income by 2022 & “Stand Up India” scheme
- iii. Low CD ratio – bank wise/ branch wise strategy road map for increased lending
- iv. Encourage economic associations of SMF – FPOs, FPCs, Farmer federations
- v. Focus on handloom & handicraft sectors
- vi. Agri Term Loan at competitive rates
- vii. Simplicity & uniformity of loan application forms
- viii. Improved term lending through Area Based Schemes
- ix. Financing of Bhoomi Heen Kisans/Artisans/JLGs/SHGs
- x. Upscaling of Bank Sakhi Model

### **6.12. Way Forward**

The strategy for improved credit environment must be pivoted on the following suggestions:

- i. More efforts needed for dispensation of long term credit to boost capital formation.
- ii. Share of loans to SMF in total loans to agriculture to be raised, as per the revised PSL guidelines of RBI.
- iii. Regional imbalances - Special focus on eastern, central, hilly and north eastern states needed.
- iv. Enhance Inclusion process – coverage of new farmers.
- v. Production response not commensurate with credit intensity - flagging marginal productivity of credit is an issue that needs to be addressed.
- vi. Encourage aggregation / collectives of farmers/ FPOs
- vii. Promotion of JLGs as an alternative channel to enable tenants to get credit from Institutional sources.
- viii. Bringing new farmers and farmers who have not availed institutional credit under banking fold and issuance of KCC to them.
- ix. Ensuring adequacy of credit to farmers, especially central, eastern and north eastern region states.
- x. All State Cooperative Banks (SCBs) and District Central Cooperative Banks (DCCBs) should have strong LT (long term) lending programme for agriculture and allied activities in good measure.
- xi. Most of the cooperative banks (whether LTCCS or STCCS) lack skill sets for term lending and hence, have low share in term lending. There is a need for massive scale

reskilling of cooperative personnel for handling LT lending activity. GOI (MoA&FW) may like to support these capacity building measures for cooperative credit structure appropriately.

## II

### **Capital Formation in Agriculture**

#### **6.13. Inconsistent about Capital Formation**

In the context of agriculture, capital formation is a major driver of agriculture productivity and growth. The concept and measurement of Capital has engaged the attention of economists since long. A plethora of literature, with both theoretical and empirical evidence, is available on the subject.

In developed countries, the concept of capital in agriculture has been broadened to include apart from fixed capital investment, livestock and tree stock. In the case of developing countries, the measurement with regard to capital formation is largely based on fixed capital investment, while differences exist across countries in terms of methodology used for capturing capital formation in the sector. Therefore, direct comparisons of capital formation in agricultural sectors, between countries can lead to misleading conclusions.

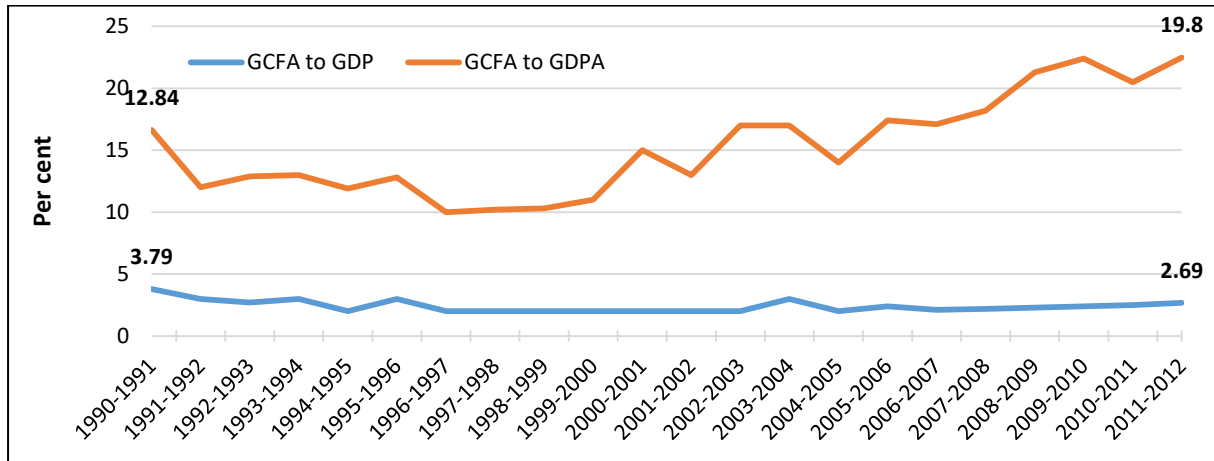
#### **6.14. Trends in Agricultural Capital Formation since the 1990s**

The trends in agricultural capital formation especially since the nineties and break up between public and private sector are analysed using CSO (narrow series) data for the purpose. The ratio of Gross Capital Formation in Agriculture (GCFA) to GDP from agriculture was 12.69 per cent in 1990-91; it has gone through various phases and reached 19.8 per cent in 2011-12. The ratio reflects the investment rate in agriculture and the increase in this ratio is reflective of the fact, that income generated from the sector is being ploughed back into the sector as investment. However, this increase has been more pronounced during the latter period.

- From 1990-91 to 1999-2000 (except 1991-92 and 1992-93) the investment rate in agriculture (captured by the ratio of GCFA to GDP emanating from the sector) has continuously declined and during the period 1999-2000 to 2003-04, it saw a fluctuating trend. However, starting 2004-05, there has been a continuous increase in the ratio (except 2010-11).
- In six years i.e., 2005-06 to 2011-12 the investment rate in agriculture jumped from around 15 per cent (2005-06) to 20 per cent (2011-12). This period also saw three important developments in the field of agriculture credit: (a) Doubling of Agriculture Credit Programme (2004-05 to 2007-08), (b) Providing crop loans at 7 per cent through the Interest Subvention Scheme for Crop loans (not for term loans) in 2006-07, and (c) Debt Waiver of agricultural loans in 2008-09.

The ratio of capital formation in agriculture (GCFA) to overall GDP has stagnated at a level below 3 per cent. The average was 2.67 per cent for the period 1990-91 to 2011-12.

**Figure 6.2 Trends in Capital Formation in Indian Agriculture (at 2004-05 prices)**



Source: CSO Data. GOI

## 6.15. Investment 'For' Agriculture: Rural Infrastructure

### 6.15.1. Rural Infrastructure

Broadly, rural infrastructure can be grouped under two broad heads; the physical and social facilities. The physical infrastructure covers power, communication, irrigation, transportation and their forward and back-ward linkages, while the social infrastructure services include water supply, education, health, sanitation, etc. The capital invested in infrastructure as defined above is considered as prerequisite for the success of economic development.

### 6.15.2. Crucial role of states/UTs

The rural infrastructure projects have their own special features, i.e., (i) large capital requirement; (ii) high sunk cost, (iii) a large proportion of the cost has to be irrevocably committed upfront before the project becomes operative, (iv) long gestation periods, (v) returns are slow to pass in, (vi) sector is sensitive to local social, political and cultural environment and policy changes and (vii) the services produced/generated are non-tradable.

The excess services generated cannot be stored or exported and deficiency in service cannot be met with by imports except for certain exceptions. All these make private capital entry difficult in the basic rural infrastructure sector. It is also important to mention, that the population that requires such infrastructure has such low levels of income and standards of living that their ability to pay is low. Therefore, the states need to invest in such infrastructure - water, sanitation, roads and housing in a more focused approach.

## 6.16. Share of Public and Private Sector in GCFA

Private sector constitutes the dominant share in the total GCFA. In 2011-12 the share of private sector was 85 per cent of the total capital formation in the agriculture sector. During the

eighties, the public agencies share (average) was around 42 per cent indicating the critical role played by it post green revolution in boosting capital formation in agriculture. This has however plummeted since the 1990s.

The secular decline in the share of the public sector seen over the decades has however started showing signs of reversal after 2013-14 (Table 6.10). For the period 1999-2000 to 2011-12, the trend growth rate for GCF in agriculture was 6.8 per cent (at constant prices). The GCF for public and private sector grew at 4.6 per cent and 7.4 per cent, respectively.

As elaborated in the paragraphs above, private sector capital formation comprises private corporate sector and individuals/ household sector. In a scenario where almost 85 per cent of the capital formation comes from the private sector the role of institutional credit in funding agriculture hardly needs to be emphasized.

**Table 6.10 Share of public and private sector in total capital formation (in Agriculture and allied activities)**

Sector	1970s	1980s	1990s	2000s	2011-12	2015-16
<b>Private</b>	66.5	58.3	76.1	81.1	84.9	81.98
<b>Public</b>	33.5	41.7	23.9	18.9	15.1	18.02

*Source: National Accounts Statistics and National Accounts Statistics, 2017.*

### 6.17. Private Sector Capital Formation and Long term credit

Agriculture credit can be classified into short term loans and long term loans (investment credit). Banks (Commercial banks, Cooperative banks and RRBs) disburse both types of loans through the banking system.

Crop loans are largely for funding the working capital requirements of farmers, while term loans are utilized for assets generation at farmers' level (read capital formation). The available evidence indicates the strong association between the term loans disbursed and private sector capital formation in agriculture.

**Table 6.11 Private sector GCF in Agriculture and long term credit-All India**

(in current prices, Rs. Crore)

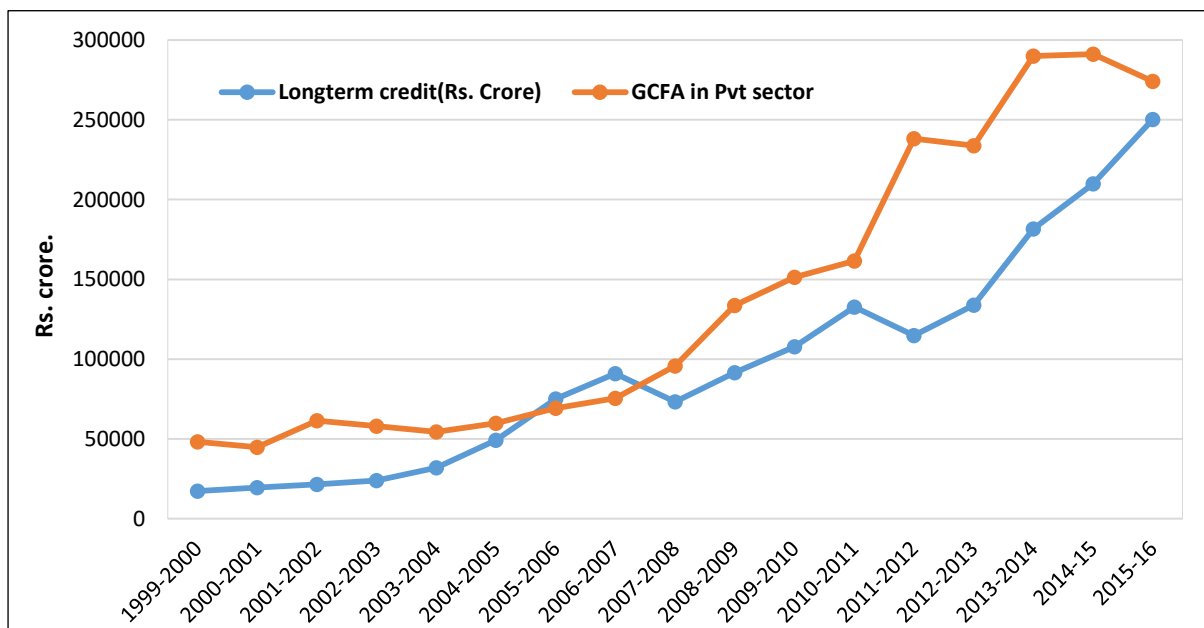
Year	GCF in Pvt sector	Long term credit (Rs. crore)	LT credit as % GCF in Pvt sector
<b>1999-2000</b>	48126	17303	35.95
<b>2000-2001</b>	44751	19513	43.60
<b>2001-2002</b>	61341	21536	35.11
<b>2002-2003</b>	57959	23974	41.36
<b>2003-2004</b>	54473	32004	58.75
<b>2004-2005</b>	59909	49247	82.20
<b>2005-2006</b>	69204	75136	108.57
<b>2006-2007</b>	75496	90945	120.46
<b>2007-2008</b>	95679	73265	76.57

Year	GCFA in Pvt sector	Long term credit (Rs. crore)	LT credit as % GCFA in Pvt sector
2008-2009	133655	91447	68.42
2009-2010	151325	107858	71.28
2010-2011	161513	132741	82.19
2011-2012	238174	114871	48.23
2012-2013	233747	133875	57.27
2013-2014	290009	181687	62.65
2014-2015	291113	209916	72.11
2015-2016	274126	250197	91.27
<b>Average (1999 to 2015-16)</b>	<b>2340600</b>	<b>1625515</b>	<b>69.45</b>

*Source: Capital formation figures from CSO, GOI and Long term credit from NABARD*

It can be observed that during the period 1999-2000 to 2015-16 long term credit emerged as the major driver of the private sector GCF in agriculture as reflected by the share of LT in PGCF (69.45%). Thus, capital formation in agriculture is predominantly dependent on what happens to investment (long term) within agriculture credit.

**Figure 6.3 Long term credit (disbursements) and private sector gross capital formation (GCF)**



*Source: CSO for capital formation and NABARD for credit.*

Note: GCF figures for 2012-13 and 2013-14 in agriculture and estimated using linear trend.

## 6.18. Increasing Investment Credit

### 6.18.1. Investment Credit Achievements

Banks have been able to achieve the overall agriculture credit announced in the Union Budgets but achievements under investment credit have begun to pick up only since 2012-13. In 2007-08, banks could achieve around 86 per cent of the Investment credit targets which reduced to 58 per cent in 2012-13.

The percentage of achievement has increased to 91 per cent in 2013-14 and to 93 per cent in 2014-15 and further to 98 per cent and 132 per cent during 2015-16 & 2016-17, respectively. Additionally, as per the 12<sup>th</sup> Five Year Plan (Report of the Working Group on Outreach of Institutional Finance, Cooperatives and Risk Management, November 2011, Planning Commission), investment credit estimated for the first two years of the plan was Rs.4,40,268 crore. Against this, the achievement is 62 per cent. For the 12<sup>th</sup> FYP as a whole, the investment credit target is pegged at Rs.13, 54, 878 crore.

**Table 6.12 Target and achievement under Investment Credit**

Year	Target (Rs.crore)	Achievement (Rs.crore)	Achievement as % of Target
2007-08	85000	73264	86
2008-09	120000	91447	76
2009-10	125000	107858	86
2010-11	155000	132741	86
2011-12	195000	114871	59
2012-13	230000	133875	58
2013-14	200000	181687	91
2014-15	225000	209916	93
2015-16	255000	250197	98
2016-17	285000	376298	132

*\*Data based on information furnished by SLBCs in respect of Commercial Banks and reporting banks in respect of RRBs and Cooperative Banks.*

*# Data submitted by Banks in ENSURE portal in respect of Cooperative and Regional Rural Banks and data furnished by Banks through mail in respect of Commercial Banks. Data on Term Loan includes disbursement under Agriculture Infrastructure and Ancillary activities.*

### **6.18.2. Tapping the potential for funding investment credit**

Banks require to step up financing in agricultural sector. NABARD has been preparing Potential Linked Credit Plans (PLPs) at district level wherein sub sector wise estimates of the potential of investment credit are available. The PLP estimates are reflective of the ground level potential as these are summed up from block level upwards. Banks can prepare Area Development Plans (ADPs) based on the identified potential for funding investment credit projects in their area, so that these can be implemented and monitored at the District level with the involvement of Bankers and District Officials along with NABARD. Such a move will have the impact of increasing the flow of investment credit thus adding to the much needed capital formation at the farm level.

### **6.18.3. Interest subvention for direct investment credit**

As done in the case of short term credit, governments (Central and State) would have to step forward to provide interest subvention on investment credit taken by farmers, particularly in case of small and marginal farmers. This has the potential to boost the achievement of targets and sub-allocations for long term credit.



## **6.19. Policy Initiatives for Agriculture**

Govt. of India has come up with a series of initiatives that affect the agriculture and allied sectors, which in-turn influence Ground Level Credit for Agriculture also. Some of the major initiatives are:

- a) **Doubling the income of farmers by 2022** - The government has been reorienting its interventions in the farm and non-farm sectors to double the income of farmers by 2022. The new policy framework is expected to facilitate crowding in private sector investments, through enhanced private sector participation in agriculture.
- b) **Pradhan Mantri Krishi Sinchai Yojana** – One of the important components of ‘Pradhan Mantri Krishi Sinchai Yojana’ is creation of additional sources of water. Completion of long pending medium & large irrigation projects is one major intervention.

**Dedicated Long Term Irrigation Fund (LTIF) with NABARD** - Institution of LTIF with an initial corpus of ` 20,000 crore for fast tracking of implementation of incomplete major and medium irrigation projects under AIBP and also two national projects in the year 2016-17 has been upsealed to Rs. 40,000 crore in 2017-18 and the total investment being provided for complete 99 AIBP projects is Rs. 76,000 crore. When completed, an additional extent of 7.6 mill. ha. would come under irrigation. As further announced in the budget for 2018-19, the scope of LTIF would be expanded to cover command area development. This is a good initiative, as historically command area development has suffered causing poor efficiency of water source created.

- c) **Soil Health Card Scheme** - Launched by the central government in February 2015, the scheme is tailor-made to issue ‘soil health card’ to farmers which will carry crop-wise recommendations of nutrients and fertilizers required for the individual farms. This is aimed to help farmers to improve productivity through judicious use of inputs. Promotion of soil test laboratories both in public & private sectors would trigger capital formation.
- d) **Paramparagat Krishi Vikas Yojana** - Paramparagat Krishi Vikas Yojana has been launched by Government of India to support and promote organic farming in a comprehensive way, and thereby improving soil health. This will encourage farmers to adopt eco-friendly concept of cultivation and reduce their dependence on agro-chemicals as the only way to improve yields. Private sector participation will get activated, particularly in the marketing domain.
- e) **Unified Agricultural Marketing e-Platform** launched to provide a common e-market platform for wholesale markets. This will generate private sector investments in various ways – storage, transportation, forwarding agencies, assaying labs etc. Further, the Model APLM Act, that provides level playing field to private sector markets will bring in private investments.

- f) **Pradhan Mantri Fasal Bima Yojana (PMFBY)** - The Pradhan Mantri Fasal Bima Yojana (PMFBY) is a path-breaking scheme which aims to provide insurance coverage and financial support to the farmers in the event of failure of any of the notified crop as a result of natural calamities, pests and diseases. It also aims at stabilising the income of farmers to ensure their continuance in farming. Further, it encourages farmers to adopt innovative and modern agricultural practices, and absorb greater flow of credit in the agriculture sector by covering the probable risks.
- g) **Model Land Leasing Act** - The Expert Committee under the chairmanship of Dr. T. Haque constituted by NITI Aayog submitted the model Agricultural Land Leasing Act, 2016. It seeks to secure the ownership rights of land owners while also providing security of tenure to tenants. It also provides for recognition of farmers cultivating on leased land to enable them to access loans through institutional credit. The Model Act proposes quicker litigation process in case of disputes, by suggesting recourse through criminal proceedings and special tribunal.
- h) **Micro Irrigation Fund:** In order to raise agricultural productivity in India, it is imperative to expand the acreage under irrigation along with the adoption of appropriate technologies for efficient utilisation of water through suitable pricing. The setting up of a Micro Irrigation Fund in NABARD with a corpus of Rs 5,000 crore would enable greater achievement of “per drop more crop” by supplementing the budgetary allocations under PMKSY.
- i) **Dairy Processing and Infrastructure Development Fund** set up in NABARD with a corpus of Rs 8,000 crore over 3 years, and an initial corpus of Rs 2,000 crore, would have a significant impact on the dairy sector and lead to the enhancement in the income of dairy farmers.
- j) **AHIDF, FAIDF and AMIDF:** The Budget 2018-19 has announced institution of 3 new funds addressing infrastructure requirements for Animal Husbandry, Fisheries and Agriculture Marketing. The total corpus for AHIDF and FAIDF combined is Rs. 10,000 crore and for AMIDF it is Rs. 2,000 crore.
- k) **Other Measures for hassle-free loan to small and marginal farmers:** Government, RBI and NABARD have initiated several measures to ensure adequate availability of credit to small and marginal farmers, which include:
- The Government provides interest subvention since 2006-07 to make short-term crop loans upto Rs.3 lakh available to farmers at the interest rate of 7 per cent per annum and in case of prompt repayment, the same gets reduced to 4 per cent.
  - Under the Interest Subvention Scheme of Government, post-harvest loans against Negotiable Warehouse Receipts (NWRs) provided by banks to Small Farmers/Marginal Farmers having Kisan Credit Card (KCC), are also available at the interest rate of 7 per

cent per annum for a period of upto six months, so as to discourage distress sale of produce by small and marginal farmers.

- Government has introduced the Kisan Credit Card (KCC) Scheme, which enables them to purchase agricultural inputs such as seeds, fertilisers, pesticides, etc. and draw cash to satisfy their consumption needs. The KCC Scheme has since been simplified which has the provision of ATM enabled debit card with, inter alia, facilities of one-time documentation, built-in cost escalation in the limit, any number of drawals within the limit, etc.
- To bring small, marginal, tenant farmers, oral lessees, etc. into the fold of institutional credit, Joint Liability Groups (JLGs) have been promoted by banks.
- Banks have been advised by Reserve Bank of India (RBI) to waive margin/security requirements of agricultural loans upto Rs.1,00,000/-.
- In order to ensure hassle free credit to all borrowers, especially in rural and semi-urban areas and keeping in view the technological developments and the different ways available with banks to avoid multiple financing, banks are advised to dispense with obtaining 'No Due Certificate' from the individual borrowers (including SHGs & JLGs) in rural and semi-urban areas for all types of loans.
- RBI has issued Standing Guidelines for Relief Measures to be provided by respective lending institutions in areas affected by natural calamities which, inter alia, include identification of beneficiaries, restructuring of existing loans, extending fresh loans, relaxed security and margin norms, moratorium, etc.

The interventions and initiatives discussed in the preceeding section show different ways in which higher capital is being mobilised into agriculture sector, from both budgetary and non-budgetary sources. This can be further strengthened to meet the targeted capital investment growth rate as laid out in volume II of this Report.

### III

## Banks and Financial Institutions

### 6.20. Role of Banks & Financial Institutions

Various interventions that need to be made for doubling farmers' income would require credit, particularly in the case of adoption of existing/new technology. These include poly-houses, drip/sprinkler irrigation, farm machinery, hybrid seeds, improved agronomic practices, etc. As some of these would be capital intensive, they may also require higher level of production credit.

In addition to credit intervention by banks for direct farm related activities, an effort would also be required to help the farmers and various farming groups for marketing activities, especially in agri-logistics and activities that allow farmers to capture greater value for their produce, such as pre-conditioning and preparing for market, by sorting, grading, packing, warehousing and transport.

Further, to improve the credit absorption capacity as also to make credit effective, the GOI/State Govt. may facilitate by way of infrastructure creation for irrigation, storage godown/ cold storages, e-markets, customized extension services, digitization of land records, computerization of PACS etc.

Some of the specific areas where NABARD/FIs and the banking system can play a catalytic role are as under:

### **6.21. Strategic areas**

i) **Financing a basket of activities:** Banks and Financial Institutions can promote and finance farming system models which integrate crop production with dairy, poultry, fisheries, dryland horticulture, sheepery, goatery, etc., depending upon the resources/potential available in a particular locality. The KCC presently being used for financing farmers can be suitably modified to include Farming System Approach. The farmers may also be provided bank loan for diversifying production mix by providing earning opportunities in non-farm sector/activities.

ii) **High value agriculture – horticulture:** In association with the Agricultural Extension agencies, Banks & Financial Institutions can promote financing of high value agriculture infrastructure like shade net, polyhouse, etc., especially for horticultural crops including vegetable and floriculture. Banks also need to promote multi-tier cropping system and mixed cropping system especially in existing plantation crops like coconut and arecanut and fruit orchards. This however would require massive skill-building efforts which needs to be taken up by the extension agencies supported by SAUs/ICAR institutions. The extension agencies themselves would need upgradation of their skill/knowledge on an ongoing basis

iii) **Financing of Farmers Producer Organizations (FPOs) to meet the entire value chain requirement of their members:** It has been successfully demonstrated that the small producers improve their earnings by acquiring better bargaining power through producer collectives. Banks and Financial Institutions can therefore channelize credit for meeting both working capital requirement and term loan requirement of members of Farmers Producer Organisation for financing the entire value chain involving aggregation, sorting, standardization, processing, packaging and marketing of the produce.

iv) **Creation of irrigation potential for enhancing production and productivity:** Banks and Financial Institutions can finance micro-irrigation schemes in a big way. Farm or Community based water harvesting structures can be promoted through bank credit; similarly, for investment on groundwater-sharing proposals between farmers. Besides, Private participation / Joint venture participation through Special Purpose Vehicle (SPV) may be

permitted for setting up of medium / large irrigation projects. This will spur investments in agriculture, which today faces a decline in investment. The financial sources for setting up these irrigation projects can come from financial institutions<sup>6</sup>.

v) **Customised Extension:** With availability of varied technologies competing with each other, there is a need to shift from general extension to customized extension services to suit the individual requirement of the farmers which can maximize the income of the farmers, particularly the Small/marginal farmer.

vi) **Integrated Approach:** At present the banks, extension agencies etc. tend to function in an isolated manner. These stakeholders would require to work in unison so as to make credit more productive.

### **6.21.1. Cost reduction strategies:**

Reduction in cost of production the farmer incurs is also a means to increase the income. Some such interventions can be as follows:

There is a need for educating the farmers on reduction of cost of cultivation. Farmers, due to lack of knowledge and education, often tend to use farm inputs (fertilizers, pesticides, insecticides) indiscriminately incurring avoidable excess expenditure, and in the process damaging production ecology also. Proper education and awareness on soil test based nutrient application, integrated pest and nutrient management, organic farming, etc., need to be popularized and promoted among the farmers through fora like SHGs, JLGs, Farmers Clubs, FPOs, etc. Extension agencies can play an important role in creation of awareness about reduction in cost of cultivation as well as for enhancing income. The financial literacy centres can also help in spread of this message.

Oral leasing of land is on the increase due to land division & fragmentation, as also migration to other locations for jobs. Due to absence of suitable tenancy laws, there is no written document available with the farmers (for land taken on lease) for submission to the banks as a collateral. As a result, such farmers do not get access to bank credit and hence have to take recourse to costlier credit from the informal system. To help such farmers to avail credit at lower interest rate from the banking system, the State Governments may promulgate laws that facilitate land leasing, under which Land Leasing Certificates/ Land Cultivator Licenses would be issued by the revenue Depts. of the state governments to the person taking land on lease which can then be submitted to the banking system for availing loan. Andhra Pradesh Govt. has already enacted such an Act which however requires some refinements. Government of India can bring out a Model Act along this line.

### **6.21.2. Risk mitigation measures**

Banks can play a pivotal role in increasing insurance penetration through covering all crop loans given to farmers under different crop insurance schemes like PMFBY, WBCIS, etc. For this to become truly effective, digitization of land records has to be completed by the state

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<sup>6</sup> IBA sub-committee on enhancing flow of credit to agriculture sector

governments in a mission mode.

## **6.22. Agriculture Credit – Management Information System**

Robust Management Information System (MIS) is a sine qua non for effective monitoring of performance, understanding the gaps and formulating right policy responses. With adoption of technology by banks, the scope for better MIS exists. Technology has changed the face of banking in India and it can as well enhance quality and timeliness of data. Processing of data into useful information for MIS and decision support systems in individual banks as well as at aggregate level is important.

For this, a uniform data reporting standards need to be put in place which will reduce reporting requirements and improve overall efficiency. In several cases, it is also seen that data collection and presentation is not gender-disaggregated, or disaggregated along other lines of importance (like borrowers' landholding class or social background, etc).

### **6.22.1. Returns as now submitted by Banks**

At present, banks are required to submit to RBI diverse set of fixed format data (called returns). Some of these returns are statutory under Reserve Bank of India Act, 1934, Banking Regulation Act 1949, Foreign Exchange Management Act, 1999, etc. Many returns submitted by banks are non-statutory. Submission of frequency of these returns varies from daily, weekly, fortnightly, monthly, quarterly, half-yearly and yearly. However, frequency for returns related to priority sector is generally quarterly or higher period. Banks also submit reports/returns to the Government, State Level Bankers' Committee and its sub-units, NABARD, etc. Besides banks, RRBs and cooperative banks also submit returns to RBI and NABARD.

Most of these returns submitted are in mixed mode – online and offline, that involve manual handling and processing of data at various stages.

## **6.23. Recommended approach**

Demand for granular data for review of policy decisions has increased over the years with an emphasis on intensive monitoring. All the commercial banks including RRBs and cooperative banks are presently working on centralized core banking environment. To ensure faster and accurate transmission of uniform data for quick decision making for the purpose of better credit planning, review and monitoring of agriculture credit, it is desirable that sector-wise, sub-sector wise, activity/purpose wise, borrower category wise, gender-wise, bank wise, state wise granular data is extracted directly from the CBS of banks and made available to all the fora like SLBC/DLCC/BLBC etc.

## Chapter 7

### Credit Guarantee Trust Fund for Term Loans`

*That, capital investments positively influence growth rate of agriculture is well recognised. Gross capital formation happens through both public and private investments. One of the important components of the latter is investments by individual farmers. Presently, the farmers are gaining greater access to crop loans, but not term loans from the credit institutions. The lenders are apprehensive of collateral adequacy and repayment capacity of the farmers. Hence, there is a felt need to set up a credit guarantee fund trust to make it easy for the lending agencies to enhance the flow of term loans to farm sector.*

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#### 7.1. Background

It is true that the volume of institutional credit has been growing steadily since 2003-04 when government decided to double the credit flow to farm sector. It reached a high of Rs.8.5 lakh crore by 2014-15, and has grown robustly thereafter year-on-year, and the targeted volume for the year 2018-19 is Rs.11 lakh crore. However, a major percentage of this goes towards short-term crop loans (about 70 per cent), leaving a much smaller portion for capital investments in agriculture and allied sectors. The crop loans that the farmers receive from Scheduled Commercial Banks / Cooperatives / Regional Rural Banks (RRBs) are mostly against land offered as collateral and are consumed in pre-harvest activities.

Not only is the quantum of term loan available low, it also does not enjoy the benefit of an interest subvention that is available on short term crop loans. Further, Banks and Financial Institutions (FIs) are not very open to term loans, as farmers are not able to offer adequate collateral, or are unable to satisfy their repayment capacity. Many a time, the farmers tend to divert the crop loans towards long term investments or even for consumption/personal expenditure purposes. Various reasons including such diversion make the lending institutions weary of term loan sanctions. In consequence, it is the farmers' need for capital investments that suffers a short shrift.

*As per the Mint Street Memo No. 4 titled – 'Agriculture Loan Bank Accounts – A Waiver Scenario Analysis', there were nearly 77 million agriculture credit accounts with scheduled commercial banks (SCB), as on March 2016, with an average credit size of Rs.1.16 lakh. Around 70 per cent of these are crop loans, which account for nearly 67 per cent of the outstanding loan amount. The loans for investment are mainly for purchasing of farming equipment (eg. tractors) and not irrigation / soil development which will help them to improve their production and quality of produce for higher realization.*

M.S. Swaminathan, the pioneer of India's Green Revolution said "Loan waivers, although temporarily necessary for the revival of farming, do not provide conditions for a secure credit system in the long term. The waiver of loans implies that banks will have to be compensated by the government for the amount involved. This means that large sums of money, which could have otherwise gone to strengthen the agricultural infrastructure and research – such as seed production, soil health enhancement and plant protection, will not be available."

The collateral offered for long term loans are mainly agricultural land. The salability of such collateral is also difficult. The farmers' farm income cash flows for more than a year have very limited visibility due to external (weather, diseases, pricing) factors. Further, the risk management framework of Banks/Financial Institutions are not able to measure such external risk for long term.

### **7.2. Need for a Guarantee Scheme: CGFT-TL**

The above context explains constraints, wherein, the Banks / Financial Institutions are reluctant to extend term loans to farmers, when their need is paramount for building necessary backward and forward linkages at the farm level. The context also emphasises the requirement for an incentive framework in the form of an assurance to the lenders is felt.

Back till the early 2000s, the micro and small enterprises (MSEs) too faced problems of credit access from Banks and Financial Institutions. It was sometime in the year 2002-03, that Government of India and the Small Industries Development Bank of India (SIDBI) set up a safety net for the lending institutions and channelize easy credit to micro and small enterprises. Since then, '**Credit Guarantee Fund Trust, for Micro and Small Enterprises (CGTMSE)**' has been in operation. The structure and operation of this Trust can be studied and adopted for purpose of enhancing term loans in agriculture, animal husbandry and fishery sectors, with suitable modifications.

A Guarantee Trust to this effect may be floated by the Ministry of Agriculture and Farmers' Welfare, Government of India in partnership with NABARD.

### **7.3. Objectives of the Scheme**

The main objective of 'CGFT-TL' is to offer security to the lending agencies – Banks and Financial Institutions, so that they relax the current resistance they show in offering the farmers needed term loans.

The lenders should find it easy to depend upon project viability and secure the credit facility against the primary security of the asset being financed.

Thirdly, the lending institution availing of the guarantee facility should endeavour to offer 'Composite Credit' to the farmers, comprising both term loan and working capital. This would amount to a single window facility.

The CGFT-TL seeks to assure the lending agency, that in the event of farmers (availing collateral free credit facility) failing to discharge their liabilities due to it (lender herein), the Guarantee Trust would make good the loss incurred upto the prescribed level. The structure of the credit facility may lay down the norm, which may vary from a minimum 50 per cent to 85 per cent.



**Proposed features-some suggestions as follows are made:**

- All Scheduled Commercial Banks (public, private, foreign), RRBs, Cooperatives, State Financial Corporations, NBFCs (Non-Banking Financial Corporations) and such other institutions as authorised by Government of India, can be allowed to avail themselves of guarantee cover in respect of their eligible credit facilities under the scheme.
- Eligibility under the scheme be made available to all categories of farmers, with an additional incentive built in to favour of the small & marginal farmers.
- The limit of loan on which guarantee is available, even without a collateral or third party guarantee, may be substantive enough, so that capital investments in agriculture gather pace. An upper limit of at least upto Rs.50 to Rs.100 lakh may be considered.
- All sub-sectors of agriculture, seasonal/calendar year crops, horticulture, dairy & livestock (both large & small ruminants), fishery & aquaculture and secondary agriculture be made eligible along all segments of the value chain.
- Include all fund/non-fund based facilities that are eligible.
- A guarantee covering upto 85 per cent may be considered, based on the magnitude of loan. The extent of loan and percentage guarantee cover available to a lending agency may be arranged in an inverse co-relation, i.e. higher the loan, lower the guarantee cover. However, a minimum of 50 per cent guarantee may be provided to even high order loans.
- The guarantee fee be collected from the borrower on yearly basis at rate laid down in the scheme. The rate may be such as not to make it a burden or disincentive for the farmer-borrower.
- Guarantee to commence from the date of payment of guarantee fee and shall cover the agreed tenure of the term credit in case of term loans/composite loans.
- The initial 'Corpus Fund' may be created by contributions from Ministry of Agriculture and NABARD, as per mutually agreed terms. NABARD may operationalise the 'Credit Guarantee Fund Trust - Term Loans' on behalf of the two partners (Government and NABARD).

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## Chapter 8

### Policy Recommendation

*In the preceding 6 chapters, six critical inputs, that are part of crop production system have been examined from various angles, and strategy for optimal management have been suggested. Each of these chapters, that deliberate on a specific aspect draw the context from the opening chapter, that shows how cost of cultivation/production has been increasing, and therefore input use needs to be rationalised, so as to reduce the cost of production and help the farmers realise resource use efficiency and cost effectiveness.*

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#### 8.1. Soil Health Management – Balanced Nutrients

8.1.1. The universal soil health card scheme (SHC) launched in 2014 is a very progressive and definitive step taken by the Government. It has laid a strong foundation for science based soil nutrient management. Though there is still considerable distance to be travelled in creating a robust and sustainable system of soil test based nutrient recommendation and management, it has by now already crossed the rubicon, and there is no going back. In order to transition from the presently supply-driven, to a demand-driven approach, some suggestions follow:

- Create an eco-system for private initiative to cater to end-to-end requirement of soil sample collection to test the distribution of card with recommendations.
- The recommendations should however be based on the research findings and advice of the NARS (National Agricultural Research System).
- Diploma and Certificate courses be customised, that will produce adequate manpower to meet the demand in both public and private sectors.
- Strengthen public sector infrastructure to serve as referral laboratories and as Regional/State Testing Laboratories.
- Encourage private sector infrastructure, in the nature of mini and major labs; mobile and static labs, capable of carrying out multiple tasks of SHC system; and also are capable of testing for comprehensive parameters (major, secondary & micro-nutrients; physio-chemical properties)
- Private enterprise be promoted by facilitating credit linked subsidy back-ended avenue.
- Since a single service based activity may not be financially viable, it may be considered to promote a single stop service centre, that meets multiple needs of farming. For example, soil testing, assaying (for commodity quality testing), extension service, input sales, farm machinery etc.
- Farming as a Service (FAAS) is the concept, that deserves promotion.
- Newer technologies like sensor based soil testing facilities may be ascertained for robustness and commercial viability and adopted in due course. This will help in reducing the time lag between collection of soil sample and recommendations.
- The presently adopted grid pattern of 10 ha. in rainfed and 2.5 ha. in irrigated situations

may be revised for narrower grids, so that sample from every farmer's field gets to be tested.

- 8.1.2. Water impacts soil and plant growth. Hence, water testing may also be included based on identified parameters, particularly when ground water is used.
- 8.1.3. In due course, plant tissue based testing for nutrient status and its management must be adopted.
- 8.1.4. Revisiting fertilizer recommendations – long term studies have demonstrated that, existing fertilizer recommendations included in the package of practices are sub-optimal for several crops. It is critical that all states review the 'General Fertilizer Recommendations' for need based improvements. ICAR and SAUs must take up this on priority.

e.g. due to continuous potassium mining without concurrent replenishment over the last many decades, Indian soils once considered as sufficient in potassium are now hungry for it.

Fertilizer recommendation should target field – achievable maximum economic yield (MEY) from the cultivar. It is defined as the yield level that gives highest possible return per ha.

- 8.1.5. Customised Fertilizers (CF), though introduced in 2008 are yet not popular Small scale industries may be allowed to manufacture CFs for small zones like Taluk or District.

However, CFs cannot catch up with straight fertilizers which benefit from subsidy. CFs also need to be given a level playing field by offering them subsidy at par with straight fertilizers.

- 8.1.6. Promote liquid fertilizers for greater efficiency of uptake and savings.
- 8.1.7. Soil Organic Carbon (SOC) is more important, so as to improve soil structure and availability of nutrients to the plants. Hence, major attention is required on increasing the utilisation of organic manures through adoption of multiple approaches – bio-agents, green manures, legumes, FYM, compost etc.
- 8.1.8. Build capacities of fertilizer input dealers, so that their advice to the farmers is scientific, evidence based and rational.
- 8.1.9. Innovation in fertilizer products has not received adequate attention. Public investment in research towards this needs to be increased.

8.1.10. Government (Public) Extension System should focus on advocating and promoting balanced use of fertilizer and soil health management, letting private sector play the dominant role in testing/backward facilities.

8.1.11. A central data base of soil sample test results should be maintained and offered access to all including researchers and private sector. It should further lead to Land Use Based Planning for production system.

## **8.2. Water Use Management**

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is a very comprehensive government initiative, that aims to address end-to-end issues all along the chain of water management. Some suggestions in this regard are:

8.2.1. 'Har Khet Ko Panni' – Increasing water sources.

- i) In addition to the ongoing 99 number of major and medium irrigation projects (AIBP-Accelerated Irrigation Benefit Project) taken up for completion by December, 2019, the remaining 50 such long pending projects may also be taken by expanding the size of the corpus fund under LTIF (Long Term Irrigation Fund).

A mission mode approach to water conservation in rainfed areas should get top priority.

- ii) A minimum of 1 (one) million small water storage/diversion weirs / water harvesting structure may be planned per annum.

MGNREGA would be the best source of funding these. In addition to creating new systems, renovation and modernization of traditional systems also need attention.

- iii) The tail ends of command areas of major and medium irrigation projects are generally deprived of water availability. The reasons could include poorly maintained distribution system, non-adherence to notified cropping patterns (opting for water guzzling crops like paddy, sugarcane etc. in lieu of low water duty crops) and excessive use by headrace farmers.

### **8.2.2. Promoting water use efficiency – 'Per drop more crop'.**

A drop of water saved is a drop of water created. This needs the highest attention through adoption of precision technology and efficient water management practices. Some suggestions are as follows:

- i. Currently the gap between the irrigation potential created (IPC) and irrigation potential used (IPU) is a staggering high of 23 million ha. (mha). Closing this gap deserves the highest attention.
- ii. Operation and Maintenance (O and M) of the distribution system is below standard, causing water leakage and wastage. This needs to improve, and involvement of people

through 'Participatory Irrigation Management (PIM)' would be useful.

- iii. Precision agriculture by way of micro-irrigation (drip and sprinkler); and sensor-drone-big data analytics based technology is important. Micro-irrigation (MI) must become a compulsory agenda in all forms of irrigation – flow, lift, small sources (WHS/DW/Ponds etc.). In all command areas of minor/medium/major irrigation projects, micro irrigation system should be compulsorily adopted.

As of date, less than 10 million ha. of the total of 63 Mha. of irrigated area is covered under M.I.

An annual coverage of a minimum of 2.5 Mha. is necessary to quickly achieve water use efficiency and narrow the gap between IPC and IPU.

Under 'Krishi Bhagaya' programme of Karnataka, small irrigation ponds dug in rainfed areas have proved very useful in protecting a standing crop from monsoon vagaries, when connected with steel conveyor and MI system. This programme deserves to be scaled up in a major way across the rainfed areas of the country.

- iv. Crop alignment and Conservation agriculture must be strictly practised in all command areas.

### **8.2.3. Ground water recharge**

- i. Ground water accounts for 60 per cent of the irrigated area in the country. Due to over-exploitation, large tracts including in the food bowl of the country (Punjab, Western Uttar Pradesh, Haryana) have turned into 'dark zones'.

These need to be treated urgently by adopting multi-pronged approach of ground water recharge, crop alignment and community based water management. Watershed based treatment should form the principle of intervention.

It is time to consider whether power supply at no cost or even at highly concessional rate is appropriate. This approach has led to 'caution lessness' habit among water users to the disadvantage of the larger farmer community. The power tariff structure may be revisited, while compensating the farmers by direct payment of a certain sum on per ha. basis linked to measured actual use. This is likely to check indiscreet use of water management.

For example, the Telengana Model of paying Rs.4,000 per acre per season to the farmers to defray some of their farm expenses may be a good way out with suitable modifications. This may bring greater discipline in drawing ground water. In fact, farmers may be willing to pay, if the service quality is improved. There is much that is wanted in this regard.

- ii. Latest technology that helps in remote operation of the water pump may also be promoted.

- iii. Ground water table needs consistent monitoring by installing piezometric in all the Gram Panchayats. Now that water budget has been estimated for all the districts under the 'District Irrigation Plans (DIPs)', a close monitoring of water use and water recharge would be possible to realise a balanced water budget. A web based platform would serve as a good dashboard for such monitoring.

#### **8.2.4. Special emphasis on rainfed areas**

The poverty map of India and the rainfed area map tend to overlap. As brought out in Volume I of the DFI Report, the ratio of farm income is lower compared to non-farm income in drought prone districts of the country.

According to the 'Rainfed Atlas' of 'Revitalising, Rainfed Agriculture Network (RRAN)', about 55 of the 100 poorest districts in the country are rainfed. Of the bottom 10 poorest districts, seven (7) are rainfed districts.

Hence, in the strategy for doubling farmers' income, the rainfed regions should get highest attention. The optimal solutions are:

- Ensure protective irrigation, which can come from small water storage structure.
- Adopt watershed management, integrated farming and conservation agriculture.
- Grow alternative crops – food crops such as millets which are climate resilient and need less of water as also other inputs.

#### **8.2.5. Water pricing and regulation**

- i. By strengthening 'Water Users' Associations (WUAs)' and transferring them the O&M responsibilities of tertiary distribution system; water rate collection; and release of water on volumetric basis, which is purchased by the WUAs should be thought of for introduction in phases. This of course is only a long term intervention.
- ii. Block system of irrigation –  
Due to continuous use of water (particularly through flood system), many soils (especially black soils with high water absorption capacity) in many major command areas have turned saline & alkaline.

A block system of irrigation, whereunder, the water is released only on one side of the main canal in alternate seasons (Kharif-Rabi) may be tested. This will motivate farmers to go for alternate and low water duty crops like pulses, oilseeds & millets in the season, when water is not released by using available soil moisture. This will improve the soil health steadily.

- iii. Promote use of recycled water to expand peri-urban cultivation and water harvesting in habitations to adopt kitchen gardening, roof top gardening, hydroponics etc.

In fact in case of large metropolitan cities, where sewerage discharges are huge, secondary treated water can be used in agriculture in the hinterland cultivation zones.

For example, in case of Bengaluru urban agglomerate (with a population of 10 million), secondary treated sewerage water is adequate to fill all the ponds in the neighbouring 3-4 rainfed districts and enable supply of protective irrigation when rains fail.

### **8.3. Seeds**

Sustained increase in agricultural production and productivity necessarily requires continuous development of new and improved varieties, as well as hybrids of crops and efficient system of production and supply of seeds to farmers. As seed is a critical input for enhancing productivity of all agricultural and horticultural crops, some of the priority areas are listed below:

8.3.1. A robust 'Seed Rolling Plan' should be ensured based on active partnership of DACFW-ICAR-States, who in turn build a network with efficient seed producers, across both public and private sectors. Seed production plan should be based on targeted SRR, VRR and SMR. Special attention is needed in case of forgotten crops like millets, horticultural crops and location-specific problems & suitability including climate change issues. The Seed Rolling Plan should also include contingency requirements for compensatory seeds arising from natural calamities. The losses incurred by seed producers due to contingency production should be compensated suitably through a specially created Sinking Fund.

#### **8.3.2. Production environment**

- i. Agronomic practices may be optimized for all the inputs including seed, keeping in view the cost of seed.
- ii. All the states should prioritize production and distribution of quality seeds of various crops across agricultural & horticultural crops.
- iii. Application of bio-technology for seed traits and quality assurance is useful.
- iv. Application of modern tools viz., QR code, bar code for all class of seeds for confirming the source is essential to ensure the seed generation system
- v. Establishment of network on developing national database of DNA profiles of varieties which are in seed production chain is useful.
- vi. All the crop varieties released and notified recently may be got registered under PPV and FR Act, if the breeder so desires.
- vii. Release of crop varieties for specific soil types i.e. acidic, calcareous and saline nature be given priority.
- viii. Rapid multiplication of the new seed variety is essential, so as to avoid time lag between release and adoption by the farmers. Currently, it is a long drawn process. All the new varieties developed by the breeders are examined and identified for release at the All India crop seed workshop. Thereafter, the Breeder/Breeder Institute prepares Release

and Notification proposal for consideration of the Central Sub-Committee on Crop Standard, Notification and Release of Varieties. After approval by this Sub-Committee for release, the proposal goes through various procedures before final notification under the Seeds Act. A lot of valuable time is lost, and if the breeder delays in submitting the proposal, there could be additional time lag.

It is therefore suggested, that once the Sub-Committee has approved for the release, pending notification under the Seed Act, atleast 75 per cent of the test stock (one that is with the Breeder, but cannot as yet be called as a nucleus seed) can be considered as 'breeder's seed' and initiated into production of 'foundation seed'. This will help in saving of about a year in reaching out the new variety to the farmers.

- ix. Encourage SHGs/FPOs to undertake HYVs and hybrid seed production on cluster basis. They can be incentivised by establishing Gram Panchayat Level Seed Processing-cum-Storage Godowns. This approach will broadbase the seed production system and reduce reliance on a few large producers as happening now.
- x. Discourage multiplication of low yielding old, as also pests and disease susceptible varieties, encourage multiplication of nutrient efficient and climate resilient varieties with consistent yield. This is necessary to weed out long standing varieties that have gone beyond the age norms. Participatory seed production involving farmers, through FPOs by creating seed production, processing-cum-seed storage godown facilities at Gram Panchayat Level is an effective strategy to produce and make available quality seeds of high yielding varieties/hybrid seeds at low price. This will be a win-win situation for both seed growing farmers as well as other farmers.
- xi. As 60-65 per cent of the farmers use farm saved seeds, technological intervention for up-gradation of the seed quality is under implementation since 2005 under Seed Village Programme. This has helped the farmers become self reliant. However, not all states are using this scheme efficiently, and hence attention is needed in this regard.

### **8.3.3. Maintaining the quality of seed**

- i. The quality of seed may be determined based on germination and survival, and not on the size.
- ii. Systematic and meticulous minimum field standard to maintain genetic purity of the seed and minimum seed standard prescribed in IMSCS be effectively followed and maintained by all seed producers.

### **8.3.4. Restructuring & reorganisation of support services**

- i. There is an urgent need for restructuring & reorganising SSCs (State Seed Corporations) to bring them in tune with the industry norms in terms of infrastructure, technologies, approach and the management culture to be able to survive in the competitive market, and to enhance their contribution to public sector seed production system.



- ii. Streamline seed research system to deliver commercially viable technologies on production, storage and processing, seed quality enhancement and control etc.
- iii. Organization and strengthening of seed certification agency need careful planning taking into consideration the anticipated acreage for certification of various crops and varieties, area of operation, farm sizes etc.

#### **8.3.5. Sale of and access of quality seeds**

- i. In relation to post-harvest handling, the Indian seed processing/ conditioning industry has perfected the techniques of quality up-gradation and maintenance to ensure high standards of physical condition and seed quality. By virtue of the diverse agro-climates, several geographical zones in the country have emerged as ideal seed storage locations under ambient conditions. In terms of seed marketing and distribution, in addition to existing seed dealers and distributors, proposed 22,000 GrAMs (Grameen Retail Agriculture Markets) will provide good opportunity for sale of seed nearer to villages. This activity can be offered necessary support and further strengthened.
- ii. 'Seed Export Hubs' with appropriate infrastructure, institutions and incentive system (more of ease of doing business their financial) should be promoted across the country, with emphasis agro-climate and crop alignment principles India can encourage as a major seed exporter to African and Asian countries, where similar climate conditions as India prevail. The youth can be supported to build enterprises.

#### **8.3.6. Enforcement for quality assurance**

Enforcement for quality assurance – Under the Seeds Act, the States are empowered to enforce adherence to prescribed standards. The enforcement machinery is weak on various counts including inadequacy of manpower. It is suggested, that an independent Directorate of Enforcement, separate from the development-extension Directorates is established at the State/UT levels. This Directorate be made responsible for enforcement under various relevant Acts in respect of all the agricultural inputs including seeds, pesticides (chemical and organic), fertilizers (chemical and organic) and others. For effectiveness,

- they should be adequately staffed;
- the staff should be technically qualified and well trained; for continuous upgradation of knowledge; refresher programmes;
- infrastructure including testing laboratories should be sufficient;
- ICT should be deployed for efficiency & accuracy eg. QR bar code for various packets/sachets will help in quality maintenance; and
- computer generated random numbers for inspection of shops will bring in objectivity & effectiveness in check.

### **8.4. Pest Management**

The recommendations aimed at bringing down the expenditure on pesticide represents a collation of policy, procedural, Research and Development, information technology

institutional and capacity building based strategies. The efficacious implementation of these recommendations is predicated upon a concerted and coordinated synergy among all the stakeholders.

#### **8.4.1. Policy**

- i. Most of the new molecules with patents are imported, which adds to the cost per unit. Special encouragement should be given for discovery and manufacture of active ingredients in India. The local manufactures should also be encouraged to export, so that they can afford to sell at lower price in the domestic market by way of cross-subsidisation to an extent.
- ii. There is a need for a comprehensive policy on products sold as ‘organics’, ‘bio-stimulants’ etc. which are neither tested by a competent body nor registered at CIB-RC. These are also not recommended by any scientific body for usage in pest management. Active ingredients in these products are not disclosed, keeping both the user and the subject experts in dark. Many a time, these organic products are used along with the other synthetic insecticides as single application. Further, as the nature of the molecule is not known, it also puts the consumer at serious risk on account of pesticide residues. The Insecticide Act should provide for comprehensive procedures for registration of all such products in a transparent and objective manner.
- iii. The registration is usually for major crops, but expansion of labels to minor crops / related crops is very essential and is possible through crop grouping. A policy be formulated and adopted by CIBRC on crop grouping and label expansion through data on field trials and also risk assessment for fixing MRLs (Maximum Residue Limits) and recommendation of PHIs.
- iv. “Prescription-based sales” of pest management inputs may be considered, as done in Kerala (spices), Maharashtra (pomegranate, grapes, sugarcane).
- v. All molecules for which registration application is filed, with the regulator for use in the country for the first time, should be registered as done earlier by clubbing section 9(3) along with 9(3B) of the Insecticide Act, 1968. This implies, that the Registration Committee needs to register a formulation after the fixation of its Maximum Residue Limit (MRL) u/s 9(3) as recommended by the JPC and set across by FSSAI as mandated; wherein, the technical needs to be compulsorily registered u/s 9(3B) with a commercialization rider to extend beyond the provisional period of 2 years, and during this period of provisional registration, balance data required to be submitted can be generated and shared for registration u/s 9(3) within a period not exceeding a total of 3 years from the date of provisional registration.

This will enable introduction of both patented or non-patented molecules in the country, and ensure data protection of minimum of 2 years and maximum of 3 years for companies willing to invest in new molecules and introduction for the first time in the country. As a result, the subsequent prospective registrants will be encouraged to go in for registration for indigenous manufacture or new import source. This will check

monopoly of the said molecule registered for the first time for use in the country and result in competitive pricing to the advantage of the farmers.

- vi. Protective cultivation has become popular and with diversification into high value crops, its adoption is growing. However, there are no formulations registered for use in protective cultivation, wherein fertigation that combines application of water, fertilizer and plant protection can be encouraged. In this regard, molecules that are suited to fertigation need to be registered.
- vii. Seed treatment registrations have been accorded priority. However, seed treatment solutions are not available for all seeds of national importance. Bio-pesticides need to be encouraged for seed treatment with a focus on export oriented produce, where pesticide residues assume critical concern.
- viii. Plant protection products needed for treatment of agri-produce during storage (post-harvest management) deserved due attention including at the stage of registration.
- ix. Pesticide treated plastic wraps for slow ripening of fruits or plant protection products need to be encouraged and evaluated.
- x. Pesticides may be considered as an essential item and price control may be opted for generic pesticides similar to the Drug Price Control.

#### **8.4.2. Procedural**

- i. All RPTLs and CIL should be upgraded into GLP and ISO 17025 complaint laboratories.
- ii. The RPTLs should network with all SPTLs for knowledge sharing and to meet the challenges in analysis of pesticides for quality control purposes.
- iii. Two documents, namely, “Requirements for establishment of RPTLs” and “Requirements for establishment of SPTLs” be prepared and shared with the concerned, so that GLP and ISO 17025 quality standards are adhered to.
- iv. As the Certified Reference Materials (CRMs) and Technical Materials (TMs) are very elaborate and expensive, CIL should maintain an inventory and share with all the RPTLs and SPTLs.
- v. All SPTLs may not have access to methods of analysis, as BIS methods are not published for all pesticides and formulations. Hence, it is suggested that manufacturing methods be made available to all SPTLs through CIBRC / CIL.
- vi. It is necessary to create and disseminate Standard Operating Procedures (SOPs) to states for establishment of SPTLs and pack houses.
- vii. Strengthen DAC&FW sponsored central sector scheme, namely, “Monitoring of Pesticide Residues at National Level (MPRNL)”. The project identifies crops and regions having preponderance of residues in India in order to focus on extension efforts for IPM and food safety (MRL fixation).

- viii. Simplify registration procedure and accelerate the pace of registration (i.e. reducing current time span of 4 years). This will enhance competition among the manufactures, which in turn may bring down prices. In addition, simplification of the registration procedure for bio-pesticides/ botanicals is also essential. Expansion of label claims of already registered pesticides on other crops should also become the norm.
- ix. Establish registration procedures for organics / natural products / concoctions / mixtures of natural products / products based on traditional knowledge for encouraging them in accordance with desired norms. Quality standards also need to be monitored through effective regulation.
- x. Strengthen techno-legal Cell of the Directorate of Plant Protection, Quarantine and Storage (DPPQ&S) for facilitating swift action in cases of misbranded/spurious instances of pesticides.
- xi. Lay down requirements for establishment of SPTLs”, so that quality standards needed for GLP and ISO 17025 compliance becomes the objective and norm.
- xii. Each State falls under one or more of particular agro-climatic zone(s) and these influence a particular crop pattern and unique pest scenario. This needs to be studied and analysed from the perspective of Package of Practices (PoPs) issued by the respective SAUs. This will help in mapping the required kind of pesticides vis-a-vis manufacturers and importers of formulated pesticides within the state and / or nearby locations.
- xiii. Crop Cluster Development approach may also be adopted for crop planning. This will help in promoting efficient way of pest management. The rate of pesticide dose in application should be linked to the seed variety in the given crop cluster or agro-climate zone or state, as the case may be.
- xiv. Basic harmonized training modules be formulated, and translated into all regional languages to help provide a holistic approach to address the issues related to safe & effective use of pesticides. The next step will involve crop specific detailed training based on the generic and not the brand name.
- xv. All websites of the State Agriculture & Horticulture Departments need to be at least bilingual i.e. English & regional language. This will help in connecting with other states for new learnings and adoption of best practices.

#### **8.4.3. Research and Development**

- i. Institutions (both ICAR and SAUs/CAUs) should adopt region-wise model clusters with a view to reach farmers by providing them timely advisory on plant protection measures to bring down unnecessary expenditure. This will help farmers to take appropriate decisions with respect to plant protection management including application of agro-chemicals.
- ii. The region-wise and crop-wise usage of plant protection molecules need to be recorded religiously. Regular statistics in respect of these, similar to yield estimates will help to plan appropriate region-wise measures to check abuse of plant protection molecules.

- iii. Collaborative institute projects with a timeframe of 3-5 years should be identified and rolled out by taking district as a unit of study. The identification of districts based on vulnerability can be made by plant health scientists (entomology, pathology and soil science) of the ICAR/SAU/CAU institutes/organisations. The researcher from the domain of Agriculture & Economics and Agricultural Extension may also be associated.
- iv. Undertake analysis of pesticide residues in agricultural commodities, soil, water etc. through supervised field trials to generate data on persistence and dissipation of newer and existing molecules for fixation of safe waiting periods, MRLs, and approval of label claims. Presently ICAR-All India Network Project on Pesticide residues (AINP-PR) at IARI, New Delhi conducts such studies through its 15 NABL accredited coordinated centres located in different parts of the country.
- v. Promote research on enhancement of pesticide efficacy and stability through use of adjuvants (synergists, potentiators, stabilizers) and employing proper dispensing mechanism (spray technologies) to reduce sizeable quantity of pesticide consumption should be strengthened. Availability of new molecules, that are less labour intensive, less harmful to environment, those that facilitate less for more coverage and there by labour saving.
- vi. Research should be targeted for elevating the level of pest resistance to major invaders rather than developing resistant cultivars, which is an uncertain and time consuming task. Cost reduction in pesticide use is on pro-rata basis with resistance level. Stability of such varieties is greater than those with resistance.
- vii. Development of fore-warning system with suitable precision in respect of key pests. This will enable timely pest management interventions and reduce pesticide load in the environment.
- viii. Creation of field diagnosis protocols that serve as a step-by-step guide for diagnosis of field problems. A protocol should encompass all the known problems of a crop and include various diagnostic approaches like visual, chemical, digital, etc. These protocols should be revised from time-to-time as new technologies, new problems, new research findings etc., come to light.
- ix. Nuclear technique, also known as sterile insect technique (SIT) is one of the IPM practices, that can be promoted in managing fruit flies, moths etc. It is a form of sterilization of insects and systematic release of huge number of male insects. The sterile males compete with insects in the wild, and through mating with wild females, contribute to reducing overall pest numbers.

#### **8.4.4. Information technology**

- i. Create a Portal that the forum of analysts can access for information/knowledge on all methods and Centralized Prescription Registry (CRMs), and also discuss various challenges in analysis.

- ii. National data/inventory of pesticides registered in the country be maintained.
- iii. Create a Portal in collaboration with the States and Pesticide Associations which will provide information on all the registered pesticide dealers along with their details including education qualification. The Portal should also include information on pesticides produced and sold by the companies along with their prices.
- iv. Collation and compilation of comprehensive data on the consumption of pesticides/bio-pesticides, and making it available on a dedicated portal will help in analytics.
- v. A dedicated “Coding Cell” be established at Directorate of the State, where the inspector samples are received, coded and sent to SPTLs for tamper proof analysis.
- vi. Electronic platform for pest surveillance needs to be developed and rolled out in coordination with state governments. Some tools like PESTWATCH are available which provide on-line information for pest monitoring and forecasting. FAO provides satellite-based images of large locust habitat areas supported by rainfall and green vegetation data for the technical staff; helping to undertake better monitoring and reduce locust population. Such modules may be developed or adopted for pest surveillance for either a state approach or cluster approach. This will help in real time dissemination of pest management techniques to the farmers. The data generated through the electronic pest surveillance will also help in creation of Centralized Prescription Repository (CPR). The current system is largely manual, limiting the quality and utility of surveillance and its outcome.
- vii. Create of a Centralised Prescription Repository (CPR), that caters to all the diverse cropping situations and preferences. The CPR should contain all the authentic prescriptions to tackle pest situations at different crop stages and at varying intensities of damage for different regions of the country. Further, the CPR should include the entire range of options such as (biological, organics, conventional, mechanical, cultural, etc.) specific to different agro-climatic zones. The CPR should be continuously updated with inputs from the latest research findings, changing pest scenarios, policies and other regulations, technologies developed, etc. This should be backed by suitable policies making adherence to CPR mandatory.
- viii. Big data analytics of pest situations reported from across the country: As digital extension systems are continuously expanding in the country, there is a need for establishing a big data analytics and interpretation centre. This Centre should be able to provide all the necessary alerts across all the districts for each of the cultivated crops. Effective data analytics can help in interpretation of data and drawing of messages for limiting the spread of pest from their original place of occurrences. Data analytics is of vital importance for predicting pest occurrences and quarantine
- ix. Geo-Positioning System (GPS) can reduce pesticide consumption by approximately 10 per cent, as it prevents double treatments in wedges and while turning. GPS can be used to calculate the needed amount of pesticides and can be connected to sowing/planting machines allowing the seeds or the plants to be placed in a pattern, which subsequently allow to hoe the plants across the rows and also closer to the rows.

- x. Fertilizers and pesticides (biological & chemical) are primarily required respectively for the growth of crops & control of pests, respectively. Unmanned Aerial Vehicles (UAVs) can be adopted to avoid risk to human health and environment that are likely when application of pesticides & fertilizers is undertaken manually. Such applications can be localized, restricted or specific in nature and protect spray operators from exposure during application. Multiple uses of such UAVs can also relay remote sensing images that may be analysed by use of an appropriate software.
- xi. Electronically-controlled or managed chemical spray application technology can be more precisely used for application of agricultural pesticides at intended targets. Reduced chemical drift will improve water quality by minimizing the delivery of chemical compounds through the air into water bodies. Such application systems require the use of GPS data loggers (i.e., devices that record the track, time and location of field trips for download to maps) in order to document site-specific compliance with all label requirements for drift mitigation.

#### **8.4.5. Institutional**

- i. Establishment of RPTLs in states where the use of pesticides is extensive. The RPTLs should be endowed with requisite infrastructure, analytical equipments and trained manpower. They should be able to analyze all the pesticides as in the schedule for identification of spurious pesticides, and should serve as a 'Model' to SPTLs. All RPTLs and CIL should be GLP and ISO 17025 complaint. The RPTLs should create a kind of networking with all SPTLs for knowledge sharing and to meet the challenges in analysis of pesticides for quality control purposes.
- ii. Establishment of new Central Integrated Pest Management Centres (CIPMCs) and strengthening of existing CIPMCs will help in vigorous monitoring and surveillance of agriculture fields, and in encouraging farmers to adopt IPM. In many states with large geographical area, a single CIPMC as exists now is not adequate. A rationalisation is required based on geographical area and cropping intensity.
- iii. Establish additional SPTLs in sync with the number of registered pesticide dealers and strengthening of existing SPTLs. In this regard, the central government may share a SOP with the states, which, inter alia, may include best practices, optimum number of pesticide testing laboratories needed, list of equipments, information about accreditation etc. Every state should establish at least one SPTL. All major states may further designate one SPTL as lead laboratory, where all facilities as in RPTLs are available. Such lead labs can help in analysis of samples from other states for second verification purposes, and for Inter-Laboratory Comparisons (ILCs). All SPTLs should be GLP and ISO 17025 complaint.
- iv. It is important to set up an independent and dedicated Enforcement Cell in the State Agriculture Department for monitoring and supervision of all enforcement related activities in accordance with the provisions laid down in the Insecticides Act.

- v. Establishment of modern 'Pack Houses' for bolstering backward linkages. In this regard, the Central Government may share a SOP with the States.

#### **8.4.6. Capacity building**

- i. Manpower training to ensure supply of quality pesticides: Regular training of enforcement officials/officers on pesticide quality control and prosecution procedure and training of laboratory analysts at periodic intervals be organised to update their skill
- ii. Sensitisation of farmers about use of recommended pesticides as per label prescription, right dose - right time, method of application etc. For example, pesticide and water are mixed to the full capacity of the sprayer; while injection syringes and implantation methods can be more efficient and targeted and therefore economical.

The farmers can be trained & oriented on a continuous basis by deploying multi-media, field of demonstrations etc.

- iii. Regular training of extension officers on pest management including IPM: The officers including the field staff need updation of their knowledge, particularly in respect of new technologies and practices.

### **8.5. Agricultural Mechanisation**

8.5.1. It is advisable to adopt a more broader definition encompassing deployment of machinery across all the sub-sectors of agriculture (crop husbandry, horticulture, dairy, livestock, poultry, small ruminants, fishery etc.) and call it as 'Agricultural Mechanisation', and not limit it to 'Farm Mechanisation'.

8.5.2. From the income perspective, that involves reducing the cost of production, increasing the total output and capture of maximum value of the output, mechanised operations are more effective vis-a-vis the manual or draft power.

8.5.3. The consumption of farm power in India stands at an average of 2.02 kw/ha. in 2017-18 and compares very poorly even with Asia-Pacific countries. A target of at least 4 kw/ha. should be the aim by 2022. And it is achievable.

8.5.4. Considering the preponderance of small & marginal holdings in the country, R and D should aim at developing and designing scale-neutral machinery. Further, machinery that can suit different terrain of the geography deserves priority attention.

8.5.5. Agriculture Machineries can become part of 'Farming as a Service' (FaaS), which means, that farmers should have easy access to mechanisation and related services on rent in preference to owning the same. This can be facilitated by promoting:

- 'Custom Hiring Centres' (CHCs) at the rate of a minimum of 1 (one) per village (when large) and 1 (one) per Gram Panchayat comprising in cluster of small villages. These



should be able to meet the demand for all basic services, and would therefore be expected to possess low duty machinery.

- ‘Agriculture Machinery Banks’ (AMBs) at the district/sub-district level, possessing heavy duty machinery like combine harvester, laser land leveller etc.
- ‘State/Regional Services’ possessing more sophisticated and heavier machineries, that can service larger areas to meet certain specific demands; and also possess ICT/GIS/Space technology based services.
- These centres at different levels, should be supported to broaden their technologies to include modern systems like drones, sensor based applications, etc. and also those needed in the sub-sectors of animal husbandry, fisheries, etc.

**Promotion modes:**

The above types of services can be promoted by adopting one or more of the approaches below:

- i) Enterprise mode – the youth can be specifically trained and financially supported (credit linked back-end subsidy) to set up CHCs. In order to make such enterprises viable, other agricultural services can also be integrated to offer ‘One Stop Shop’. Some of the services deliverable are pesticide, fertilizer & seed retailship, I.T. based extension services etc.
- ii) SHG/FPO/Trust/PACS based CHCs.
- iii) NGO/CSR (Corporate Social Responsibility) based CHCs and AMBs.

**Shared utility or Uberisation:**

It is possible that some of the machineries are owned by individual farmers. Tractors are a common example. Aggregation platforms have proved highly successful in city transport services. On similar lines, uberisation is feasible in agricultural mechanisation. Hence networking of individual owners, CHCs, AMBs and Regional/State Service Centres can happen by onboarding a common platform and meet the demand in real time and cost effectively. Professional Service Providers with large investments and capable of establishing a brand name can opt to promote franchise model for quick scale up across the region/state. The youth can grow up professionally as franchise based entrepreneurs. Since agricultural operations are seasonal and time bound, the farmer is need of a service cannot afford to wait and would benefit only response to his call is positive with nil/least time lag.

Further, transaction cost will need to be rational, and therefore, the machinery will need to sent to the farmer’s work site from the nearest location. Uberisation is the most optimal solution to such demands. This brings an advantage of enhancing the use-time of the machinery purchased, and therefore, the realisation of a positive RoI (Return on Investment).

**Service facilities:**

It is important to ensure availability of repair and service facilities in close proximity, so that operation & maintenance issues are addressed. Mobile service centres can also be promoted to cater to minor repair demands. This requirement also generates scope for enterprise creation.

The concept of FaaS goes beyond providing machinery on hire. It encompasses a number of services including offering labour, managing actual field operations in respect of not only agricultural machinery, but also other agricultural operations. For example, harvesting of coconut, arecanut and the like is a specialised function, and the traditional tree climber may not always be available these days. A 'FaaS' entrepreneur can meet such a service demand.

In sugarcane belts, it is common to see labour contractors undertaking harvesting, and labour groups travelling long distances, even across the states. Mechanised services through FaaS can become effective at lesser social cost, that migration bring in movement/migration of labour.

8.5.5. Machinery for waste management – In the Indo-Gangetic Plains (IGP), where rice-wheat is the dominant cropping system, burning of rice straw to meet the deadline of wheat sowing time is a common practice. This is not only not sound ecologically but also causes a loss of opportunity to capture the value that lies in the paddy straw. This wasteful practice describes most agricultural activities. In the strategy for doubling farmers' income, gainful use of all biological products, and not just the grain or fruit, is necessary to generate additional farm incomes. Hence, agricultural mechanisation plans must include farm waste management machines and devices, and make residue management a productive activity.

## **8.6. Agricultural Credit**

8.6.1. The Committee suggests that all state governments take up digitization of land records on a "Mission Mode" to enable the farmers / banks to have easy access to land records for extending hassle-free and timely loans to farmers. Similar is the need for urgent improvements in cultivators' records, wherein, the real cultivator is recorded and such data made accessible to banks too.

8.6.2. The legal framework and lease land market are imperfect and devoid of uniformity across the states. Hence, a legalisation mechanism that protects the interests of both tenants and land owners, along the lines of AP Licensed Cultivators Act and NITI Aayog's Model Land Lease Act, with appropriate improvements to both, may be put in place by state governments. In Andhra Pradesh, the revenue authorities issue Loan Eligibility Cards to Tenant Farmers (under 'Andhra Pradesh Land Licensed Cultivators Act No 18 of 2011). Such tenancy /lease certificates, while protecting the owner's rights, would enable real cultivators to obtain loans. Government of India may develop a Model Act for this purpose. This, accompanied by a new proposed mechanism of a Credit Guarantee Fund, should be able to bring more such farmers into the ambit of institutional credit.

8.6.3. With a view to making credit available to large number of eligible and willing small & marginal farmers, it is suggested that all banks endeavour to achieve an annual increase of 10 per cent in number of SMF accounts. KCCs may be issued to all eligible farmers.

8.6.4. Due to factors like high dependence of agriculture on monsoon, vagaries of nature, poor information availability in rural centres and occasional loan waivers, banks may have higher

perceived risks in lending to small and marginal farmers. As the agricultural credit to the small and marginal farmers should rise substantially, and should simultaneously be ensured that stressed assets in this sector do not arise, it is suggested that Government of India may consider establishment of an Agriculture Credit Risk Guarantee Fund (ACRGF).

8.6.5. Government of India may consider introducing interest subvention for Agriculture Term Loans to increase the magnitude of investment loans and scale up Gross Capital Formation in agriculture.

8.6.6. The share of rural co-operatives in the total agricultural credit disbursements has been declining over the years. Considering, that these cooperative credit institutions play an important role in largely providing agricultural credit to farmers, especially the small and marginal, there is an urgent need to strengthen the short term and long term cooperative credit structure. The potentially viable PACSs (Primary Agricultural Cooperative Societies) should be computerised within a defined timeframe of three years and integrated with CBS (Core Banking System) of DCCBs (District Central Cooperative Banks). The LTCCS (long term credit cooperative structure) should also be reformed and revitalised through a comprehensive package of legal, financial, information and communication technology and skill upgradation of cooperative personnel.

8.6.7. The collective strength of farmers could enable them to increase their competitiveness through easier access to credit and technology, reducing costs of distribution and providing greater marketing power and negotiation capacity for better price realisation. Farmer Producer Organisations (FPOs) could emerge as one of the most effective pathways to address agricultural challenges. FPOs in agriculture should be actively promoted to aggregate farm produce, get efficiency and improve access to credit. Through adequate policy and infrastructure support, these aggregators can become the 'connective tissue', linking supply and demand, bridging a major missing link. Policy support in the form of establishing multi-tier federations to form a National Farmers Development Board (NFDB) on the lines of NDDDB could be necessary. It may be examined whether SFAC can be restructured & re-mandated to play this crucial role. This requires an immediate policy initiative of tax exemptions, including income tax exemption to all such FPOs.

8.6.8. For the purpose of efficient credit planning, review and monitoring of agriculture credit, it is desirable that sector-wise, sub-sector wise, activity/purpose wise, borrower category wise (including gender disaggregated), bank wise, state wise granular data is extracted directly from the CBS of banks and made available to all the forums like SLBC/DLCC/BLBC etc.,.

8.6.9. To improve the credit absorption capacity as also to make credit more effective, central & state government may facilitate infrastructure creation by way of irrigation, storage godown/ cold storages, e- markets, etc.

8.6.10. The current irrigation level at 45 per cent of GCA (Gross Cropped Areas) needs to be

enhanced to 60 per cent in 5 years. The deficit states need to draw up necessary action plan to enhance irrigation potential through suitable investments under RIDF (Rural Infrastructure Development Fund), LTIF (Long Term Irrigation Fund) and (MIF) Micro-Irrigation Fund etc. Government of India support to these Corpus Funds to be continued. However, irrigation potential created (IPC) needs to be optimally utilised by focussing on command area development and water use efficiency. As of now, the gap between IPC and Irrigation Potential Used (IPU) is as high as 23 million ha and needs to be bridged.

8.6.11. Financing a basket of activities: Banks and Financial Institutions can promote and finance farming system models which integrate crop production with dairy, poultry, fisheries, dryland horticulture, sheepery, goatery, non-farm sector loans, etc., depending upon the resources/potential available in a particular locality.

8.6.12. In association with the State Extension agencies, Banks & Financial Institutions can promote financing of high value agriculture infrastructure like shade net, polyhouse, etc., especially for horticultural crops, vegetable and floriculture.

8.6.13. Customised Extension: With availability of varied technologies competing with each other there is a need to shift from general extension to customized extension services to suit the individual requirement of the farmers which can maximize the income of the farmers, particularly the small/marginal farmer

8.6.14. Most of the cooperative banks (whether LTCCS or STCCS) lack skill sets for term lending and hence, have low share in term lending. There is a need for massive scale reskilling of cooperative personnel for handling LT lending activity. Ministry of Agriculture & Farmers' Welfare may like to support these capacity building measures for cooperative credit structure appropriately.

8.6.15. At present, many farmers are not able to avail agriculture loan for want of Record of Rights (RoRs) or non-issue of ROR for sub-divided land holdings. State Governments may issue Land Pattas/Record of Rights to all farmers who have inherited land through subdivision of their family property, irrespective of the size of the landholding inherited by them. This will help farmers to avail loan for agriculture (ST/LT) to do so without any administrative hurdles.

8.6.16. In order to provide market access & better prices to farmers, (GOI) Government of India may encourage formation of large number of FPOs including Farmers Producer Companies (FPCs). Based on the experience of "PRODUCE" Fund, GoI may create a Fund in NABARD with appropriate corpus to encourage grassroots efforts for formation of FPOs/FPCs and nurture them for a period of 5 years.

8.6.17. All Banks viz. Cooperatives, RRBs, CBs should be encouraged to lend to FPCs, with credit guarantee cover from SFAC both for their working capital & block capital.

8.6.18. Many of the FPOs/FPCs struggle to establish and start their business in the initial years. During this period, some of the problems that these FPOs face are: banks not coming forward to sanction loans, as the equity is very low; non-existence of physical assets that can be offered as collateral security; and non-availability of audited balance sheets etc. This is the critical period, when if no business is started, members may lose faith in the efficacy of the FPOs/FPCs. Many a time, farmers get motivated only after seeing the benefits accruing to those farmers who have already joined as members. Therefore, all state governments may come out with a scheme, to extend equity support of at least upto Rs. 10 lakh to all those FPOs/FPCs which are registered and plan to take up business activity.

8.6.19. To ensure that specified allocations meant for farmers and within this category-small and marginal farmers, reach them, the distinction between direct and indirect lending should be explicitly brought back, and 8 per cent of the direct lending target of 13.5 per cent should be achieved by lending to small and marginal farmers.

8.6.20. Given that the banks and financial institutions are normally reluctant to offer investment loans to farmers, particularly those belonging to small and marginal categories, the Committee recommends to setup a Credit Guarantee Fund Trust for Term Loans, as detailed in Chapter 7

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## Annexures

**Figure: Conservation furrow in cotton and pigeonpea cultivation at Aurangabad, Maharashtra**



**Figure: Ridge and furrow method soybean cultivation at Tikamgarh, Madhya Pradesh**



**Figure: Mulching with paddy straw**



**Figure: Plastic mulch**



**Figure: Direct seed rice cultivation in Manipur**



**Figure: Farm ponds in Davanagere, Karnataka**



**Figure Masonry check dam constructed at Warangal, Telangana**



**Figure: Low cost sandbag checkdams at Singhbhom**



**Figure: Water harvesting structures (Jalkhunds) in hilly regions**

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