TOWARDS DOUBLING COTTON FARMER INCOMES IN MAHARASHTRA

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List of Abbreviations

Abbreviation	Description
APMC	Agricultural Produce Market Committee
BCI	Better Cotton Initiative
CICR	Central Institute for Cotton Research
CIRCOT	Central Institute for Research on Cotton Technology
DAP	Diammonium phosphate
eNAM	electronic National Agriculture Market
FPO	Farmer Producer Organization
FYM	Farm Yard Manure
HDP	High Density Planting
ICAC	International Cotton Advisory Committee
IPM	Integrated Pest Management
KCC	Kisan Credit Card
LBM	Lint Based Marketing
MECE	Mutually Exclusive, Collectively Exhaustive
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MSP	Minimum Support Price
NABARD	National Bank for Agriculture and Rural Development
NITI	National Institution for Transforming India
NPK	Nitrogen, Phosphorus, Potassium
ODK	Open Data Kit
PIB	Press Information Bureau
PMFBY	Pradhan Mantri Fasal Bima Yojana
RBI	Reserve Bank of India
SHC	Soil Health Card

Executive Summary

India's cotton ecosystem has the potential for a radical change that can benefit all involved value chain players, especially the millions of small cotton farmers that form the backbone of India's cotton industry. Indian cotton farmers today sit on a wealth of potential; access to inputs and machinery has improved greatly in recent years, bringing farmers to a point where they have similar access as their counterparts in developed cotton nations. Moreover, local climate favors cotton strongly – India's climate is so favorable to cotton that it is in one of the few countries in the world that can cultivate all four species of commercially grown cotton.[1] Adding to the list of advantages, labor costs in India are still low, even though recent labor migration to cities has somewhat increased rural wages. Even lack of water, which is often cited as a limiting factor for Indian cotton, is not reason enough to truly hamper progress: India's monsoon rains provide sufficient amounts of water for cotton cultivation that are comparable to those of international competitors.[2]

However, the reality on the ground belies this tremendous potential. Indian cotton farmers today are plagued by low yields – in 2018, average Indian cotton yield lay at 509 kg lint per hectare, roughly a fourth of what farmers in Australia (1,931 kg lint/ha), Brazil (1,708 kg lint/ha) and China (1,761 kg lint/ha) achieved.[3] Low yields (e.g. driven by pest attacks) and limited income over several years have created a high incidence of unsustainable debt among farmers, which has created additional financial and social pressures.[4] Lastly, Indian cotton marketing systems are still poorly developed: farmers predominantly sell their produce to local middlemen who offer opaque pricing schemes that prevent farmers from reaping the benefits of high quality in their cotton.[5]

This report outlines a strategy towards doubling net household income of Indian farmers. Research is focused on the Indian state of Maharashtra (which is the largest cotton growing state by area but has the lowest yields domestically), but results can be applied to farmers across India and even internationally to other developing cotton growing nations. The recommendations are packaged within a larger strategy that seeks to holistically address farmer livelihoods, including efforts around diversification, gender empowerment and environmental sustainability. From the set of recommendations, two possible game changing approaches have been derived through extensive primary and secondary research including farmer surveys, value chain interviews, expert interviews and online research:

- **High Density Planting (HDP)**: This refers to a shift in agronomic practices towards a short-dense-early cotton cultivation system. HDP promises to close the yield gap between Indian farmers and their international counterparts while providing numerous secondary benefits, such as increased independence from water and chemical pesticides.
- **Lint Based Marketing (LBM)**: This refers to a shift in cotton marketing from opaque pricing and weighing of seed cotton towards transparent pricing and weighing of cotton lint. LBM strengthens the connection between cotton quality and farmer price realization. It offers benefits to players across the value chain, ranging from farmers to ginners and other downstream actors.

India's cotton ecosystem can significantly benefit from the implementation of the recommended interventions – if carried out fully, cotton farmers in Maharashtra and across other states can more than double their total net household incomes, undergoing a radical change and living up to their full potential.

[1] CICR, "Technical Bulletin No 13 - Cotton Varieties and Hybrids", Accessed 2019
[2] Interview with Dr. Keshav Kranthi, Head of Technical at ICAC, 2018
[3] USDA, Statistics Download from PSD Database, 2019
[4] TechnoServe Farmer Survey, 2018
[5] TechnoServe Value Chain Analysis, 2019

Introduction: The Current Situation of Cotton in Maharashtra

The Indian agriculture sector has seen a slow and consistent rise over the last decades with an ever-increasing production to feed a growing population, both domestic and abroad.[6] This green revolution has not only increased national agriculture and allied sector GDP, but also resulted in a consistent rise of real farmer incomes (see Figure 1).[7]

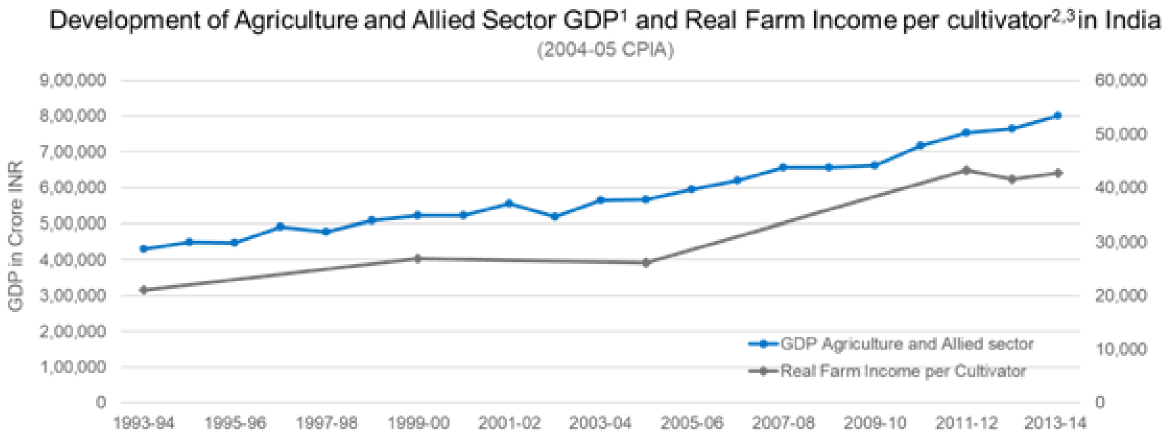


Figure 1: Agriculture and Allied Sector GDP and Real Farm Income in India grow together

However, although real farmer incomes have been rising, the situation of Indian farmers today remains strained when viewed as a larger picture. Recent analyses show that the gap between farm income and non-agriculture income are staggering: where net farm income per cultivator in India was around INR 78,000 in 2011, net income per non-agriculture worker (rural and urban) in the same year more than tripled cultivator income at INR 247,000 (a cultivator was defined as a "… farmer or his family members engaged in agriculture as their main activity" while non-agriculture workers were defined as "… those who work outside agriculture).[8]

The observed hardship of farmers has recently prompted the government of India to devise a seven-point strategy towards doubling cotton farmer income by 2022. This strategy aims to increase production and reduce costs by enabling farmers to use inputs efficiently. It also targets more effective linkages of farmers into market systems via better post-harvest management, stronger processing systems, and reforms in agriculture marketing. All existing on-farm efforts are to be further supported by risk mitigation measures, such as crop insurance and diversification of farmer income through horticulture and animal husbandry.[9]

The government's bold goal of doubling farmer incomes has united government, private sector and non-profit efforts towards improving farmer livelihoods, but it faces a number of significant challenges: Indian agriculture is highly diverse, both in the crops grown (100+ different crops are grown in India) and in terms of climatic conditions (India has 6 major climatic zones, from desert to subtropical), meaning that policy and interventions geared at improving farmer incomes need a large degree of specialization and adaptive design. At the same time, Indian landholdings are strongly fragmented, with an average landholding size of only 1.15 hectares[10], and poor rural infrastructure results in high input costs and large post-harvest losses. Lack of knowledge and poor education amongst Indian farmers further aggravate the challenges faced by any organization aiming to improve incomes of farmers working on any one crop, let alone the income of all Indian farmers.

[6] Central Statistics Organization, "Historic Agriculture GDP - 1954-2015", 2015
[7] NITI Aayog, "Doubling Farmers' Income - Rationale, Strategy, Prospects and Action Plan", 2017
[8] Chand et al., "Estimates and Analysis of Farm Income in India", 2015
[9] PIB, "Agriculture Ministry is working sincerely to fulfil our Prime Minister's dream to Double Farmers Income by 2022", 2017
[10] PIB, "Highlights of Agriculture Census", 2011

Where India's goal of doubling farmer income by 2022 applies to all its farmers, this report focuses on cotton as one of India's key cash crops. Cotton has been a major factor in Indian agriculture ever since the British industrial revolution but has been cultivated domestically on the Indian sub-continent long before that.[11] Today India is the largest producer and the second-largest consumer of cotton in the world[12], but when viewed on a global scale, India's productivity is very low. Average cotton yields in India lie at about 4.8 quintals of cotton lint per hectare, a value easily bested by the United States (9.6 quintals per hectare), Australia (18.1 quintals per hectare), China (17.5 quintals per hectare) and Brazil (17.1 quintals per hectare).[13] Within India, cotton is grown in Northern, Central and Southern regions with most cultivation taking place in Gujarat, Maharashtra, Telangana, Haryana, Andhra Pradesh, Madhya Pradesh, Karnataka, Punjab and Rajasthan. Significant differences in productivity exist between these states: where Punjab leads productivity in India at 6.3 quintals of lint per hectare of cotton, Maharashtra has the lowest yields of all states at only 3.5 quintals of lint per hectare of cotton (data referenced is an average of the cotton seasons from 2012 to 2016).[14]

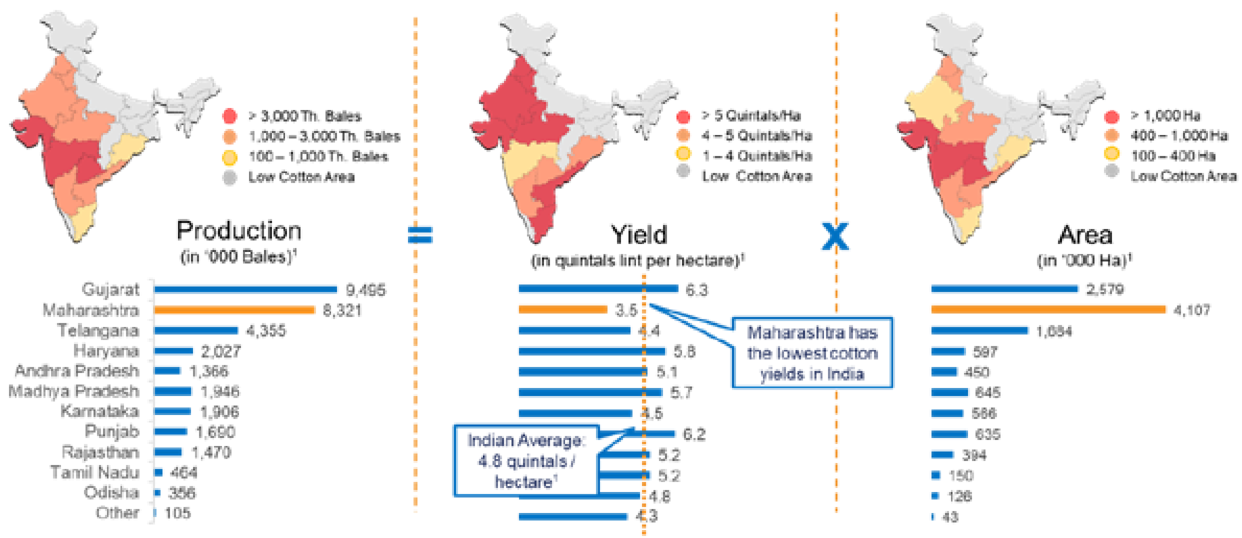


Figure 2: Area, production and yield for cotton vary amongst Indian states

While India performs poorly in a global comparison, voluntary sustainability standards have had an increasing role to play in improving farmer livelihoods locally. India is, by far, the largest producer of organic cotton, accounting for about 60,000 metric tons lint which is 51% of the world's production.[15] Furthermore, approximately over 550,000 farmers licensed by the Better Cotton Initiative (BCI) in India cultivated over 775,000 hectares to produce nearly 500,000 metric tons of Better Cotton lint[16]. The Better Cotton Standard System emphasizes more sustainable production of cotton through seven key principles that cover social, environmental and economic criteria, and it has succeeded at improving farmer livelihoods: In the 2016-17 season, BCI farmers in India had 8% higher yields and 21% higher profits (net income/ha) than comparison farmers[17]. While they are carried out at smaller scale than BCI, Fairtrade and organic cotton were also shown to improve livelihoods. The Fairtrade approach offers farmers attractive prices provided they produce goods in an environmentally sustainable and socially equitable manner with a focus on continuous improvement in production practices. For those farmers who pass the strict, 3-year certification process

[11] CICR, "Agri-History of Cotton in India - An Overview", 1997
[12] ICAC, Statistics Download from World Cotton Database, 2017
[13] USDA, Statistics Download from PSD Database, 2019
[14] NFSM, "Area, Production & Yield of Commercial Crops", 2018
[15] Textile Commission, Organic Cotton Market Report, 2018
[16] BCI, "Better Cotton Growth & Innovation Fund", 2018
[17] BCI, "Farmer Results", Accessed 2019

required for organic cotton, excellent results have also been observed: Evidence from the literature suggests that despite lower input costs, organic cotton farmers obtain yields on par with those of conventional cotton farmers and realize prices that are up to 20% higher.[18]

Within India, this report focuses on cotton farmers in Maharashtra, as they face several challenges:

1. **Cotton farming is liable for risks**: Some of the major risks facing cotton farmers are droughts, pests (in particular the pink bollworm, which has led to severe crop losses in recent years) and price volatility. Crop insurance is used by only 54% of farmers.[19]
2. **Cotton revenue is low**: As discussed above, Maharashtra has the lowest cotton yields among India's core cotton growing states.[20] This is pushed by the fact that most of Maharashtra's cotton farmers are predominantly rainfed[20] putting them at more risk of crop losses due to droughts. Furthermore, landholdings in Maharashtra are small and fragmented at an average size of 1.44 hectares[21]. Cotton farmers are also unorganized, making them price takers in their value chain.
3. **Cotton cultivation is expensive**: Farmers are overly reliant on expensive hybrid seeds, chemical fertilizers and chemical pesticides.[22] At the same time, the cost of agricultural labor is increasing due to labor migration to cities.

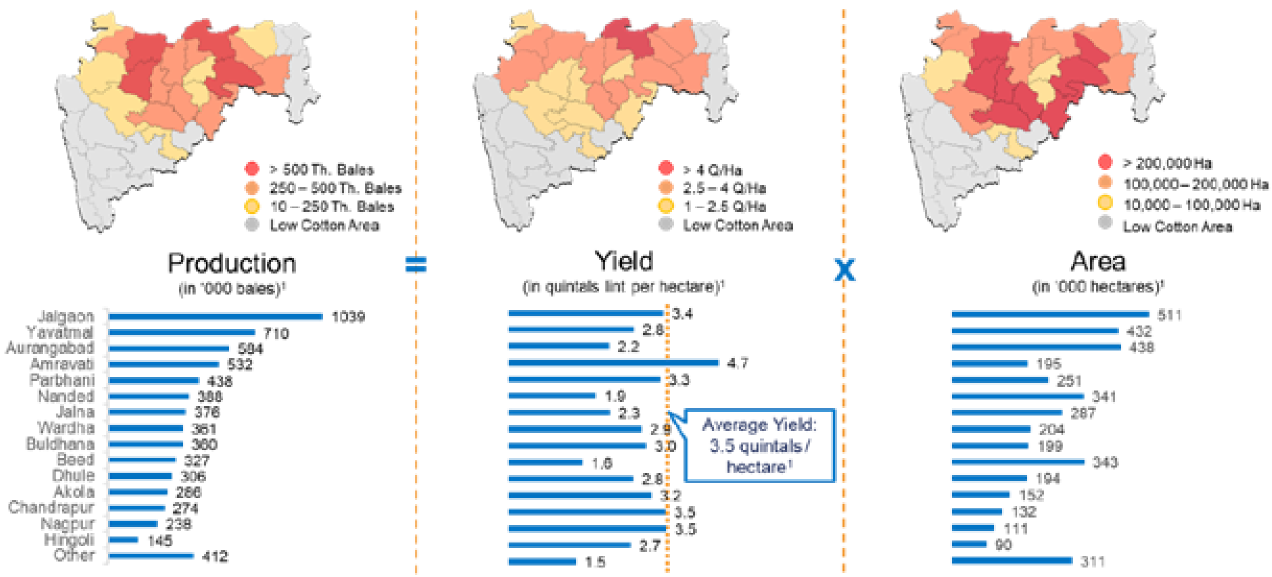


Figure 3: Area, production and yield for cotton vary amongst districts[23]

Within Maharashtra, cotton is mainly grown in 15 districts in the Central and Eastern regions (see Figure 3). Strong intra-state differences between farmer situations exists, with yields varying from 1.6 quintals of lint per hectare in Beed to 4.7 in Amravati (data referenced is an average of the cotton seasons from 2012 to 2016).[23] The average yield in Maharashtra lay at 3.5 quintals of lint per hectare.[24]

Given the situation of cotton farmers in Maharashtra, this report compiles, analyzes and prioritizes interventions towards doubling the net real incomes of cotton farming households in Maharashtra. All results shown were syndicated with numerous experts from the cotton industry, including representatives of the government, the private sector and NGOs. It is the hope of the authors that this study guides all those

[18] Eyhorn et al., "Impact of Organic Cotton Farming on the Livelihoods of Smallholders", 2005
[19] TechnoServe Farmer Survey, 2018
[20] NFSM, "Area, Production & Yield of Commercial Crops", 2018
[21] Ministry of Agriculture and Farmer Welfare, "Agriculture Census 2010-11", 2014
[22] TechnoServe Farmer Survey, 2018
[23] Department of Agriculture Maharashtra, "Final Estimates of Area, Production & Productivity of Principal Crops", 2012-16
[24] NFSM, "Area, Production & Yield of Commercial Crops", 2018

wishing to alleviate the burden of cotton farmers towards bold and impactful programs that will change the landscape of cotton farming in Maharashtra.

Methodology

The aim of this study on “Doubling Cotton Farmer Incomes in Maharashtra” is to find a bold and impactful set of interventions that positively affect farmer livelihoods in Maharashtra, and, in sum, can more than double net cotton farmer household incomes. As the availability of data on cotton farmer livelihoods in Maharashtra was severely limited at the time of the creation of this study, a comprehensive approach spanning secondary and primary research was used to build a data basis on which to make recommendations.

Figure 4: Three step approach used in the creation of this report

Data and insights for this study were collected and synthesized in a three-step approach:

1. **Diagnosis**: A structured literature review and extensive open-ended expert interviews were conducted to create a long-list of potential farmer interventions. A net income baseline was established in a farmer survey spanning cotton farmers from six districts in Maharashtra. A value chain analysis was conducted using both primary data from value chain player interviews and secondary research. Collected data was cleaned and analyzed and farmers were segmented into groups with distinct intervention requirements. The diagnosis step painted a clear picture of the constraints faced by cotton farmers in improving their net incomes.
2. **Intervention Design**: The long-list of identified interventions compiled during diagnosis was prioritized on the basis of an impact filter and an ease-of-implementation filter. The resulting shortlist of interventions was applied to farmers in a segment-specific manner, and net income impact was quantified. The intervention design step created a shortlist of quantified interventions for field implementation.
3. **Validation & Syndication**: The shortlist of quantified interventions was validated in syndication expert interviews. Expert feedback was integrated, and interventions optimized. The validation & syndication step ensured high accuracy and relevance of the finalized report.

The rest of this chapter further details the three-step approach described above.

Diagnosis

Diagnosis consisted of multiple connected data collection and analysis efforts, which are described individually in the following.

Literature Review

A comprehensive literature review of interventions aimed at improving cotton farmer livelihoods in Maharashtra was conducted in a structured approach. A MECE ("mutually exclusive, collectively exhaustive") framework was used to ensure a comprehensive spread of research (see Figure 5). Research analyzed was focused on Maharashtra, although studies from larger India and other developing cotton nations were also assessed. A full list of secondary research quoted in this paper can be found in the bibliography of this report, although a much larger set of studies was assessed during initial literature review.

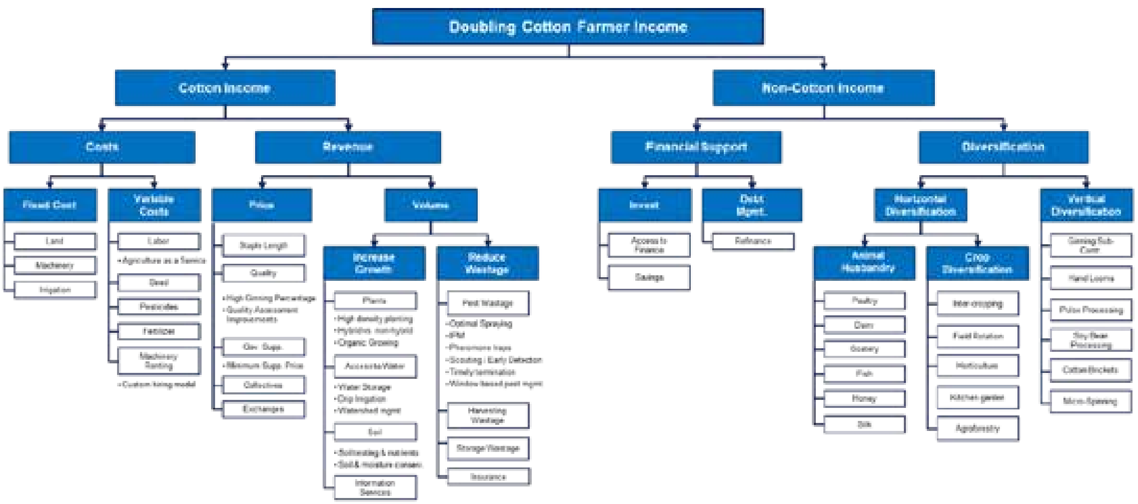


Figure 5: A MECE framework was used to structure secondary research

Open Ended Expert Interviews

Open ended expert interviews were conducted with various stakeholders in the Indian cotton industry. Questions asked in this set of interviews were broad and allowed participants to elaborate on their opinions and experience. All mentioned interventions and approaches were collected for more detailed analysis in literature review. Participants include representatives from the government (state and district representatives), NGOs, academic research institutes, private sector players and international development agencies. In total, 27 open ended interviews are conducted. A full list of experts interviewed in the creation of this study can be seen in the "Acknowledgements" section of this report.

Farmer Survey

A large-scale farmer survey of 726 cotton farmers was conducted from November 2018 to January 2019. Field teams used tablets and the Open Datakit (ODK) survey software to collect responses; a single survey response usually took 30-45 minutes to collect. Sole requirement for farmer participation was for the individual in question to have farmed at least one acre of cotton in the 2017 cotton season (June 2017 - May 2018). Farmer responses were collected from six districts in Maharashtra: Akola, Amravati, Jalna, Jalgaon, Parbhani and Yavatmal. Sampling of farmers for surveys within districts was carried out with support from local village contacts, provided by locally active partner organizations: Tata Trusts, WOTR, Jain Irrigation, Chetna Organic and BCI. Field staff selected a diverse set of farmers, paying special attention to ensuring that farmers selected were not disproportionately program farmers (i.e. farmers that were receiving NGO support from local partners). Within each district, at least two blocks were covered, and within each block at least three villages were surveyed. The exact number of surveys captured in each of the named districts and the reason for selecting the specified districts can be seen in Table 1.

District	Reasons for Selecting District for Farmer Survey[25,26,27]	Samples collected
Akola	Akola is one of Maharashtra's traditional cotton growing districts. It is located in the Vidarbha region, which has been in the focus of cotton news due to local farmer hardships. Like all Vidarbha districts, Akola is predominantly rainfed.	120 farmers
Amravati	Amravati is one of Maharashtra's traditional cotton growing districts, also located in the Vidarbha region. It is the fourth largest producer of cotton in Maharashtra and has enjoyed high yields in recent years. Like all Vidarbha districts, Amravati is predominantly rainfed.	92 farmers
Jalna	Jalna is a district with good irrigation facilities but some of the lowest cotton yields in Maharashtra. An increased number of farmers was surveyed in this district, as initial field results contained almost no rainfed farmers.	163 farmers
Jalgaon	Jalgaon has the largest production of cotton in Maharashtra. Compared to other districts in Maharashtra, farmers here are well-irrigated and have good access to water.	123 farmers
Parbhani	Parbhani is the fifth largest producer of cotton in Maharashtra. It is a well irrigated district with moderate yields and moderate rainfalls.	118 farmers
Yavatmal	Yavatmal is one of Maharashtra's traditional cotton growing districts, also located in the Vidarbha region. It is the second largest cotton producing district in Maharashtra. Like all Vidarbha districts, Yavatmal is predominantly rainfed.	102 farmers

Table 1: A diverse set of districts with high cotton-relevance was selected for surveying

Value Chain Analysis

A detailed value chain analysis was conducted for the cotton value chain in Maharashtra. Special focus was given to the pre-processing section of the value chain (defined as including farmers, aggregators and ginners), as this section of the value chain is most relevant to cotton farmers. Since farmer economics were already covered in the farmer survey, most work focused on interviews with aggregators and ginners to better understand their economics. It should be noted that while farmers were interviewed about the results of the 2017-18 cotton season, value chain interviews were based on the current situation in Maharashtra at the time of the conducted interviews, which took place from December 2018 to January 2019. A total of 23 aggregator interviews and 25 ginner interviews were conducted across four districts: Akola, Amravati, Jalna and Yavatmal. All districts selected were also covered in the conducted farmer survey. The exact number of value chain responses captured in each of the named districts and the reason for selecting the specified districts can be seen in Table 2.

[25] Maharashtra Department of Agriculture, "Production, Area and Yield", 2012-16
[26] Ministry of Water Resources, "Water and Related Statistics", 2013
[27] MOSPI, "Statistical Year Book of India", 2017

District	Reasons for Selecting District for Value Chain Analysis[28]	Interviews conducted
Akola	Akola was selected as a district displaying moderate aggregator dominance. Farmers here mostly sell to aggregators, but ginner and Agricultural Produce Market Committee (APMC) competition for cotton is still present.	5 aggregators, 7 ginners
Amravati	Amravati was selected as a second district displaying moderate aggregator dominance. Farmers here mostly sell to aggregators, but about one third of cotton produced in this district is sold to ginners or through APMCs.	3 aggregators, 4 ginners
Jalna	Jalna was selected as farmers here are almost fully dependent on aggregators in selling their produce, providing an extreme case of aggregator dominance. Jalna has a comparatively small number of ginners, and some cotton is exported to Gujarat.	9 aggregators, 6 ginners
Yavatmal	Yavatmal was selected as farmers here predominantly sell their produce to APMCs or directly to ginners, providing a counterpoint to other, aggregator dominated, districts. Many competitive ginners exist in this district.	6 aggregators, 8 ginners

Table 2: Districts for value chain analysis were selected to exhibit varying market systems

The value chain information for spinners, textile mills, and retailers was assessed based on information published in the quarterly earnings reports of publicly traded cotton value chain players, and the pricing of products at each stage of the value chain was estimated based on expert interviews. Since the value chain for cotton is heavily dependent on the final product being produced (e.g. soft luxury shirt of organic cotton vs. coarse, poorly treated shirt for street-side sales), all prices shown were agreed to be to produce “a shirt of average quality” in expert interviews. The retail price of the finished shirt was defined to be about INR 900.

Data Cleaning & Analysis

Data management was carried out using the ODK software suite (ODK aggregate, ODK briefcase) and uploaded to Google Sheets for further analysis. Data cleaning was carried out in Google Sheets; changes to existing data were verified with farmers and documented. Nine of 726 samples were excluded from further analysis due to data inconsistencies, leaving a total of 717 samples for final analysis.

[28] TechnoServe Farmer Survey, 2018

Intervention Design

Intervention design consisted of prioritizing a long-list of interventions to derive a shortlist for final recommendations. The impact of shortlisted interventions was then quantified for each of the identified farmer segments.

Intervention Prioritization

Intervention prioritization was carried out based on two applied filters. The first was an impact filter, which judged the ability of interventions to improve net farmer incomes and overcome identified farmer constraints. The second was an ease-of-implementation filter, which judged the financial requirements and do-ability of interventions. Application of filters to the identified interventions was carried out based on farmer survey data, value chain interviews, secondary research and expert interviews with a detailed scoring system (see Table 3).

Filter	Assessment Dimension	Scoring
Impact	**Financial Impact**	**3 points** for a major increase in net farmer income, which significantly improves farmer livelihood
		2 points for a medium net income benefit, which has a moderate effect on farmer livelihood
		1 point for a small net income improvement, which has no major effect on farmer livelihood
		0 points if no improvement in net income is generated
	Social	**1 point** if the intervention has social benefits (e.g. environment, health)
		0 points if the intervention has no social benefits
	Scope	**1 point** if the intervention addresses targeted constraints holistically
		0 points if the intervention does not address targeted constraints holistically
	Market Power	**1 point** if the intervention empowers farmers in the value chain
		0 points if the intervention does not empower farmers in the value chain
Ease of Implementation	**Financial Viability**	**5 points** if individual farmers with poor access to finance can practice the intervention
		4 points if individual farmers with stable access to finance can practice the intervention
		3 points if a collective with low capital investment can implement the intervention
		2 points if a collective with high capital investment can implement the intervention
		1 point if government or institutional support is required to make the intervention possible
	Complexity	**1 point** if the intervention is easy to adopt
		0 points if significant training and technical knowledge are required
	Scalability	**1 point** is awarded if the intervention is easily scalable
		0 points if the intervention is not easily scalable
	Farmer Acceptance	**1 point** if the intervention is readily accepted by farmers
		0 points if mobilization is difficult
	Policy & Innovation	**1 point** if the intervention requires no major policy shift or innovation
		0 points if the policy change or innovation is required to carry out the intervention

Table 3: A scoring system was applied to filter for impact and ease-of-implementation

For the impact filter, interventions were categorized as being high in ability to resolve farmer constraints if they reached a total score of 5-6 points, medium if they reached a total score of 3-4 points and low if they reached a total score of 0-2 points. High impact interventions all passed the impact filter, while low impact interventions did not. Medium interventions were further considered if they addressed one of the key farmer constraints identified in the analysis for this report: water, seed or value chain. For the ease-of-implementation filter, interventions were placed on a matrix and a cut-off was determined that balanced financial viability and ease of implementation (see "Prioritized Interventions" chapter for more details).

Detailed information about individual interventions and their ability to pass selected filters is provided in the appendix of this report as well as the "Prioritized Interventions" chapter of this document. In total, 56 interventions were analyzed as part of the intervention long-list, of which 16 were recommended as part of the shortlist for segment-specific application (see Figure 6). It should be noted that social interventions (e.g. around women empowerment) were not assessed in detail in this study, as IDH has commissioned a parallel study analyzing this issue in detail.

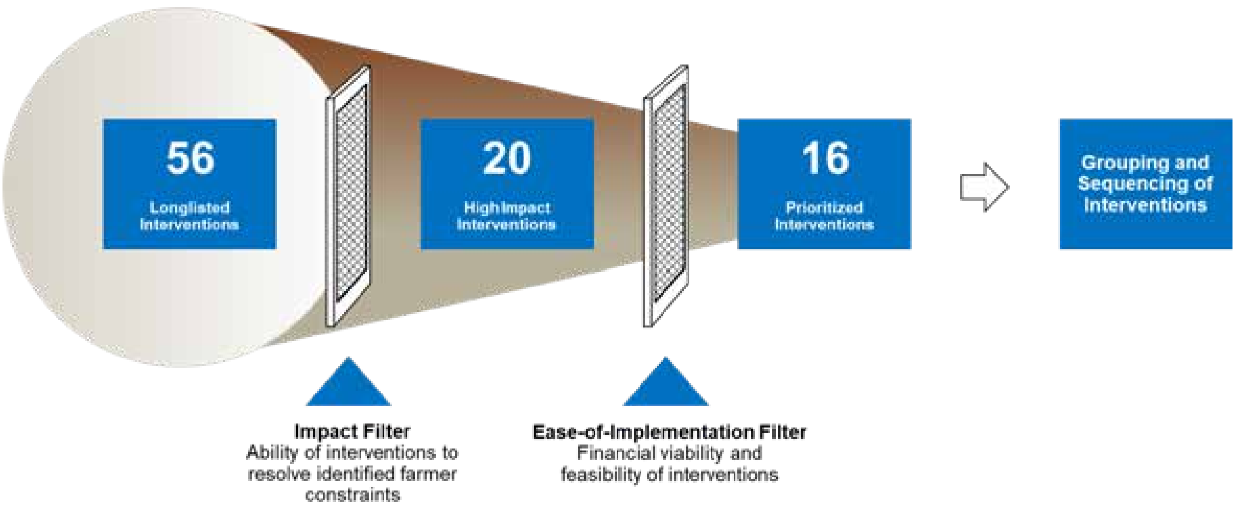


Figure 6: Two filters were applied to the long-list of identified interventions

Impact Quantification

Intervention impact was quantified based on primary and secondary data. A baseline was set with data from the conducted farmer survey, and this baseline was adjusted based on quantitative information (e.g. yield increases, cost reductions) found in published research studies and a set of farmer success stories collected by TechnoServe. Impacts were calculated in a segment-specific manner, allowing segment-specific information on the overall effect of the interventions proposed in this report.

Validation and Syndication

Validation and syndication were carried out by discussing collected results with various cotton stakeholders.

Syndication Expert Interviews

Syndication expert interviews were conducted with various stakeholders in the Indian cotton industry. Key results of the conducted analysis were shared and discussed. Feedback was discussed and integrated into the final report where appropriate. Participants included representatives from the government (state and district representatives), NGOs, academic research institutes, private sector players and international development agencies. In total, 27 open-ended interviews were conducted. A full list of experts interviewed in the creation of this study can be seen in the "Acknowledgements" section of this report.

Chapter 1: Farmer Constraints

The farmers in Maharashtra are a diverse group with varying backgrounds, constraints and livelihoods; the 717 farmers surveyed in this report showed strong differences in terms of landholding, access to water, household size, education and several other factors (see Table 4).

Topic	Description of Farmer Situation
Household Size	Average household size in the sample lay at 7 members per household but ranged from minimum of 2 to a maximum of 22. On average, households contained 3 adult men, 2 adult women and 2 children.
Farming Leadership	99.5% of farmers interviewed were male. Only 4 women were identified as leading the cultivation efforts on their farm household (this does not represent the overall role of women on farms and farmer households, where women share workloads with male family members)
Education	At 52%, the majority of farmers surveyed had received some form of basic education (primary, middle or higher education). 6% of farmers were illiterate, while 26% had received higher secondary education and 16% had attended graduate or postgraduate programs.
Social Groups	Farmers belonging to a scheduled tribe or caste made up 8% of the sample. Another 54% of farmers surveyed belonged to other backward castes, while 27% belonged to general castes and 10% identified as belonging to other groups.
Poverty Level	35% of surveyed farmers owned yellow ration cards, putting these households below the poverty line. At the same time, 62% of farmers received saffron ration cards, indicating that these households had yearly net incomes between INR 15,000 and INR 100,000. 2% of farmers owned a white ration card (net income above INR 100,000) and 2% reported owning no ration card.
NGO Support	17% of farmers were part of a collective or FPO and 19% of farmers received support from locally active NGOs. The majority of farmers did not receive any outside support.

Table 4: Farmer demographics varied within the surveyed sample

In an effort to accurately reflect situations on the ground, this report segmented farmers to allow for segment-specific analysis and intervention design. The core segmentation criterion selected was access to water, which varies widely across India and Maharashtra.

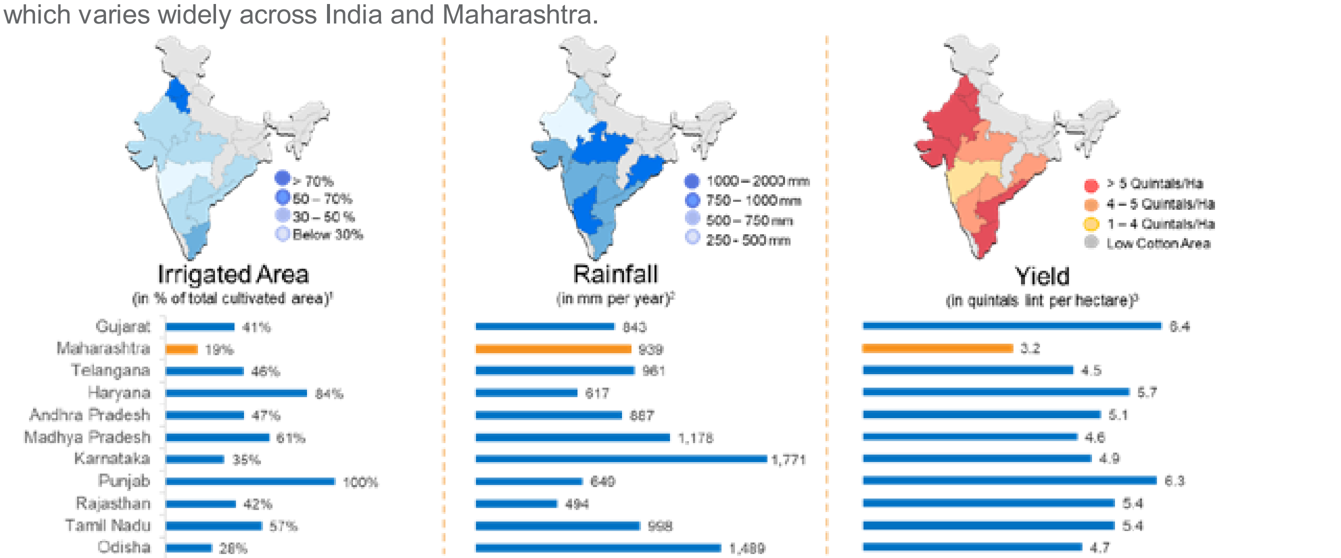


Figure 7: State-wise irrigated area, rainfall and yield for core cotton growing states in India

At the state level, Maharashtra receives moderate amounts of rainfall. Average rainfall over the time frame from 2012-2016 was 939 mm, giving Maharashtra the 6th highest rainfalls of India's 11 core cotton growing states.[29] In terms of irrigation, Maharashtra is lagging other states. Only 19% of Maharashtra's total

[29] State Wise Rainfall, OGD Platform India 2013.

cultivated area is irrigated, placing Maharashtra last in terms of irrigation among India's 11 core cotton growing states (see Figure 7).[30]

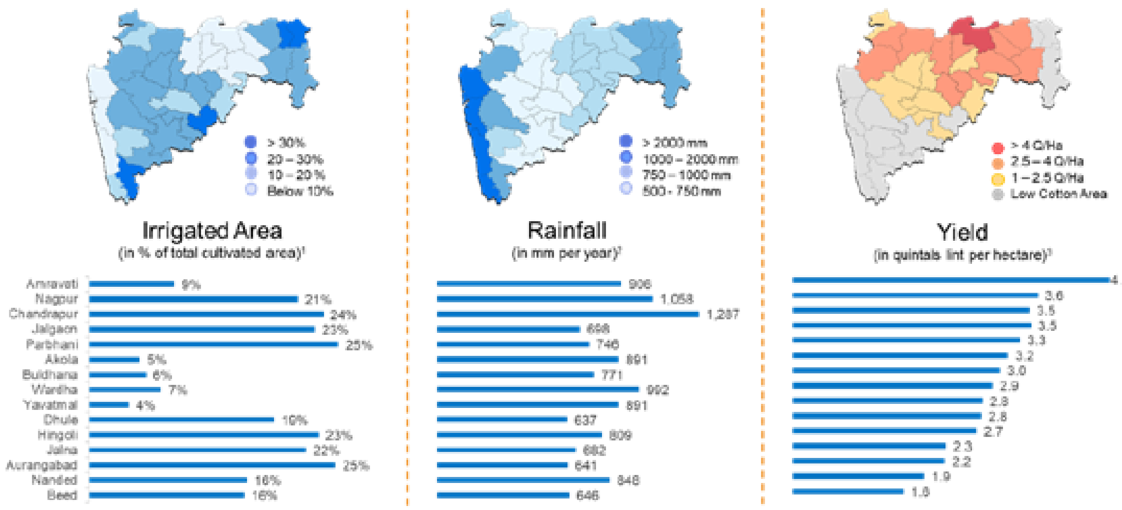


Figure 8: District-wise irrigated area, rainfall and yield for core cotton-growing districts in Maharashtra

At the district level, access to water and irrigation varies widely in Maharashtra. While the coastline and Eastern regions receive heavy rainfall, central Maharashtra shows only moderate rainfall. In the time frame from 2012 to 2016, the average rainfall in the central districts hovered around 750 mm, lower than Maharashtra's overall average.[31] At the same time, irrigated area makes up only a small portion of total cultivated area in many districts. The Vidarbha region, a hot spot for cotton production in Maharashtra, is particularly poorly irrigated. The Vidarbha districts -- Akola, Amravati and Akola -- all showed less than 10% irrigated area (see Figure 8).[32]

	Rainfed	**Partially Irrigated**	**Saturated Irrigation**
Irrigation	• Fully dependent on rain	• 1-4 flood or sprinkle irrigations p.a. • Drip irrigation with "some" water access	• 5+ flood or sprinkler irrigations p.a. • Drip irrigation with "full" water access
Landholding	• 3.2 hectares total • 1.7 hectares cotton crop	• 3.8 hectares total • 2.0 hectares cotton crop • 1.7 hectares irrigated cotton crop	• 3.7 hectares total • 2.2 hectares of cotton crop • 2.1 hectares irrigated cotton crop
Crop Portfolio	• Soya and cotton as cash crops • Intercropping with tur & grams	• Soya and cotton as cash crops • Intercropping with tur and other pulses • Diversification with some medium value crops common (e.g. sweet lime)	• Large set of cash crops (cotton, soya, sugar cane, …) • High value diversification common (e.g. vegetables, fruits, …)
Crop Season	• Predominantly kharif	• Predominantly *kharif*	• Both *kharif* and *rabi* (cotton is only grown in kharif, other crops year-round)
Total Annual Net Household Income	• ~90,000 INR per annum	• ~120,000 INR per annum	• ~215,000 INR per annum

Figure 9: Identified farmers segments and their characteristics

Our segmentation of farmers according to their ability to access water ultimately resulted in three segments: rainfed, partially irrigated and saturated irrigation. The rainfed segment was defined as consisting of farmers that were fully reliant on rain for irrigation – no secondary irrigation was installed on their land. Planting of

[30] Annual Rainfall, Statistical Handbook of India, 2018

[31] IMD, Statistics Download from Customized Rainfall Information System (CRIS), Accessed 2018

[32] CRIDA, Agriculture Contingency Plans, 2011

cotton crop took place in kharif with minimal crop diversification. This segment made up 37% of farmers surveyed, and total net household income lay at INR 90,000.

The partially irrigated segment was defined as consisting of farmers that carried out 1 to 4 irrigations on their cotton. In other words, this segment consisted of farmers that were able to carry out protective irrigation but did not have access to large and consistent amounts of water for perennial irrigation. Planting of cotton crop took place in kharif, and moderate amounts of crop rotation in rabi were observed. Partially irrigated farmers also planted a more extensive set of crops, including horticultural crops such as sweet lime. This segment made up 49% of farmers surveyed, and total net household income lay at around INR 120,000.

The saturated irrigation segment was defined as consisting of farmers that carried out 5 or more irrigations on their cotton crop. Farmers from this segment had year-round access to water and were able to consistently irrigate their crop. Planting of cotton crop took place in kharif, and farmers often planted secondary crops, either in crop rotation or on separate plots. Saturated irrigation farmers planted a wide variety of other crops, ranging from sugar cane to vegetables and fruits. This segment made up 14% of farmers surveyed, and total net household income lay at INR 215,000 (see Figure 9).

Farmer constraints were analyzed across a number of dimensions for each of the identified farmers' segments. Selected constraint-dimensions covered farming inputs such as seed, fertilizers and pesticides, but also touched on the cotton value chain, access to finance and diversification into other crops and non-agriculture income. Table 5 shows a full list of analyzed constraints, the core findings from their analysis and the degree to which they act as a constraint for each of the identified farmers' segments. Three constraints – seed, water and value chain – were identified as being key constraints after review of secondary data and expert interviews (shaded in orange in the table). Improving the situation of farmers in these key areas is judged to significantly alter farmer net incomes for the positive.

Topic	Description of Farmer Situation	Constraint for		
		Rainfed	Partial irrigation	Saturated Irrigation
Water	Lack of access to water remains a key constraint. Many farmers are rainfed, and even many irrigated farmers lack water for their irrigation systems.	●	◑	○
Seed	Seed variety is overwhelming. Farmers rely on poorly informed local networks or biased retailers for information. Use of too many variants decreases quality	●	●	●
Fertilizers	Farmers make poorly informed decisions on fertilizers. Soil testing is not common, leading to overuse, especially of fertilizers for vegetative growth	◑	◑	◔
Pesticides	Farmers are poorly informed and poorly time sprayings. Many pest measures are carried out reactively rather than proactively	◑	◑	◑
Labor and Mechanization	Labor shortage is rising, leading to higher labor costs. Harvest losses can occur if labor cannot be hired in time. Advanced mechanization solutions not locally available. Semi-automated machinery gives little productivity increases	◑	◕	◕
Value Chain	Farmers are price-takers and are not rewarded for high quality cotton. Aggregators often capture value that could also be captured by farmers	●	●	●
Access to Finance	Farmers have access to small and medium government loans. Business loans from private banks are difficult to access due to lack of collaterals	◑	◑	◔
Crop Options	Crop options are restricted by water availability with soya bean being the only other cash crop available to most	◕	◑	◔

Non-Ag Income	Lack of local opportunities prevents diversification in non-agriculture activities. Agriculture allied activities such as animal husbandry require know-how			

Table 5: Constraints were analyzed for identified farmer segments

Access to Water is key determinant of net farmer income

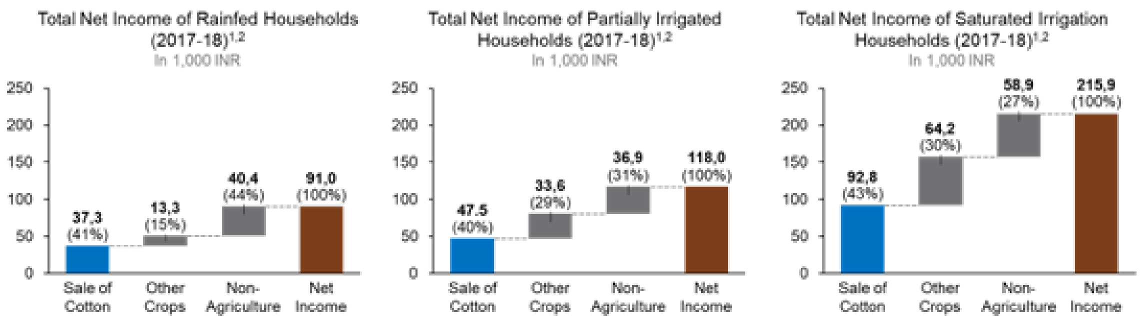


Figure 10: Access to water significantly increases net household income

The heavy constraint that water puts on farmers is the reason this report segments farmers according to their ability to access water. It is clear that access to water improves total net household income for farmers, as rainfed farmers have a net household income of only INR 91,000 on average, whereas partially irrigated farmers and saturated irrigation farmers have net household incomes of INR 118,000 and INR 215,900, respectively. At the same time, the breakup of total net household income for each of the three identified farmer segments changes across segments (see Figure 10).

Where rainfed farmers make only a small portion (13%) of their total net household income from cultivation of non-cotton crops (other crops), both the partially irrigated and saturated irrigation farmer segments more than double the portion of their net income that is generated from this source (29% and 30% respectively). On the flipside, the importance of non-agriculture activity as a source of net household income falls with increasing access to water: rainfed farmers earn 44% of their net income from non-agriculture activities (such as agriculture labor for other farmers or non-agriculture labor for government projects), while partially irrigated and saturated irrigation farmers earn only 31% and 29% of their total net household income from non-agriculture work. In other words, as rainfed farmers are limited in ability to increase their net income via agriculture, they strive to increase their net incomes through the alternative of non-agricultural work.

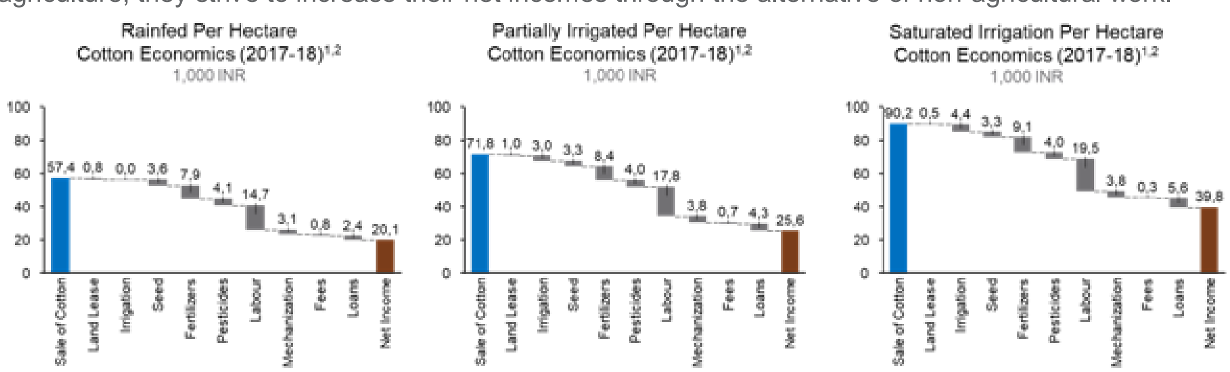


Figure 11: Net per hectare cotton income rises with increasing access to water

Access to water not only increases total net household farmer incomes, but also the yields and profitability of cotton farming. Overall, the net per hectare income made from cotton cultivation by farmers in this study increased from INR 20,100 for rainfed farmers to INR 25,600 for partially irrigated farmers and INR 39,800 for saturated irrigation farmers. This increase in profits was driven by the fact that yields consistently increased with more complete access to water, while costs of cultivation remained relatively constant across segments (only the cost of harvesting and the cost of irrigation significantly increase with more access to water, as it is directly linked to increased yields). A detailed breakdown of the cost of cultivation for each of the farmer segments is shown in Figure 11.

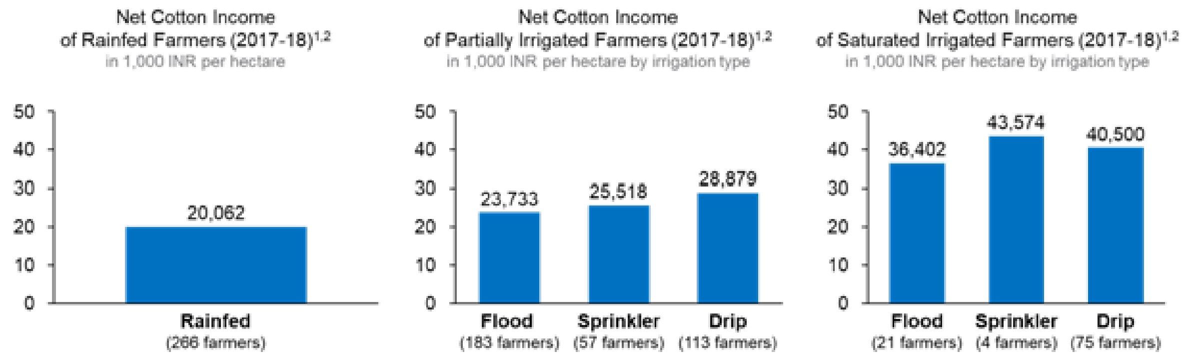


Figure 12: Irrigation improvements increase net per hectare cotton income

A further key determinant of farmer success was the type of irrigation system used. Partially irrigated farmers with flood irrigation made about INR 23,300 net cotton income per hectare, a value which was improved upon by partially irrigated farmers using sprinkler irrigation (INR 25,500) and partially irrigated farmers using drip irrigation (INR 28,900). Similar trends were observed within the saturated irrigation segment. Farmers in this segment had net cotton income per hectare of INR 36,400, whereas sprinkler irrigated farmers made INR 43,600 per hectare and drip irrigated farmers INR 40,500 (it should be noted that the high net cotton income per hectare for sprinkler irrigated farmers in the saturated irrigation segment was likely skewed upwards - only 4 farmers in this segment used sprinkler irrigation, while all other forms of irrigation had representative samples of at least 20 farmers). In general, more advanced irrigation systems like sprinkler and drip irrigation provided a net income benefit to farmers.

Seed choices are complex and limited

Farmers in Maharashtra face an overwhelming number of options when purchasing seeds. More than 1000 distinct seed products are available on the seed market with new products being released each year.[33] Amongst this high number of seeds, farmers are tasked with finding the optimal combination of traits for their local conditions and agronomic practices. Broadly speaking, farmers can optimize for: crop duration (e.g. short duration crop can finish key growth phases during the monsoon season, reducing water requirements for farmers with poor access to irrigation, but long duration crops are often preferred by farmers to allow a higher number of cotton pickings), drought resistance (e.g. local *desi* varieties are considered to be more drought resistant than modern hybrids), pest resistance (e.g. transgenic Bt cotton with improved resistance to key pests such as pink bollworm is highly popular amongst Indian cotton farmers), size (e.g. more compact growth is suitable for high density planting and for mechanical harvesting, while more bushy growth is often preferred in current hybrid systems), fiber quality indicators (staple length, g/tex and micronaire have a significant impact on the price of cotton lint), harvest index (i.e. the relation of

[33] Interview with Dr. TP Rajendran, 2019

fruit growth and vegetative growth in plants - higher harvest index values are considered beneficial, as they indicate per plant lint output), and yield (while yield is affected by a number of factors already named, farmers can select for boll weight and a high number of bolls per plant).

The large number of seed products available and the complex task of selecting correct traits for local conditions push farmers to diversify their risks by planting multiple seed products at the same time. If any variety then fails, the impact on the farmer will be mitigated through better yields from other varieties grown. The majority of farmers interviewed for this study planted multiple seed products on their land, with some farmers planting as many as seven different options (see Figure 12).

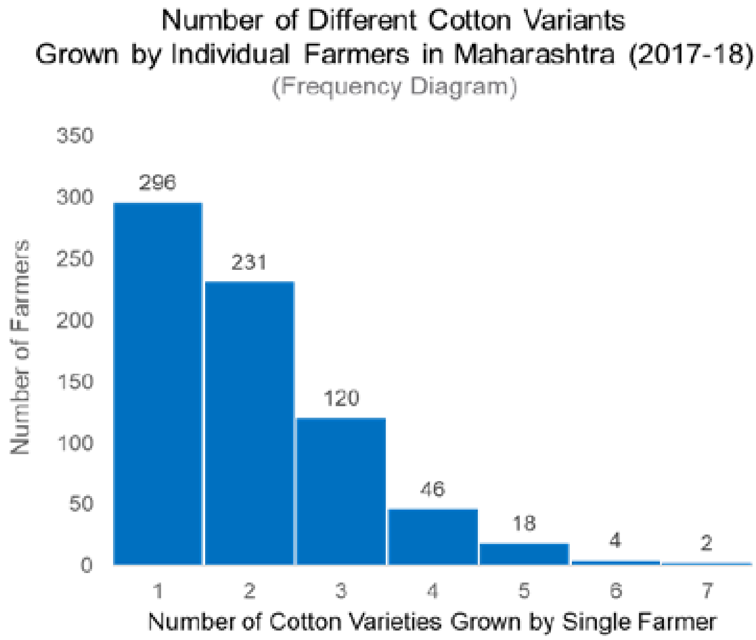


Figure 13: Farmers diversify risk by planting multiple seed varieties in any given season

In addition to planting multiple different cotton seed products, farmers in Maharashtra also rapidly switch to new varieties each cotton season. As much as 50% of all seed options grown in the 2017-18 season by farmers in this study had not been grown by the farmers in the previous season.[34] The large number of varieties grown and the rapid rotation to new seeds prevents farmers from building up specialized knowledge in any one selected cotton variety.

Sourcing of seeds for cotton cultivation happens almost exclusively through local vendors in Maharashtra; 98% of seed packages purchased by farmers in this study were bought from local vendors, while only 1.4% were purchased from government sources and 0.6% were sourced from other parties, including NGOs and local networks. Ninety-nine percent of the seeds purchased were hybrids; the remaining 1% mainly consisted of farmers that said they were not sure whether their variety was straight or hybrid. In other words, hybrids currently dominate the seed market in Maharashtra, and there is a lack of alternatives for farmers wishing to grow straight varieties. The dominance of hybrid seeds places a financial burden on farmers. Seeds harvested from hybrid parents cannot be replanted as the replanted cotton (F2 generation) suffers from inbreeding depression and heterosis, resulting in decreased yields and quality when planted.[35] This means that farmers need to purchase new hybrid seeds every year to ensure high yields. For each hectare, 5 seed packages are purchased on average, with prices ranging from INR 740 to INR 850 (the government mandated price for Bt hybrids was at 800 INR per package of 450 grams in the 2017-18 growing season)[36], leading to a total per hectare burden of about INR 3,000 for seed purchases. Development of straight varieties with high yields in the Indian context is therefore discussed as a key recommendation for government action in the chapter titled Government Context, of this report.

[34] TechnoServe Focus Group Discussions, 2018
[35] Panni *et al.*, "Heterotic Studies and Inbreeding Depression in F2 Population of Upland Cotton", 2010
[36] NSAI, "Government cuts Bt cotton seed price to INR 740", 2018

Chemical fertilizer is overused even though alternatives are popular

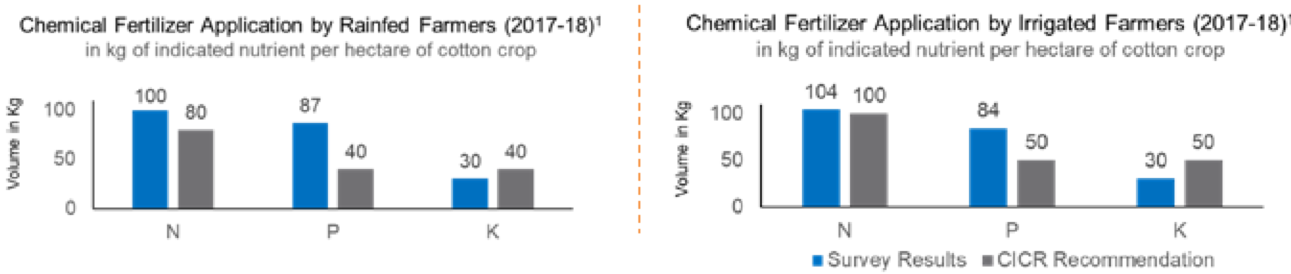


Figure 14: Farmers apply excess fertilizer to their fields

Farmers surveyed for this report used excess quantities of fertilizers, especially phosphorus. Where the recommended per hectare doses of Nitrogen, Phosphorus and Potassium (NPK) for rainfed cotton farmers lies at 80:40:40 (in Kgs) according to the Indian Central Institute for Cotton Research (CICR) recommendations[37], rainfed farmers in Maharashtra actually applied fertilizers in a split of 100:87:30, indicating an overuse of both nitrogen and phosphorus, paired with a need for increased use of potassium. A similar but less extreme picture emerged when analyzing the fertilizer usage of irrigated farmers. The CICR recommends a 100:50:50 split of NPK for irrigated farmers[38], but irrigated farmers surveyed for this report actually applied fertilizers in a split of 104:84:30 (see Figure 14) These results point to a strong need for further farmer education and increased use of scientific methods for applying appropriate amounts of fertilizers. On average, farmers spent INR 7,200 on chemical fertilizers per acre of cotton cultivation (excluding the cost of labor for application of those fertilizers).

Biological fertilizers were popular amongst farmers surveyed for this report; overall, 54% of the sample reported having applied a biological fertilizer in the 2017-18 cotton season. Almost all of these farmers (97%) used farmyard manure (FYM) from cows as the biological fertilizer of choice (the remaining 3% used alternatives such as composting and other types of animal droppings, e.g. sheep dung and poultry manure). In terms of costs, three groups of FYM using farmers were identified: one group of farmers owned cattle and left it to graze freely on their cotton land after the end of the cotton season, resulting in passive fertilizer application. A second group owned cattle and collected manure, which was then transported to their cotton field by third parties for a fee of INR 600-900 per trolley.[39] The third group had no cattle and purchased all FYM from external sources for around INR 3,000 per trolley. One trolley contains about 1 ton of dry FYM and up to 3 tons of wet FYM.[40] Averaged across all farmers (including those not using biological fertilizers), INR 1,000 were spent on biological fertilizers per hectare of cotton crop (excluding the cost of labor for application of those fertilizers).

[37] CICR, “Approved Package of Practices for Cotton: Maharashtra State”, 2006-07
[38] CICR, “Approved Package of Practices for Cotton: Maharashtra State”, 2006-07
[39] TechnoServe Focus Group Discussions, 2018
[40] TechnoServe Focus Group Discussions, 2018

Chemical pesticides are universally used

Chemical pesticides were commonly used by farmers, although the number of applied sprayings varied widely. Where most farmers applied somewhere between 3 and 8 pesticide sprayings for their cotton crop, higher numbers of sprayings were observed, with farmers applying up to 22 sprayings on their crop (see Figure 15). The high variability in the number of sprays points to a need for better farmer education and standardization of practice. Overall farmers spent INR 3,900 on chemical pesticides per hectare of cotton crop (excluding the cost of labor for application of those pesticides).

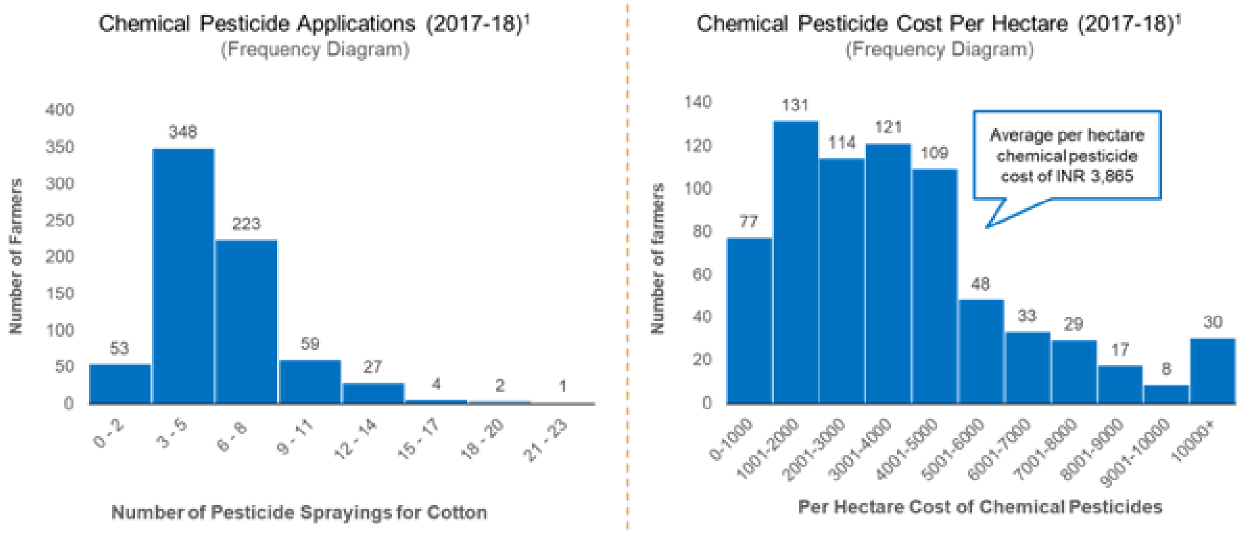


Figure 15: Spending on pesticides varies amongst farmers

Only 20% of the farmers surveyed for this report used biological pesticides for their cotton crop. Of these, 86% used Neem Ark as the biological pesticide of choice. Amongst Neem Ark users, two groups of farmers were identified. The first group of farmers collected Neem leaves/seeds locally or purchase Neem leaves / seeds at local markets and then homebrewed Neem spray, resulting in costs of INR 0 to INR 350 per hectare.[41] The second group of Neem Ark using farmers purchased Neem extract from markets and diluted it to create Neem spray. This costs about INR 350 to INR 600 INR per hectare[42]. Amongst the farmers using biological pesticides, 16% opted for non-Neem pesticides, such as cow urine or Dashparni ark. Averaged across all farmers (including those not using biological pesticides, INR 160 were spent on biological pesticides per hectare of cotton crop (excluding the cost of labor for application of those biological pesticides).

[41] TechnoServe Focus Group Discussions, 2018
[42] TechnoServe Focus Group Discussions, 2018

Indian farms rely on labor with moderate mechanization

Labor is the largest input cost incurred by farmers, making up about half of the total cost of cultivation for farmers (see Figure 11). A number of farm activities requiring labor are carried out for cotton, including land preparation, sowing, irrigation, fertilizer and pesticide application, weeding and harvesting. These activities have varying out of pocket costs for farmers, depending on their labor intensity and the degree to which they are carried out using household labor (see Figure 16). On average, farmers in Maharashtra spent INR 18,800 on labor for cotton cultivation. Most costly amongst the activities needed for cotton farming are weeding and harvesting.

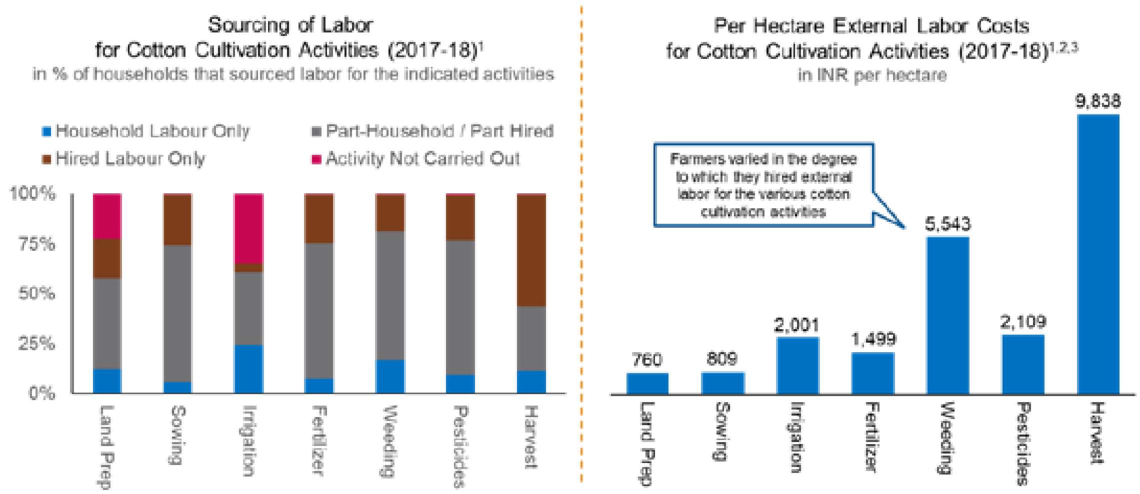


Figure 16: Labor costs are mostly driven by weeding and harvesting

Weeding work is usually carried out as a mixture of household labor and externally hired labor: 17% of households reported carrying out weeding activities all on their own, 64% of households said they shared weeding work with external labor and 19% of households reported having all weeding work done by external labor. While farmers doing weeding by household labor only spent no additional money on weeding, those households that did hire external labor for weeding spent an average of INR 5,500 per hectare for this activity.

In contrast to weeding, where a large portion of labor was done by households, harvesting is mostly carried out purely through external help: 12% of farmers reported doing harvesting purely on household labor basis, 32% of households said they shared harvesting work with external labor, and 56% of households reported having all harvesting work done by external labor. While farmers doing harvesting by pure household labor spent no additional money on harvesting, those households that did hire external labor for harvest spent an average of INR 9,800 per hectare for this activity; however, this amount varied strongly depending on yield. External workers are paid between 5-15 INR per kilogram of cotton harvested (the rate varies by region and season - later pickings within the season are more expensive, as the amount of cotton that a single laborer can pick within a day decreases). As cotton harvesting is paid by weight, higher yields always translate into more harvesting labor expenses.

On the flipside of labor lies mechanization, which is growing in importance on Indian farms – 85% of farmers surveyed used one of the core farm implements analyzed in this report: tractor, harrow, weeder, hoe, seed drill and harvesters. Usage of a tractor was most common amongst farmers - 75% of farmers reported using a tractor for land preparation or other activities on their farms. Also very common is the use of mechanization for weeding to reduce expenses on this major source of labor costs: 38% of farmers used a harrow for their cotton crop, 24% used a weeder and 13% used a hoe to contain weeds. Unfortunately, other mechanization solutions are not yet commonly used. Less than 1% of farmers reported using seed drills for efficient planting of cotton or mechanical harvesters for efficient harvesting. The reasons for the low adoption of these technologies are varied. Seed drills are little employed because the current cultivation of hybrid cottons is carried out in low density planting, which requires little precision and can be carried out cheaply with manual labor. Mechanical harvesters are hindered by landholding fragmentation, seed varieties grown (hybrid cotton grows large and bushy while harvesters can only work with small compact plants), and high trash content in cotton (mechanically harvested cotton requires additional cleaning equipment[43], which most gins in Maharashtra do not possess). Both seed drills and mechanical harvesters hold potential for the future in Maharashtra (e.g. if High Density Planting becomes more common), but currently they are not viable on most cotton landholdings.

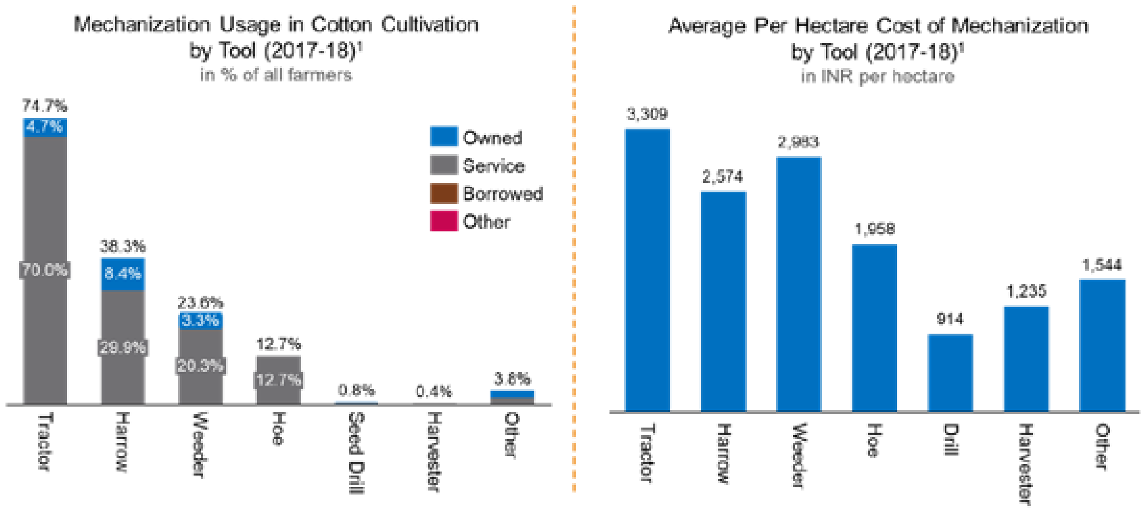


Figure 17: A limited number of mechanization solutions are common in cotton

Machinery for cotton cultivation is almost sourced as a service. Ownership of farm implements is still rare and reserved for farmers with good financial situations, e.g. only 4.7% of farmers using tractors owned the tractor themselves, and only 8.4% of farmers using a harrow actually owned it. Purchasing of mechanization as a service has varying price points, depending on the services provided (see Figure 17). Overall farmers in Maharashtra spent INR 3,300 on mechanization per hectare of cotton crop on average, picking only a subset of the equipment listed above for their farm.

[43] Singh et al., "Cotton Mechanization in India", 2014

The pre-processing cotton value chain is dominated by aggregators

Cotton farmers are the source of raw products, cotton lint and seed, that are used in numerous high-profile industries on a global scale. While cotton lint is used predominantly in the garment industry, it is also used to make cotton wound wraps for hospitals, coverings for home furniture, book bindings and zipper tapes.[44] At the same time, cotton seed is pressed to extract cooking oil and the remaining materials are used as animal feed. The analysis carried out in this report focuses predominantly on the garment sector, as this sector is the driving force behind large-scale cotton cultivation and accounts for the majority of cotton lint consumption.[45] Analysis is furthermore focused on the cotton value chain in Maharashtra - a strong focus was put on understanding the early section of the value chain, in which the farmers are most active.

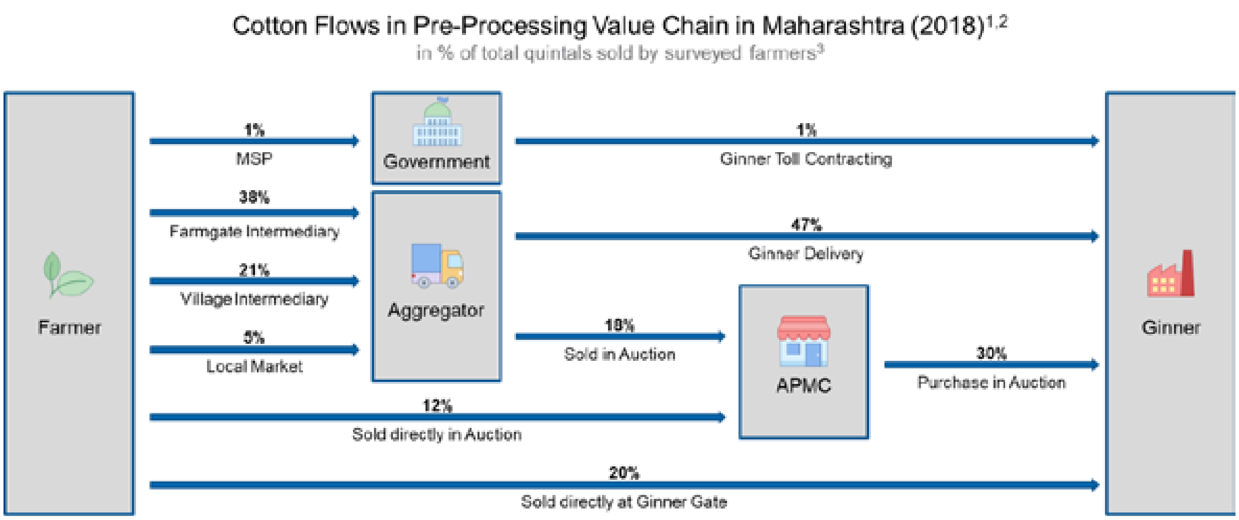


Figure 18: The cotton pre-processing value chain is aggregator-dominated

The early section of the value chain contains a number of players: farmers, aggregators, ginners, Agricultural Produce Market Committees (APMCs) and government procurement agencies. Farmers lie at the very beginning of the value chain and produce raw cotton, which is then moved to local ginneries where the raw seed cotton is turned into compact bales of cotton lint and cotton seed. The process of moving cotton from farmer to ginner can be taken up by farmer directly, but more often some form of intermediary is employed. In the four districts analyzed in this report, 20% of total cotton sold in the 2017-18 season was sold directly to ginners on average. Intermediaries are most often local middlemen (aggregators), who purchase cotton from farmers at the farmgate, in the village or at local markets. They take care of transport and sell their cotton at an increased price to ginners. Sales to local aggregators make up 64% of the cotton sold by farmers on average. Another possibility for cotton to move from farmers to ginners is through APMCs. At these government-run markets, cotton is sold through a process of auction. Both farmers and intermediaries sell cotton to ginners at APMCs. About 20% of cotton sold by farmers is sold directly to an APMC on average. Lastly, cotton can also be procured by the government under its Minimum Support Price (MSP) scheme. Government purchased cotton is not sold to ginners directly; rather the governments pays ginners a fixed fee (toll) to have the government cotton stocks turned into lint bales and seed. These cotton products are then traded on open markets by the government. In the last few years, the Minimum Support Price has been moving below local cotton prices[46]; only 1% of all cotton sold by farmers surveyed for this

[44] National Cotton Council of America, “Cotton's Major Uses”, Accessed 2019
[45] National Cotton Council of America, “Cotton's Major Uses”, Accessed 2019
[46] CACP, “Price Policy for Kharif Crops - The Marketing Season 2018-19”, 2018

report for the 2017-18 cotton season was through government procurement agencies, which purchase cotton from farmers when market prices fall below MSP.

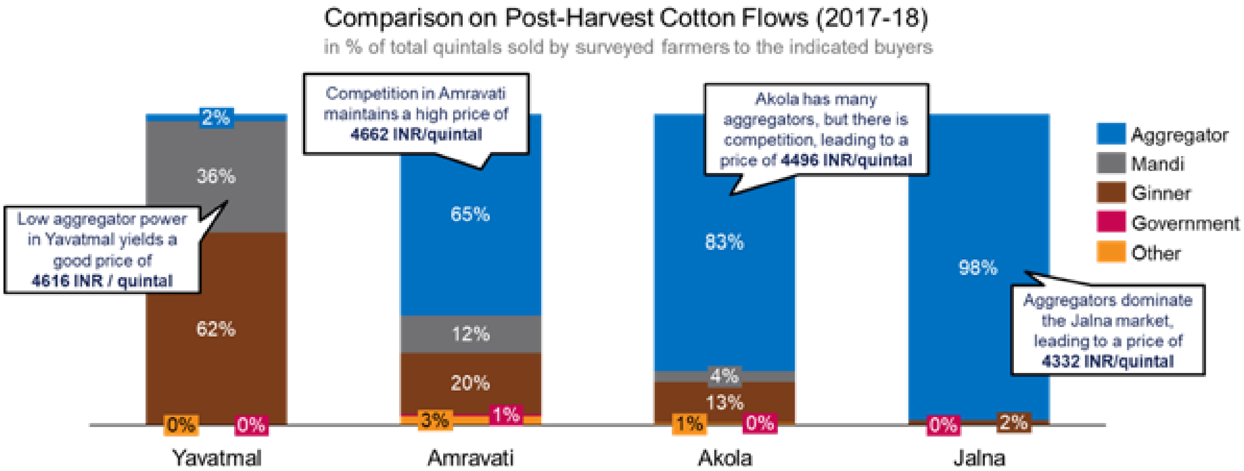


Figure 19: Aggregator dominance affects farmer price realization

While an averaged picture of cotton flows in the pre-processing value chain (see Figure 18) shows that a sizeable portion of the overall cotton sold moves through APMCs or is sold directly to ginners, a closer look reveals strong inter-district differences (see Figure 19). While some districts, such as Akola and Amravati show mixed flows of cotton, other districts like Yavatmal and Jalna lie at extremes. In Yavatmal only 2% of cotton was sold from farmers to local middlemen, while in Jalna 98% of cotton was sold from farmers to local middlemen. The data collected for this study reveals that aggregator dominance has negative effects on farmer price realization (see Figure 19). Farmers in districts with competition between aggregators, ginners and APMCs such as Yavatmal and Amravati received more than INR 4,600 per quintal for their cotton crop in the 2017-18 season, while farmers in Akola, where 83% of cotton flows through aggregators, received about INR 4,500 per quintal and Jalna farmers received only about INR 4,330 per quintal.

The value chain interviews conducted in the scope of this study also revealed details about aggregator and ginner margins that are important for any government or non-profit organization wishing to engage in forward integration interventions with cotton farmers. The conducted analysis of aggregator margins revealed that aggregators have a margin of around INR 840 per bale of cotton, which translates into about INR 180 per quintal (see Figure 20). This margin considers the main costs faced by aggregators, which are labor for loading (about INR 250 per bale of cotton), transportation (about INR 290 per bale of cotton) and labor for unloading (about INR 60 per bale of cotton). It does not account for the cost of capital, which was not fully assessed in this study, but factors in weight manipulation practices such as downwards rounding and water addition. Downwards rounding refers to the fact that aggregators tend to determine the quantity of cotton at the farm gate in a fashion that is beneficial to them (downwards rounding of weight).

On an average, the conducted interviews show that downward rounding allowed aggregators to realize an "increase in weight" of about 2% between farm gate and the ginner.[47] A similar practice is water addition, which refers to the fact that some aggregators add water to cotton purchased at the farm gate in an effort to increase the weight of their produce before it reaches the ginner. Water addition was also found to increase the weight of cotton by about 2% between farm gate and the ginner, although the practice varied in prevalence between districts and was most commonly found in Jalna.[48]

[47] TechnoServe Value Chain Interviews, 2018
[48] TechnoServe Value Chain Interviews, 2018

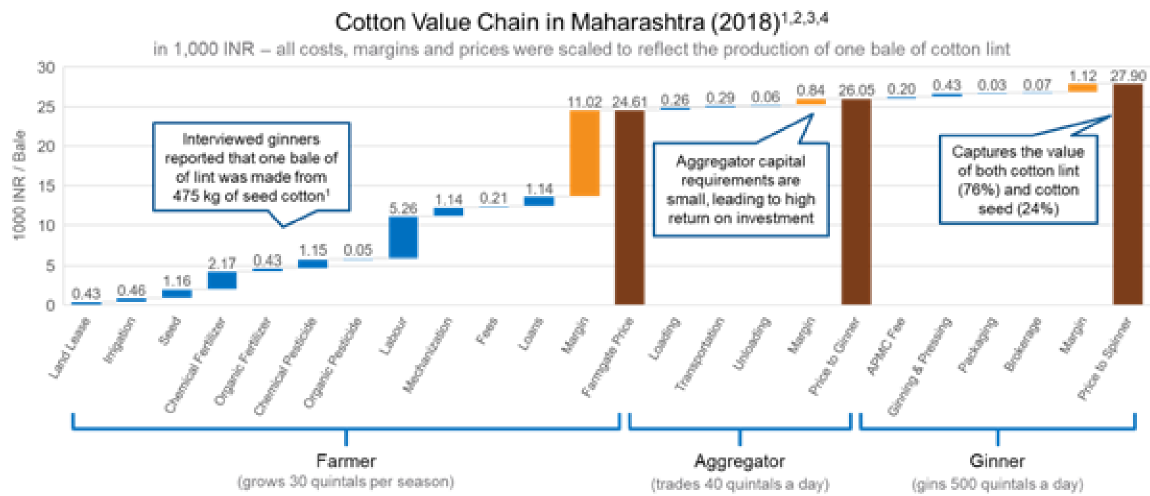


Figure 20: Farmers make the largest margin in the cotton value, but at low volume

At the next stage of the value chain, the conducted analysis of ginners showed a margin of INR 1,100 per bale of cotton (see Figure 20). This margin considers the main costs faced by ginners, which are APMC fees (about INR 200 per bale of cotton), ginning & pressing costs (about INR 430 per bale of cotton), packaging (about INR 30 per bale of cotton) and brokerage (about INR 70 per bale of cotton). It does not account for the cost of capital, which was not fully assessed in this study, but factors in ginning technicalities such as moisture adjustment and wastage. Moisture adjustment refers to the fact that ginners add water to their cotton to optimize moisture content of cotton for their ginning equipment and later for spinning mills. According to the value chain interviews conducted for this study, moisture adjustment during ginning results in a 1.8% increase in the weight of lint gained during ginning.[49] Wastage refers to the fact that cotton arriving at ginning units usually contains a certain amount of trash (e.g. leaves, twigs from cotton fields), which is removed during ginning. About 1.5% of the weight of seed cotton arriving at ginning mills in Maharashtra is lost as wastage during ginning.[50]

This study also analyzed the profitability of more downstream market players, such as spinners, textile mills and retailers to get a full picture of the cotton value chain. It was found that during the production of one cotton shirt with a final retail value of about INR 900, spinners realize a profit of about INR 9 on top of costs of INR 71 (11% margin). For the same cotton shirt, a textile mill realizes a profit of about INR 35 on top of input costs of INR 230 (13% margin). Finally, retailers, who were considered to also engage in cutting, trimming and making of shirts, realized a profit of INR 93 at inputs costs of INR 774 (11% margin). This data shows that while the later sections of the value chain have high absolute profits, their margins are of moderate size (see Figure 21).

Overall, the conducted value chain, especially the analysis of aggregators and ginners, shows that there is room for interventions aiming to integrate farmers into markets more efficiently. Reduced reliance on aggregators, for example, has the potential to increase the prices farmers receive for their cotton during cotton season. A number of interventions around farmer collectivization and integration of farmers into the value chain are therefore analyzed in later sections of this report.

[49] TechnoServe Value Chain Interviews, 2018
[50] TechnoServe Value Chain Interviews, 2018

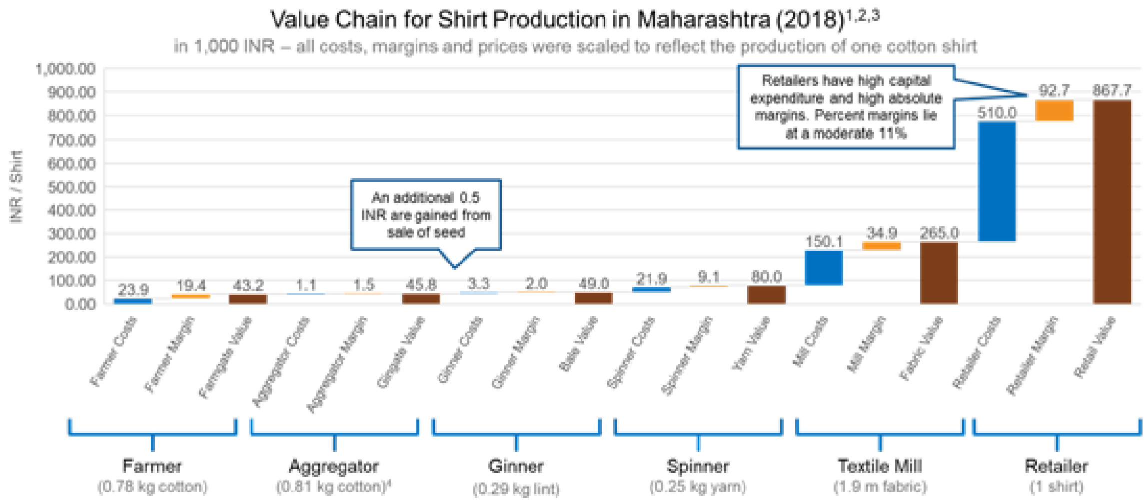
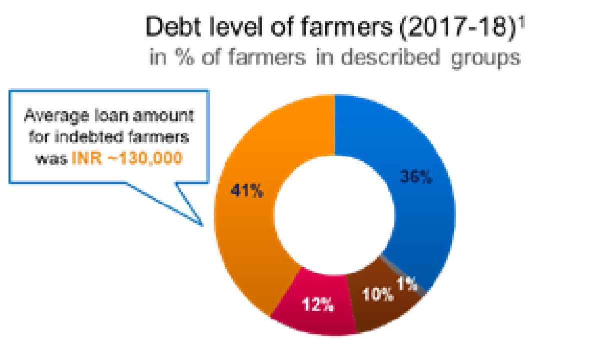


Figure 21: Retailers have high absolute margins that are in line with their capital investment

Farmers' access to finance is limited to crop loans

Farmer debt and access to finance are important topics when considering the livelihoods of cotton farmers in Maharashtra. In general, farmers initially have some amount of access to finance. In fact, 64% of the farmers surveyed for this report had active loans in the 2017-18 cotton season. The majority of farmers received these loans from banks (75% of farmers) and cooperatives (16% of farmers), with the remaining 9% of farmers receiving loans from family members (1% of farmers), local lenders (6% of farmers) and other sources (2% of farmers). Where bank and cooperative loans were given at government subsidized interest rates of 7% and 8% per annum respectively, local lenders charged an exorbitant annual interest rate of 48% on average. Farmer loans were predominantly agriculture loans: 98% of farmers with debts reported having taken crop loans, while 2% had business loans, 2% had educational loans and 3% had personal loans.



Farmer Debt Group	Debt to Total Net Income Ratio
No Debt	0
Low Debt	0 – 0.1
Medium Debt	0.1 – 0.5
High Debt	0.5 – 1.0
Very High Debt	> 1.0

Figure 22: Farmer Debt is prevalent and unsustainable

The high percentage of farmers with loans in the 2017-18 cotton season indicates that initial access to finance for agriculture is not initially a problem for farmers. Focus group discussions with farmers confirmed this notion and pointed to the more relevant problem of high farmer debt, which prevents farmers from accessing further finance, as financial institutes are not willing to make loans to already indebted farmers.[51] Of the farmers surveyed for this study, 64% had active loans in the 2017-18 cotton season, although the degree to which farmers were indebted varied. Of the indebted farmers, 36% had small to medium debts with values below their annual net income, but the remaining 64% (41% of the total farmer sample) had non-manageable debts that exceeded their annual net income (see Figure 22: Farmer Debt is prevalent and unsustainable).

[51] TechnoServe Farmer Survey, 2018

Crop options are determined by access to water

As access to water grows, farmers balance their agriculture activities - diversifying from cotton to include more high value crops. Comparing the cropping system of rain fed, partially irrigated and saturated irrigation farmers, it becomes clear that while farmers with less access to water heavily engage in intercropping as a simple form of crop diversification, more irrigated farmers tend to engage in more intensive forms of crop diversification by growing other crops on secondary plots of land or by growing a second crop in rotation after cotton. Fifty-six percent of rainfed farmers reported performing intercropping on their cotton crop, but this value sank to 44% and 32% in partially irrigated and saturated irrigation farmers respectively. At the same time, only 3% of rainfed farmers reported growing a second crop in rotation and 47% reported growing other crops on secondary plots, values which were increased upon by partially irrigated farmers (12% engaged in second crop rotations and 64% had crops on secondary plots) and saturated irrigation farmers (5% engaged in second crop rotations and 63% had other crops on secondary plots). ´

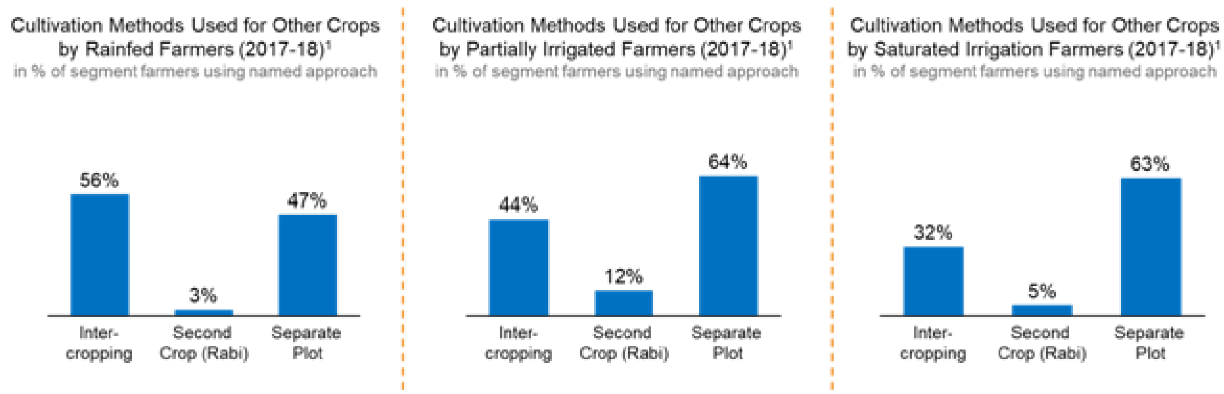


Figure 23: Cultivation methods used to grow other crops change with increasing access to water

Even more important than the differences between the cropping systems of rain fed, partially irrigated and saturated irrigation farmers are the changes in the crop options available to farmers as their access to water increases. Where rain fed farmers predominantly grow soya bean and grams (predominantly pigeon pea) for diversification with a small amount of diversification into grains (9% of rain fed farmers reported growing grains), partially irrigated and saturated irrigation farmers increasingly diversified towards grains, fruits and vegetables while moving away from soya bean and grams This data shows that farmers generally are interested in diversifying towards more high value crops, but lack of access to water is often holding them back from moves towards these income-increasing crops.

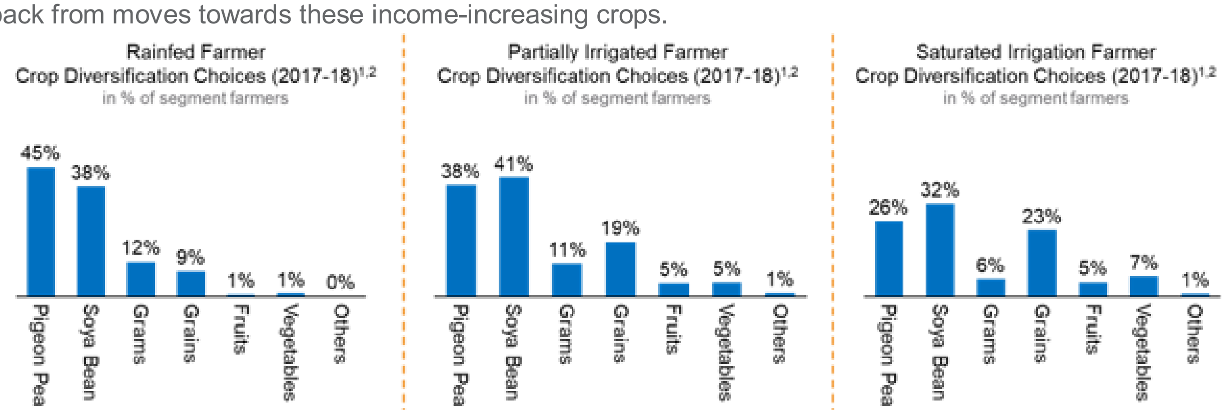


Figure 24).

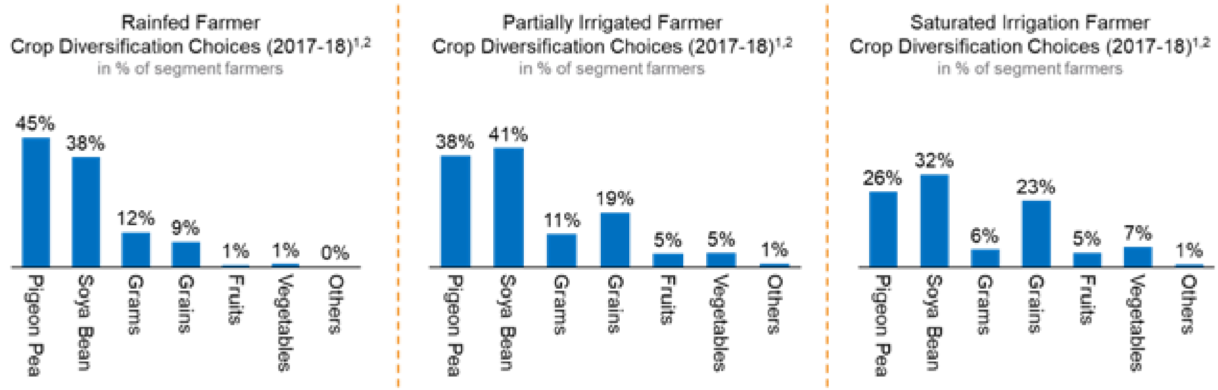


Figure 24: Farmers grow more high-value crop with increased water access

Non-agriculture activities are pursued to diversify income

Non-agriculture activity was pursued by farmers across all segments. Roughly 50% of farmers in each segment analyzed participated in some form of non-agricultural work (49% of rain fed farmers, 50% of partially irrigated farmers and 48% of saturated irrigation farmers). However, the activities carried out by farmers in each of these segments varied strongly. Rain fed farmers predominantly worked in low-investment jobs; 35% of the non-agriculture work done by rain fed farmers was agricultural labor on other farms (defined as "non-agricultural" because it did not happen on owned land), 21% was non-agricultural labor (e.g. for government projects as part of MGNREGA scheme) and 16% was salaried work, leaving only 29% of high-investment activities such as business and animal husbandry. Partially irrigated farmers shifted their non-agricultural activity profiles towards high-investment activities: 21% of the non-agricultural work done in this segment was in animal husbandry and 19% was in businesses while salaried work, non-agricultural labor and agricultural labor on other farms reduced in importance. This trend towards more "entrepreneurial" activities continued when analyzing saturated irrigation farmers: 23% of saturated irrigation farmers doing non-agriculture work engaged in animal husbandry and 20% operated a business (see Figure 25).

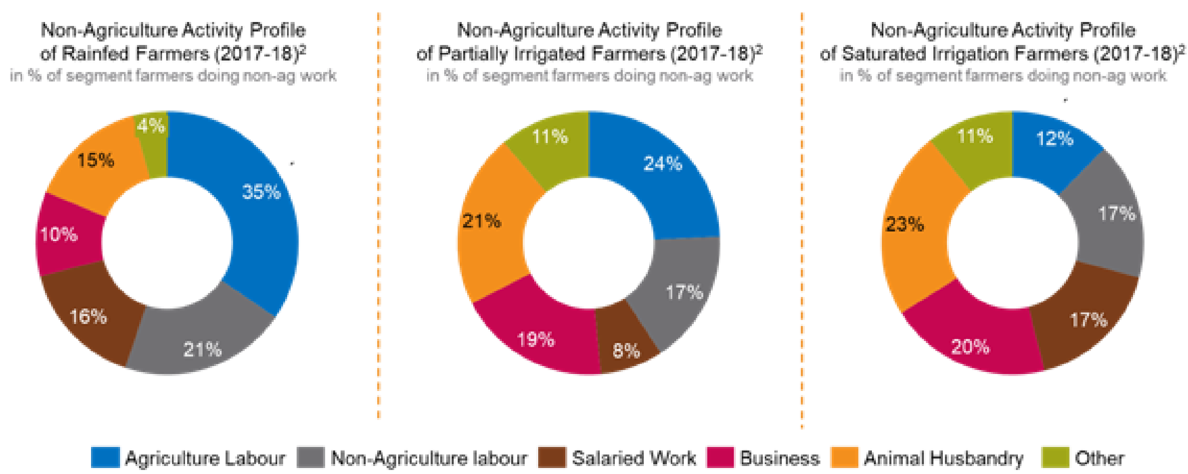


Figure 25: Farmers pursue more high-invest activities as their access to water rises

Chapter 2: Government Context

Government engagement in agriculture plays an important role in India. Both central and state governments actively promote agriculture and extend support to farmers by increasing investment in the sector. Between 2012-13 and 2016-17, total central government agriculture spending doubled from about 58,000 crore INR to 116,000 crore INR.[52] In the same time frame, Maharashtra government's agriculture spend rose from 3,500 crore INR to 9,600 crore INR with a maximum annual spending of 11,800 crore INR in 2015-16.[53]

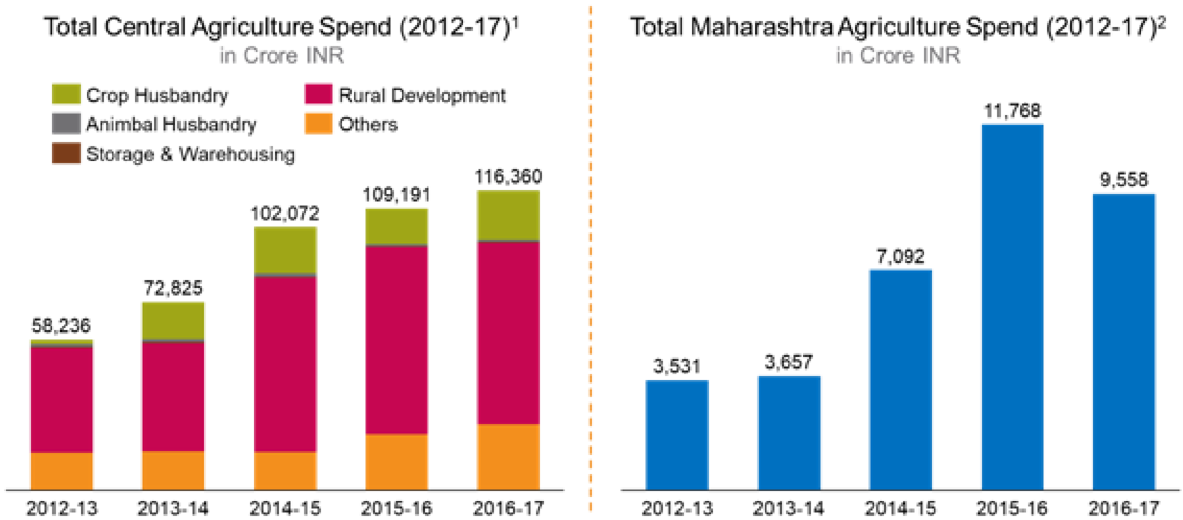


Figure 26: Central and state government's agriculture spending has been rising

Government context in cotton farming was analyzed across a number of dimensions. Selected context-dimensions covered farming inputs such as seed, fertilizers and pesticides, but also touched on the cotton value chain, access to finance and diversification into other crops and non-agriculture income. Table 6 shows a full list of analyzed context, the key findings from the respective analysis and the degree to which government action in each topic is relevant to each of the three farmer segments identified in this report. Three issues – seed, water and value chain – were identified as being key constraints after review of secondary data and expert interviews (shaded in orange in the table). Improving the situation of farmers in these key areas is judged to significantly alter net farmer incomes for the positive.

[52] Ministry of Finance, "Indian Public Finance Statistics 2016-17", 2018
[53] Directorate of Economics and Statistics, "Economic Survey of Maharashtra 2017-18", 2018

Constraint	Description of issues	Constraints for		
		Rain fed	Partially Irrigated	Saturated Irrigation
Water	Several large-scale irrigation projects underway. Multiple programs subsidizing small-scale improvements such as water harvesting and irrigation systems	●	◑	○
Seed	Seed prices for hybrid and straight seed are mandated centrally. Policy needs to be changed to encourage open pollinating variants resurgence	●	●	●
Fertilizers	Heavily regulated sector, with fixed urea price and variable P & K prices; rapidly rising P & K prices skewing consumption further in favor of urea	◑	◑	◔
Pesticides	No major government context or constraints identified in field surveys and expert interviews. Farmers have ready access to a large amount of pesticides.	○	○	○
Labor and Mechanization	Job guarantee scheme driving agricultural labor shortage and increase in wages[54]	◑	◕	◕
Value Chain	Govt. commits to buy all cotton at Minimum Support Price (MSP), but market prices have topped MSP. eNAM has highly limited facilities for cotton.	●	●	●
Access to Finance	KCC and Primary Agricultural Cooperative Societies supporting farmers. Farmer loan waivers reducing farmer debt burden but skewing expectations	◕	◑	◔
Crop Options	No major government context or constraints	○	○	○
Non-Ag Income	Numerous subsidies for diversification into non-agriculture allied activities are provided	◔	◔	◔

Table 6: Government constraints were analyzed for identified farmer segments

Various government schemes promote irrigation

Central and state governments are making efforts to ease the burden of farmers by conducting macro-level irrigation projects and by subsidizing irrigation solutions at the farm level. The Maharashtra government alone has committed to implementing 4043 macro-irrigation and water resource management projects covering a potential irrigation area of 82,12,116 hectares, 1615 of which have been completed to date.[55] Precision irrigation techniques and on farm management are being actively promoted by government with an aim to conserve water and create awareness about better farm management practices and judicious use of water resources. To accelerate the pace at which advanced irrigation systems are adopted, various water management schemes have been introduced (see Figure 27).

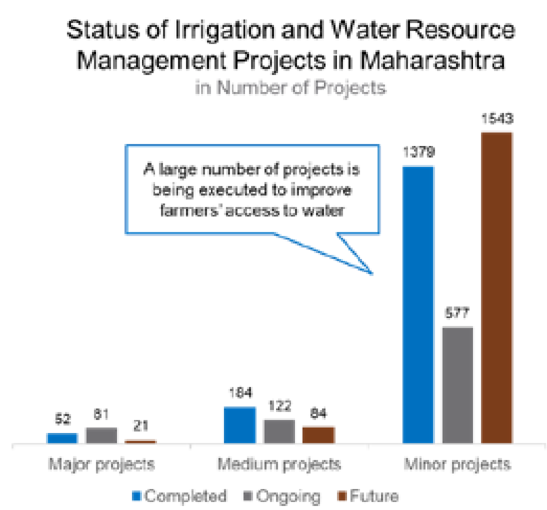


Figure 27: A multitude of water development programs is underway

[54] FICCI, "Labour in Indian Agriculture – A Growing Challenge", 2018
[55] MWRRA, "District Wise Irrigation Project Statistics", 2018

Scheme	Pattern of Assistance
Rainfed Area Development (RAD) Scheme[56]	Collection of subsidies for digging a pond/ well (limited up to INR 60,000 per farm), creating a tube well (limited to INR 15,000 – 25,000 per farm) or a lift irrigation system (limited to INR 10,000 per farm)
Water Harvesting under National Mission for Sustainable Agriculture (NMSA)[57]	For individuals: 50% of cost, limited to INR 75,000 For communities: 100% of the cost limited to INR 20 Lakhs/Unit
Pradhan Mantri Krishi Sinchai Yojana (PMKSY)[58]	Assistance for irrigation, watershed management and micro irrigation
Per Drop More Crop (PDMC) – Micro Irrigation[59]	55% subsidy funded by central government and state government in 60:40 ratio for drip irrigation or sprinkler irrigation

Table 7: A number of schemes support micro-irrigation solution distribution

Government action is needed to promote straight, transgenic seeds

One of the key constraints that emerged from the analysis of farmer survey responses around seeds is the fact that farmers in Maharashtra rely almost exclusively hybrid seeds with no easily available straight varieties existing as alternatives in the market.[60] While hybrid seeds do perform well on some Indian farms, an international comparison of seed usage quickly shows that India is the only major cotton growing country in the world that uses transgenic hybrids instead of straight, transgenic varieties (see Table 8).

Country	Type of seeds (hybrid / straight) used	Transgenic seeds available?[61]	Straight, transgenic varieties used?
USA	Cotton growers in the United States predominantly grow straight upland cotton varieties[62]	93% of seeds planted are transgenic	Yes
Australia	In Australia, the state-owned CSIRO has bred >100 straight cotton variants, which are widely grown[63]	98% of seeds planted are transgenic	Yes
Brazil	In Australia, the state-owned CSIRO has bred >100 straight cotton variants, which are widely grown[64]	78% of seeds planted are transgenic	Yes
India	India grows hybrid Bt cottons. Local Desi varieties and other straight options are virtually not used[65]	96% of seeds planted are transgenic, but only hybrid Bt seed is available	No (CICR is currently testing 8 new varieties)[66]
China	China grows both hybrids (Southern region) and straight varieties (Northwest region), where the latter region has higher yield[67]	95% of seeds planted are transgenic	Yes

Table 8: India is the only major cotton growing nation that does not plant straight, transgenic varieties

The use of hybrid seeds puts an additional burden on Indian farmers, who are forced to pay high prices for hybrid seeds every season while their international counterparts can re-sow seeds from previous seasons. In the Focus Group Discussions carried out during the creation of this study, it emerged that farmers were willing to try using straight varieties in cultivation but shied back from this practice because they wish to grow Bt cottons with increased pest resistance.[68] This report, therefore, clearly recommends government

[56] Department of Agriculture Cooperation and FW, Programmes, Schemes & New Initiatives, Accessed 2019
[57] Department of Agriculture Cooperation and FW, Programmes, Schemes & New Initiatives, Accessed 2019
[58] Ministry of Agriculture & FW, "Operational Guidelines of Per Drop More Crop (Micro Irrigation)", 2017
[59] Ministry of Agriculture & FW, "Operational Guidelines of Per Drop More Crop (Micro Irrigation)", 2017
[60] TechnoServe Farmer Survey, 2018
[61] ISAAA, "Global Status of Commercialized Biotech/GM Crops", 2016
[62] Cotton Incorporated, "Properties of the Growing Regions", Accessed 2018
[63] CSIRO, "Over 100 Varieties and Counting", Accessed 2019
[64] Hilbeck et al., "Environmental Risk Assessment of Genetically Modified Organisms", 2006
[65] TechnoServe Farmer Survey, 2018
[66] Interview with Dr. VN Waghmare, Director CICR, 2019
[67] Dai and Dong, "Intensive Farming Technologies in India", 2014
[68] TechnoServe Focus Group Discussions, 2018

action towards the introduction of new transgenic varieties into Indian markets. Two paths towards introduction of these varieties can be pursued:

1. **Seed development**: Development of new seed varieties on the basis of existing Indian varieties. This approach allows for exact tailoring of seed varieties to the Indian conditions but is relatively slow. CICR is already in the process of developing local *desi* cotton varieties with Bt genes and has created 8 new variants, of which 5 have been licensed for the 2019-20 cotton season. Further research is needed to confirm the benefits of these varieties before optimization and large-scale roll-out can take place.[69]
2. **Seed import**: Testing of seed varieties that have been developed in foreign countries (e.g. seeds from the Australian CSIRO) for usage in India. This approach may not yield varieties that are perfect for the Indian context, but it has the potential of quickly introducing highly optimized cotton varieties in an act of technology transfer.

The Soil Health Card scheme allows smart fertilizer usage

Indiscriminate use of fertilizers has increasingly been a factor in reduced soil quality as well as rising cultivation costs. Government efforts towards promoting more informed usage of fertilizers have focused on developing soil health cards (SHCs) for farmers across the nation. Data from the Department of Agriculture indicates that targets for the distribution of Soil Health Cards are being met. Distribution in the first SHC program cycle from 2015 to 2017 reached the targeted 130 lakh SHCs distributed.[70] Similarly, the distribution in the second SHC program cycle from 2017 to 2019 is on track for completion: 85 of 129 lakh targeted soil health cards had already been distributed by January 2019.[71] This initiative will help in educating farmers about the soil profiles of their land to adopt a more informed approach towards fertilizer usage.

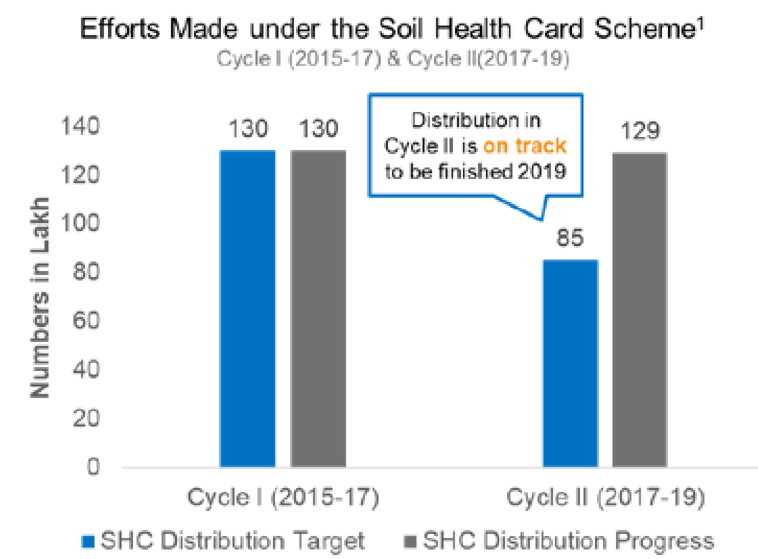


Figure 28: Soil Health Cards are successfully being deployed to farmers

Government action around fertilizers also includes the fixing of prices for certain products. In recent years, the government has set fixed prices for urea, while allowing variable prices of DAP, NPK and Potash; the most recent price for urea lay at 268 INR per 50 kg bag of fertilizer.[72] Farmers surveyed for this study generally reported paying higher than government notified prices 304 INR per bag of urea, which might be explained by the fact that government mandated urea prices are exclusive of charges against neem coating and taxes. A comparison of indicative prices for DAP, NPK and Potash communicated by the government[73] showed that farmers paid high prices for Potash, while DAP and NPK prices were competitive in Maharashtra (see Table 9).

[69] Interview with Dr. VN Waghmare, Director CICR, 2019
[70] Ministry of Agriculture & FW - SHC Progress Report Cycle II - 2017
[71] Ministry of Agriculture & FW - SHC Progress Report Cycle II - 2019
[72] GoI Department of Fertilizers, “MRP of Urea”, 2018
[73] GoI Department of Fertilizers, “MRP of P and K Fertilizers”, 2018

Fertilizers (50 kg bag)	Government Price (INR)		Farmer Survey Price (INR)
	April-17	March-18	
Urea	268		304
DAP	1090	1194	1152
NPK (10:26:26)	1071	1148	1012
MOP (Potash)	572	614	766
Note: Urea price is exclusive of charges against neem coating and taxes			

Table 9: Prices for urea are fixed by the government while other fertilizer prices fluctuate

Government actions on rural employment increase farm labor costs

A decrease in the agricultural labor force and government actions aimed at improving the livelihood of rural communities are rapidly increasing the costs of labor for farmers.

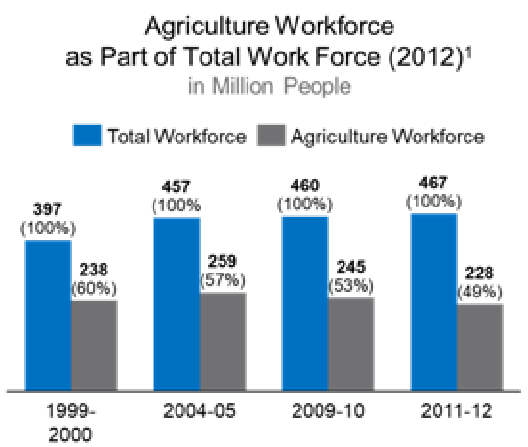


Figure 29: The Indian agriculture labor force is declining

Overall, the number of people employed in the Indian agriculture sector has been declining in the last 20 years, even though the overall labor force increased in the same time frame: comparing data from the most recent census data in 2010-11 with data from the 1999-2000 census shows that the total number of people working in agriculture decreased during the interim by 10 million, while the overall workforce increased by 70 million people from 397 million to 467 million (see Figure 29).[74] This reduction in labor availability for farmers puts a strong upwards pressure on the price of labor.

The upwards price pressure on labor due to changing demographics is further increased due to government actions aimed at improving rural livelihoods, predominantly the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA). MGNREGA wages set a baseline of sorts for manual labor in rural settings, as laborers will always compare farm wages and government wages under the program when deciding on where to work. MGNREGA wages have been increasing steadily, rising from 165 INR per day in 2014/15 to 193 INR per day in 2018/19.[75] While it is clear that this increase in wages is strongly benefitting rural farm laborers, cotton farmers are negatively affected by increased wages for all types of labor required for cultivation[74].

MSP and eNAM influence the cotton value chain

Government work around the cotton value chain is relatively restricted, with most work flowing into the execution of cotton procurement under the Minimum Support Price (MSP) scheme and the maintenance of

[74] FICCI, "Labor in Indian Agriculture – A Growing Challenge", 2015.
[75] MGNREGA, "Maharashtra at a Glance", 2019

APMCs across India. More recently, the electronic National Agriculture Market (eNAM) has risen as a concept promising to improve farmer price realization

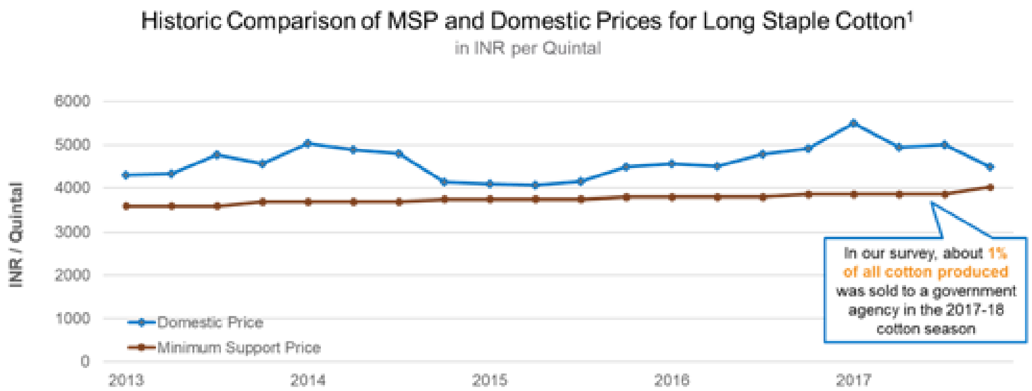


Figure 30: The Minimum Support Price for cotton has been moving below market prices

MSP is an effective government instrument for ensuring minimum levels of revenue for farmers during market gluts of selected commodities. In recent years, the MSP for cotton has been moving below market prices. It means that farmers rarely sold cotton to government procurement agencies at MSP. They have been selling cotton at higher prices in the open market instead (see Figure 31).[76] The survey conducted for this report, for the 2017-18 cotton season, shows that only 1% of all cotton sold by farmers was procured by government agencies.

Another relevant addition, from the government context, in the cotton value chain is eNAM which promises to link farmers to the national agriculture markets more effectively. eNAM uses digital processes and real-time tracking of prices for selected commodities. eNAM is based on the existing network of APMC mandis, which are connected through the portal. While eNAM has great potential for improving price realization for cotton farmers in Maharashtra, the current reality is that eNAM in cotton does not exist in the state. It has 585 active markets across India, of which 60 are in Maharashtra, but only one − the APMC at Varora in Chandrapur − traded cotton in January. Even the total volume traded was below 1000 quintals.[77] While there are many reasons for this gap, the chief among them is the fact that traders are not using eNAM to purchase cotton, as they can procure easily, and potentially at a lower rate, directly from farmers. Farmers don't use eNAM, as they generally prefer instant cash payments to the delayed electronic payments carried out on the platform. Furthermore, the use of eNAM requires engaging with new technologies, which not all farmers are comfortable with. In conclusion, while eNAM presents a great opportunity for changing the cotton value chain in Maharashtra for the better, it is currently underutilized and needs strong government backing to become vitalized.

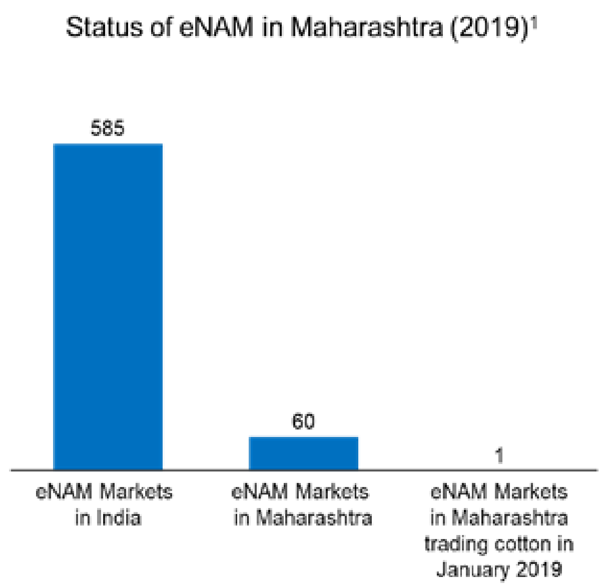


Figure 31: eNAM's role in cotton in Maharashtra is currently negligible

[76] CACP, "Price Policy for Kharif Crops - The Marketing Season 2018-19", 2018
[77] Ministry of Agriculture and FW, "Trading Details", Accessed 2019

Crop loans, crop insurance and loan waivers support cotton farmers in Maharashtra

Access to finance and financial instruments remains a major challenge for farmers in Maharashtra. The government, therefore, is heavily invested in supporting farmers. It has been setting targets for the distribution of agricultural loans. These targets have regularly been exceeded: the set target of INR 10,000 billion annual credit disbursement for 2017-18 is estimated to have been exceeded by about 17%[78] (see Figure 32 for more details). The most popular way for farmers to access financial support is through the Kisan Credit Card scheme, which is a credit card that gives them an easy-access line of credit at government subsidized interest rates. The total amount of KCC crop loans outstanding in 2017-18 is about INR 3,900 billion.[79]

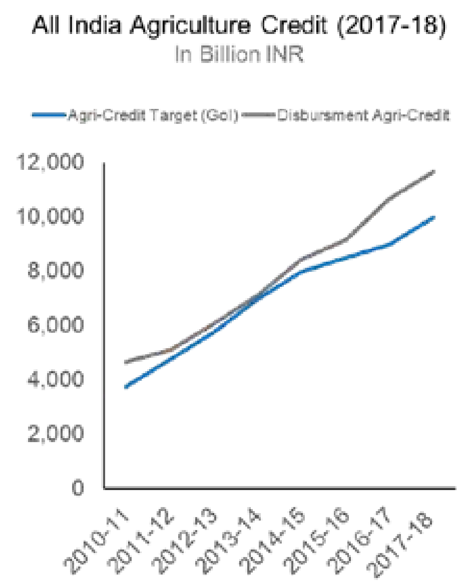


Figure 32: Agriculture credit targets have been exceeded in recent years

Crop insurance is given to farmers under the Pradhan Mantri Fasal Bima Yojana (PMFBY) scheme which has been heavily subsidizing insurance for farmers in Maharashtra. For instance, farmers only paid premiums of INR 420 crore in Kharif 2017, but received total benefits of INR 2,860 crore thanks to heavy subsidizing of premiums by Central and State governments.[80] Nonetheless, the number of farmers under PMFBY coverage has decreased in the recent years, moving from around 11 million in Kharif 2016 to 9.7 million in Kharif 2018.[81] Further improvements in the area insured should be targeted, as insurance significantly reduces the risk of farmers losing their entire livelihoods in any given season.

Loan waivers are an increasingly popular device for reducing the farmer debt burden in India. Maharashtra carried out a large scale loan waiver in 2017, and waived INR 34,000 crore of agricultural loans; a total of 3.1 million farmers benefited from this policy.[82] While it is clear that loan waivers positively affect farmers' livelihoods in the short run, they are a divisive instrument: While they do alleviate farmer hardship, loan waivers also encourage imprudent financial decision, as farmers may begin to expect new loan waivers in the future and spend more money than is financially prudent.

[78] RBI, "Annual Report 2017-18", 2018
[79] RBI, "Annual Report 2017-18", 2018
[80] Ministry of Agriculture & FW, "Rabi 2016-17 State Wise Farmer Details", Accessed 2019
[81] Ministry of Agriculture & FW, "Rabi 2016-17 State Wise Farmer Details", Accessed 2019
[82] PIB, "Waiving of Agricultural Loan", 2018

Many subsidies for animal husbandry exist

Diversification is a key source of net farmer income, and it has, therefore, been identified as an area of interest by both central and state governments. Animal husbandry is a highly subsidized activity, as multiple schemes and programs exist around the goal of encouraging farmers to engage in the rearing of cows, goats, poultry or other animals. Table 10 lists a number of these schemes and categorizes schemes into livestock subsidies, animal health support and feed & fodder subsidies:

	Name of Subsidy	Description of Subsidy[83,84,85,86]
Livestock Subsidies	**Dairy Entrepreneurship Development Scheme**	Central govt provides subsidy to the tune of 25% of the project cost for establishment of small dairy units up to 10 animals and for other dairy processing infrastructure.
	Integrated Poultry Development Scheme	Distribution of a day old 100 chicks with 50% assistance from state government.
	Navinya Purna Scheme	Distribution of dairy animals, 10 +1 goats, 1000 broiler birds for poultry, 75% subsidy by central government on animal costs.
	Livestock Insurance Scheme	Provides protection against loss of animals. Insurance premium is subsidized to the tune of 50%
Animal Health Support	**Foot and Mouth Disease Control Program (FMD-CP)**	100% subsidy on preventive vaccination of cattle population against Foot and Mouth disease.
	National Animal Disease Reporting System (NADRS)	Disease outbreak information collected and reported to the govt. for timely decisions.
	Establishment and Strengthening of existing Veterinary Hospitals and Dispensaries (ESVHD)	Financial assistance by central and state government on 60:40 basis to construct and strengthen veterinary hospitals and dispensaries.
	Central Fodder Development Scheme	Various subsidies in different amounts to increase fodder availability.
Feed & Fodder Subsidies	**Fodder Seed Procurement and Distribution**	Under National Livestock Mission, 75% subsidy from central government for procurement cost.
	Establishment of Fodder Block Making Units	50% subsidy from central government up to a max. of INR 75 lakh.
	Establishment of Silage Making Units	75% subsidy from central government up to a max. of INR 10,000.
	Subsidy for hand & power-driven chaff cutter	Min. 50% subsidy assistance by central government.

Table 10: Government subsidies for promoting animal husbandry

[83] NABARD, “Dairy Entrepreneurship Development Scheme”, Accessed 2019
[84] Maharashtra Department of Animal Husbandry, “Schemes and Policies”, Accessed 2019
[85] GoI Department of Animal Husbandry, Dairying and Fisheries, “Livestock Health”, Accessed 2019
[86] Ministry of Agriculture & FW, “Administrative Approval for the Implementation of National Livestock Mission”, 2014

Chapter 3: Prioritized Interventions

The prioritized intervention section outlines the process of filtering that reduced the long-list of 56 identified cotton farmer interventions to a shortlist of prioritized interventions. Two possibly game-changing approaches, High Density Planting and Lint Based Marketing, are then discussed in detail, before the overall effect of the prioritized interventions on net farmer income in Maharashtra is assessed.

Filtering for impact and ease-of-implementation

As discussed in the methods section of this report, a long-list of interventions was collected through secondary research and expert interviews at the onset of this study. This long-list was then filtered for impact and ease-of-implementation to yield a shortlist of high priority interventions for further analysis.

Filtering for impact reduced the long-list of interventions from 56 total interventions to 20 high-impact interventions according to the approach laid out in the methodology section of this report (see Figure 33 for filtering results and see appendix for details on intervention scoring).

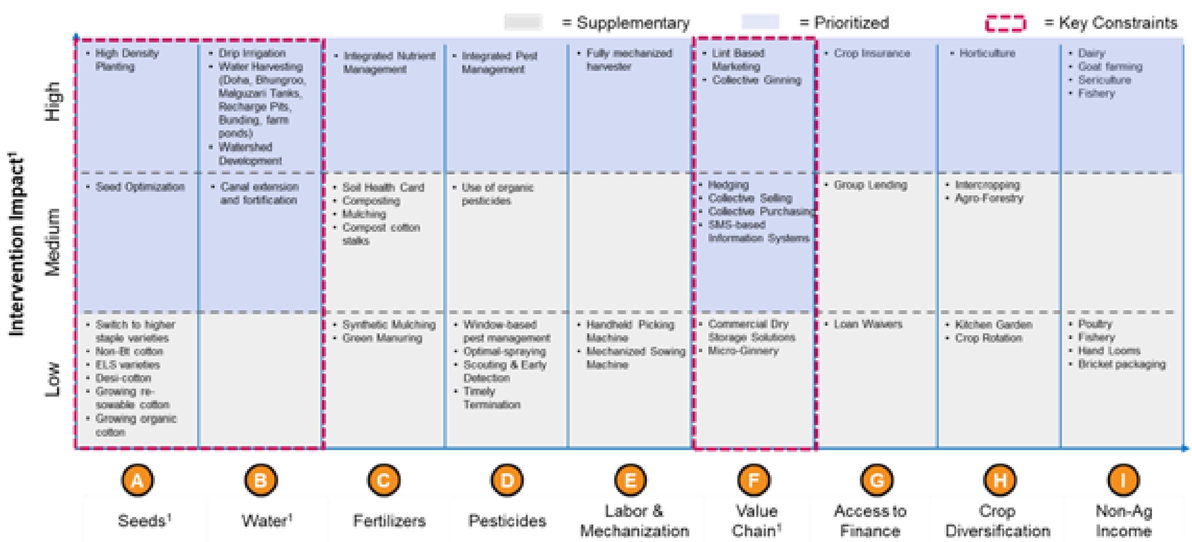


Figure 33: Impact filtering was carried out for the ability of interventions to resolve farmers constraints

The remaining 20 interventions were then further scored to be placed on a matrix where filtering was done based on a cut-off. The cut-off was placed to balance financial viability and feasibility in prioritized interventions. The resulting filtering removed four more interventions from the final shortlist of prioritized interventions (see Figure 34 for filtering results and see appendix for details on intervention scoring).

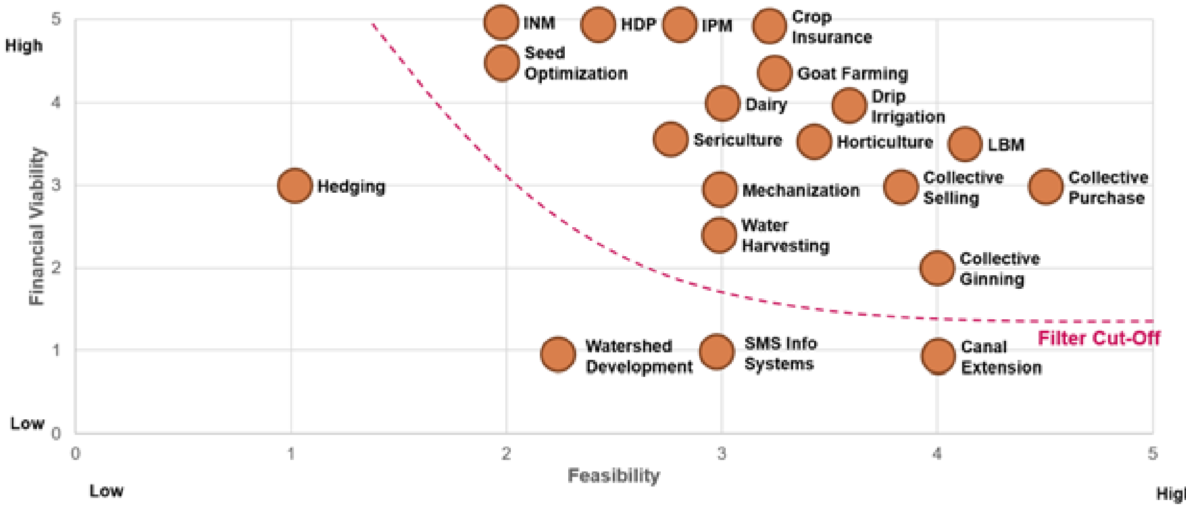


Figure 34: Interventions were further assessed for their financial viability and feasibility

The resulting shortlist was then further analyzed by placing all 16 identified interventions on a two-dimensional matrix visualizing ease-of-implementation and potential impact for each intervention in comparison to the other shortlisted intervention. Distinct groups were identified based on similarities in ranking and content (see Figure 35).

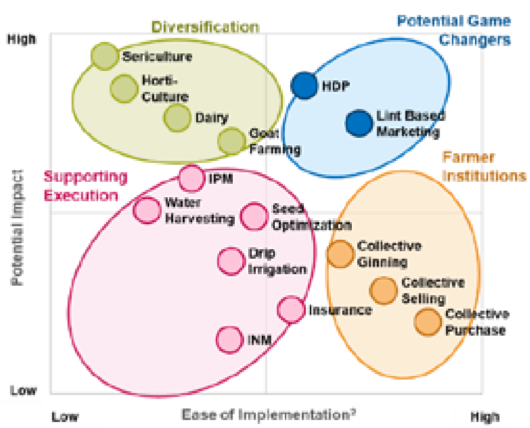


Figure 35: A relative ranking of prioritized interventions reveals four prioritization groups

The relative ranking of interventions yielded four distinct groups of shortlisted interventions: farmer institution building interventions, supporting implementation interventions, diversification interventions and possible game-changer interventions and approaches (see **Figure 35**).

Collective purchasing, collective selling and collective ginning were identified as farmer institution interventions. These interventions are easy to implement within existing collectives and can be further scaled by setting up new FPOs. Their impact is less prominent than that of game-changing interventions, but still relevant towards improving net cotton farmer income in Maharashtra.

Goat farming, dairy farming, sericulture and horticulture were identified as diversification interventions. All these interventions have a very high net income impact and allow farmers to establish secondary income sources outside of their main agriculture activities. However, these interventions have high set-up costs and require significant know-how and training to function successfully.

Water harvesting, drip irrigation, seed optimization, Integrated Pest Management (IPM), insurance distribution and Integrated Nutrient Management (INM) were identified as supporting execution interventions. These interventions were generally lower in impact than game-changers or diversification efforts and tended to be suitable to only subsets of the existing farmer population (e.g. water harvesting is the most useful for rainfed farmers, while its benefits for irrigated farmers are marginal). At the same time, their ease-of-implementation ranged from moderate (e.g. insurance distribution) to difficult (e.g. IPM, water harvesting). Overall, these interventions should be carried out in conjunction with other ongoing work to support core interventions (e.g. IPM and INM can be introduced together with HDP in order to ensure the success of this game-changer) and they should be carried out to selectively address specific farmer needs (e.g. water harvesting should be introduced to rainfed farmer ecosystems).

Lint Based Marketing (LBM) and High-Density Planting (HDP) emerged as possible game-changer interventions. Both these interventions had a relatively high ease-of-implementation combined with groundbreaking potential for systematic changes in the cotton ecosystem; LBM on the marketing side of cotton cultivation and HDP on the agronomy side of cotton cultivation. Both identified game-changing interventions are discussed in more detail in the latter parts of the "Prioritized Interventions" section of this report.

After prioritization and grouping, identified interventions were further analyzed for their suitability to each of the identified farmer segments as well as for the smallholder farmers. Table 11 shows the results of interviews with sector experts on the suitability of interventions for smallholder farmers. It can generally be said that identified interventions are largely suitable to smallholders, although a subset of interventions was deemed unsuitable: this subset mostly consists of capital or technology-intensive interventions, such as drip irrigation, mechanized harvesting and sericulture, all of which were rated at an average of 2 points out of 5 on a smallholder suitability scale (where 1 is unsuitable and 5 is fully suitable).

	Type	Intervention	Expert 1	Expert 2	Expert 3	Average
Cotton Focus	Farmer Institutions	Collective Selling	5	5	5	**5**
		Collective Purchasing	5	4	5	**4.5**
		Collective Ginning	5	5	5	**5**
	Supporting Execution	Water harvesting	4	3	3	**3.5**
		Drip Irrigation	2	2	3	**2**
		IPM	4	5	5	**4.5**
		Seed Optimization	4	4	4	**4**
		Mechanized Harvesting	2	2	2	**2**
		Integrated Nutrient Management	4	4	4	**4**
		Insurance	2	3	2	**2.5**
Beyond Cotton	Diversification	Goat farming	3	4	4	**3.5**
		Dairy farming	3	2	3	**2.5**
		Sericulture	2	2	2	**2**
		Horticulture	4	4	4	**4**
Cotton Focus	Possible Game changer	High Density Planting	5	4	4	**4.5**
		Lint Based Marketing System	5	5	4	**5**

Table 11: The suitability of 16 shortlisted interventions for smallholder farmers was assessed

In addition to analyzing suitability of interventions to smallholder farmers, all prioritized interventions, their respective grouping and their suitability to each of the identified farmer segments can be seen in Table 12. Detailed backup information for each intervention is further provided in the remainder of this chapter.

	Type	Intervention	Suitability for Rainfed Farmers	Suitability for Partially Irrigated Farmers	Suitability for Saturated Irrigation Farmers
Cotton Focus	**Farmer Institutions**	Collective Selling	◕	●	●
		Collective Purchasing	●	●	●
		Collective Ginning	◕	◕	●
	Supporting Execution	Water harvesting	●	◕	◔
		Drip Irrigation	○	●	●
		IPM	●	●	●
		Seed Optimization	●	●	●
		Mechanized Harvesting	◔	◑	◕
		Integrated Nutrient Management	●	●	●
		Insurance	●	●	●
Beyond Cotton	**Diversification**	Goat farming	●	◕	◕
		Dairy farming	◑	●	●
		Sericulture	◑	●	●
		Horticulture	◔	◑	●
Cotton Focus	**Possible Game changer**	High Density Planting	●	●	●
		Lint Based Marketing System	●	●	●

Table 12: The suitability of 16 shortlisted interventions was assessed for each farmer segment

Building farmer institutions effectively scales benefits

Collective Selling

Collective selling is the process in which several growers work together to sell their combined produce. This requires additional infrastructure facilities for storage, processing and packaging, with the costs shared by the collective. Collective selling focuses on marketing and selling efforts.

Supporting Factors	Inhibiting Factors
• In a success story collected by TechnoServe, farmers were able to realize a benefit of 12-15% from collective selling of organic seed cotton (see appendix)[87] • Producer collectives allow farmers to eliminate middlemen, bargain more effectively and command better prices[88] • ASA promoted FPOs in Barwani & Khargone district of Madhya Pradesh enabled farmers to save time and money on transportation, ensured that their produce was correctly weighed and allowed them to realize higher prices[89] • A study of collectives of various sizes showed that members of producer collectives benefit with an average increase in net income by 16% through collective purchasing and selling[90] • TechnoServe interviews showed that aggregators receive a margin of INR 180 per quintal of seed cotton. Collective action can help farmers capture a portion of this margin[91]	• Cooperation and coordination of farmers in an FPO is difficult and takes time to optimize • Fluctuations in market prices scare off farmers and pose a risk to collective cashflows • Immediate cash requirements clash with the operating model of most cooperatives, which usually purchase product on credit • The above-mentioned factors can be mitigated by providing education and technical assistance to newly formed cooperatives through institution and capacity building

Table 13: Supporting and Inhibiting Factors for Collective Selling

Collective selling is beneficial to all farmers. While partially irrigated and saturated irrigation farmers are not limited in their benefit at all, rainfed farmers, who are overall poorer than their irrigated counterparts, may be hindered by the credit-based purchasing system that many cooperatives employ.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Collective selling helps increase farmer price realization (★★☆)	Collective selling increases general farmer market power (★☆☆)	Collective selling requires a well-funded FPO (★★★☆☆)	Collective selling can be done with farmers universally and is easily scalable (★★★★☆)

Table 14: Scoring Results for Collective Selling (see methodology section for scoring system)

Collective Purchasing

Collective purchasing refers to the process of purchasing farming inputs as part of a larger group of farmers (i.e. a collective / FPO). This approach increases the market power of individual farmers and allows for the purchasing of inputs at lower prices than those commonly prevailing for single farmers in the open market.

Supporting Factors	Inhibiting Factors
• A study of collectives of various sizes showed that members of producer collectives benefit with an average increase in income by 16% through collective purchasing and selling[92] • A study of 5 collectives in Madhya Pradesh showed a cost reduction of INR 453 per farmer on fertilizer costs[88] • The Better Cotton Program (BCP) implemented by IKEA, provided market tie ups to FPOs. The project reduces input costs and has reduced seed costs by 50% (INR 1800/ha)[93] • A story on Deola Agri Producer Company reported a reduction of 10% on pesticides costs as well as savings of INR 50-100 per bag of urea fertilizer (see appendix)[94]	• Collectives need active management to be successful. Management incurs expenses that cut down on the benefit of the cooperative on individual members • Collectives need a certain amount of seed capital to start their operations (e.g. to buy large amounts of inputs for their members) • Both the Maharashtra and Central governments actively support cooperative building in a variety of manners ranging from subsidies to technical support however lack of access to working capital is a constraint.

[87] Interview with R. Nand Kumar, CEO of Chetna Organic Producer Company Limited, 2018
[88] Singh and Singh, "Producer Companies in India: A study of organization and performance", 2013
[89] SFAC, "Success stories of farmer producer organizations - Krishi Sutra 2", 2013
[90] The Wageningen University, Oxfam, Dalberg & Mars, "What Works to Increase Smallholder Farmers' Income", 2018
[91] TechnoServe Value Chain Interviews, 2019
[92] The Wageningen University, Oxfam, Dalberg & Mars, "What Works to Increase Smallholder Farmers' Income", 2018
[93] Singh and Singh, "Producer Companies in India: A study of organization and performance", 2013
[94] Interview with Mr. Karbhari Jadhav of Deola Agro Producer Company Limited, 2019

Table 15: Supporting and Inhibiting Factors for Collective Purchasing

Collective purchasing is well suited to all types of farmers. Decrease in farming inputs is important to farmers regardless of access to water.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Collective purchasing effectively reduces input costs for farmers (★★☆)	Farmer marketing power is increased although no social benefits are gained (★★☆)	Collective purchasing requires a collective for execution (★★★☆☆)	Collective purchasing is highly scalable and universally well received by farmers (★★★★★)

Table 16: Scoring Results for Collective Purchasing (see methodology section for scoring system)

Collective Ginning

In collective ginning, an FPO aggregates and gins raw cotton to sell the resulting products (seed and lint) for its members. This allows farmers to increase value capture through forward integration while also establishing a direct link between cotton quality and net farmer income. Multiple models exist, including toll ginning (collective pays ginner a toll to have ginning carried out) and community ginning (community builds a small ginning unit, usually without a pressing machine).

Supporting Factors	Inhibiting Factors
• Forward integration allows farmers to capture value usually captured by middle-men (INR 180/quintal)[95] and ginners (INR 220 /quintal)[96] • Enabling farmers to gin their own cotton creates a game-changing link between cotton quality and net farmer income. This link enables numerous quality-based interventions (e.g. high ginning outturn cotton results in additional net incomes of INR 340/quintal[97], general staple length and micronaire improvement could yield additional INR 200/quintal[95] • A high adoption rate in collective-based marketing is likely. Collectives can procure cotton from farmers' doorstep at a higher price than middle-men. Increased transparency in procurement practices (e.g. digital weighing scales, assessment of ginning outturn) can further bolster buy-in[98] • A FICCI study saw price increases of INR 100-500/quintal for farmers participating in a cotton collective ginning intervention[99] • A case study covered by TechnoServe showed that farmers can get a 5-29% higher price for their cotton when engaging with a collective ginning cooperative (see appendix)[100]	• Immediate price realisation is a high priority for many farmers, but this requires the FPO to have a large amount of standing capital • Costs of managing the FPO can reduce financial benefit • Risks from changes in market dynamics for example price trends, demand supply, policy change etc. • The above-mentioned factors can be mitigated by actively supporting the FPO with market advisory and farming practices from industry experts

Table 17: Supporting and Inhibiting Factors for Collective Ginning (see methodology section for scoring system)

Collective ginning is beneficial to all farmers, but it often requires farmers to accept delayed payments, which can be problematic for rainfed and partially irrigated farmers, whose finances are usually not as stable as those of saturated irrigation farmers. Collective ginning is, therefore, suitable to saturated irrigation farmers.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Collective ginning significantly increases farmer prices by providing effective market linkages (★★★)	Collective ginning provides a holistic route towards increasing farmer market power (★★☆)	Collective ginning requires an active and well-funded cooperative for execution (★★☆☆☆)	Collective ginning is scalable through FPOs and should be well received by farmers, but FPO management is complex (★★★★☆)

[95] TechnoServe Value Chain Interviews, 2018
[96] Assumes farmers engage in toll ginning at a rate of INR 810 per bale of cotton
[97] TechnoServe calculation, based on an assumption of 4% increase in ginning outturn
[98] TechnoServe Value Chain Interviews, 2018
[99] FICCI, "Evaluation of the PPIAD Project on Cotton", 2013
[100] Interview with Mr. Satish Hiwarkar, CEO of Samanvit Farmer Producer Company Limited, 2018

Table 18: Scoring Results for Collective Ginning (see methodology section for scoring system)

Supporting interventions strengthen existing efforts

Water Harvesting

Water harvesting is the practice of collecting and storing rainwater into (natural) reservoirs or tanks. Stored water can be used for household consumption and agricultural irrigation.

Supporting Factors	Inhibiting Factors
• Integrated watershed management: An initiative by ITC showed that farm incomes improved 18-46% across crops and geographies after implementation of watershed protection measures[101] • Another integrated watershed management project recorded changed cropping patterns, increased yields and a 21% increase in farming incomes in three years after implementation[102] • Doha – Doha is a water harvesting concept that involves digging streambeds to create pond-like pockets within the streams. It has helped some Marathwada farmers increase income by 38%[103] • Bhungroo is a water management system that injects and stores excess rainfall water underground. Adoption of this technology has been able to increase an average household's income by 23%[104] • Farm ponds: A study with farmers in Chittoor and Tamil Nadu showed that water harvested through farm ponds was able to increase annual incomes by INR 8500 to INR 35000 per household. Crop yield increased 51% in pigeon pea, 36% in cotton and 12% in soybean[105]	• Water harvesting is often carried out in surface level structures, which are subject to high amounts of evaporation in Maharashtra's context • Water harvesting requires a significant up-front investment for implementation • Some water solutions, e.g. Bhungroo deal with the issue of high-water evaporation by storing water underground. Government subsidies help farmers overcome the investment barriers to gaining water access

Table 19: Supporting and Inhibiting Factors for Water Harvesting

Water harvesting is crucial for rainfed farmers, as it allows them to give their crops at least 1-2 protective irrigations each year. Partially irrigated farmers also stand to benefit from further access to water, as water harvesting, and management can also improve their net incomes. However, saturated irrigation farmers have sufficient access to water, making water harvesting non-essential for them. Regardless, they can consider conserving water to reduce their ecological footprint.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Water harvesting allows farmers to protect their crops and increase yields (★★★)	Water harvesting reduces use of water from deep aquafers (★★☆)	Water harvesting is expensive and usually requires government or NGO support (★★☆☆☆)	Water harvesting is universally well accepted by farmers, but its costs make it poorly scalable (★★★★☆)

Table 20: Scoring Results for Water Harvesting (see methodology section for scoring system)

[101] WBCSD, "Co-optimizing solutions in water and agriculture Lessons from India for water security", 2017
[102] World Bank Group, "Integrated Watershed Management Adarsha", 2015
[103] Shashank Deora, "Exploratory study of Doha Model as a water harvesting structure", 2018
[104] UNCC, "Bhungroo: Managing Drought in India", 2015
[105] Kumar et al., "Farm level rainwater harvesting for dryland agriculture in India: Performance assessment and institutional and policy needs", 2010

Drip Irrigation

Drip irrigation is a form of precise and regulated micro irrigation in which water is slowly delivered to the root system of multiple plants. Water is either dripped onto the soil surface above the roots, or directly to the root zone.

Supporting Factors	Inhibiting Factors

• A CICR study conducted across multiple Indian states reports that drip irrigation results in water savings of about 53%[106]
• At the same time multiple studies in India found that drip irrigation increases cotton yield by 19% on an average (10%[106], 21%[107] and 25%[108]) in comparison to lack of irrigation
• Drip irrigation also realizes benefits in fertilizer application and weeding:
  ◦ Drip systems discourage weeds as water is only delivered where it's needed[107]
  ◦ Drip systems allow uniform distribution of fertilizers and ensure efficient use of nutrients[108]
• Drip irrigation prevents soil erosion and helps in controlling soil-borne fungal diseases, which grow quickly under moist conditions[108]
• The survey conducted for this report showed a water dependent net per hectare cotton income differential of INR 8,000 to 20,000 /hectare between rainfed and drip irrigated farmers[109]
	• The main reasons for a low adoption rate for this technology are the high set up and maintenance costs of the drip irrigation system. The set-up cost of drip irrigation is approximately INR 48,000 per acre (excl. subsidy ranging from 40% - 60%)[110]
	• Lack of awareness and technical knowledge and low financing ability in villages also keep farmers away from trying this technology
	• The above-mentioned issues can be resolved by ensuring better access to finance, creating awareness about government subsidies and providing training on drip irrigation usage.

Table 21: Supporting and Inhibiting Factors for Drip Irrigation

Rainfed farmers do not have access to water, so drip irrigation is not useful for them. However, partially irrigated farmers who are flood irrigated should consider switching to drip irrigation to further improve their net incomes. The same is true for saturated irrigation farmers, although most of them already use drip irrigation.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Drip irrigation allows farmers to grow more high-value crops or to increase yields of existing crops (★★★)	Drip irrigation increase water use efficiency, providing environmental benefits (★★☆)	Farmers with stable finance can individually engage in drip irrigation (★★★★☆)	Drip irrigation is easy to use and well accepted by farmers, but it is poorly scalable, as it requires individual farmer upgrade and teaching (★★★☆☆)

Table 22: Scoring Results for Drip Irrigation (see methodology section for scoring system)

Integrated Pest Management

Integrated Pest Management describes a package of practices that aims to reduce use of chemical pesticides in farming, while increasing or maintaining farm outcome. While exact definitions vary, common aspects of IPM strategies are use of organic pesticides, release of natural predators, deep ploughing to remove cotton stocks and targeted window-based pest management of any chemical pesticides used.

[106] CICR, "Technical Bulletin No. 31", 1993
[107] Mohan and Panwar, "An economic analysis of drip irrigation system in cotton crop in Khargone district of Madhya Pradesh", 2015
[108] Hemlata Alanse, "Economic Analysis of Market Performance of Cotton Crop under Drip Irrigation System in Dhar District", 2014
[109] TechnoServe Farmer Survey, 2018
[110] TechnoServe Value Chain Interviews, 2018

Supporting Factors	Inhibiting Factors
• A meta-study of 85 IPM projects from Asia and Africa found a mean yield increase of 40.9% and pesticide cost reductions of 30.7% across multiple crops in IPM projects[111] • Various case studies in India showed 66%[112], 9.3%[113], and 81%[114] increased yields • Plant protection costs were found to fall by 52%[112], 26.1%[113], 11%[114] at the same time • IPM is still hardly used in India – recent studies estimate that only 5% of cotton farmers use IPM[115] • There are strong external benefits from implementing IPM in cotton, including positive environmental benefits and increased farmer / worker health. These two issues and others were estimated to create external costs of $4-19 per kg of active ingredient in chemical pesticides[116] • A case study conducted by TechnoServe showed an 80% increase in yields paired with a 30% decrease in the cost of cultivation from IPM (see appendix)[117]	• Many farmers are reluctant to move away from the tried-and-tested use of chemical pesticides due to fear of potential crop losses[118] • Farmers often do not continue IPM practices independently. Continuation is mainly determined by complexity, economics and observability of interventions[119] • IPM requires inputs not readily accessible to all farmers (e.g. biological agents) • All factors named above can be corrected for with collective action (e.g. education and input management via FPO). Full roll-out requires government campaigns

Table 23: Supporting and Inhibiting Factors for Integrated Pest Management

IPM is well suited for all types of farmers. As pests thrive when water is readily available, irrigated farmers especially stand to benefit from IPM

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
IPM reduces costs and increases yield by protecting crops (★★★)	IPM reduces pesticide usage, generating health and environmental benefits (★★☆)	IPM can be carried out by all farmers, as it saves cost overall (★★★★★)	IPM should face high farmer acceptance. It requires no government action. It is however complex and difficult to scale (★★★☆☆)

Table 24: Scoring Results for Integrated Pest Management (see methodology section for scoring system)

Seed Optimization

Seed optimization refers to the process of selecting optimal seeds for given soil, water and input conditions. It is a natural process for any farmer or NGO to carry out at the beginning of a season.

Supporting Factors	Inhibiting Factors
• Correct selection of seed is generally recommended by research institutions and cotton experts across the cotton value chain[120] • Poor selection of variety for climate and agriculture practices can result in strongly detrimental effects: a TechnoServe case study showed that certain *Desi* varieties can result in crop failure under HDP[121] • Seed optimization is particularly relevant when switching to new agronomic practices, e.g. High Density Planting[122]	• Local traders are the main source of both seed and information for farmers in Maharashtra. Traders are poorly incentivized and often poorly informed themselves • Seed variety is overwhelming. More than 1,000 varieties are grown in India, overwhelming farmers with options[123] • Collective-based information dissemination and well-designed information distribution systems (paper, electronic) can help farmers make informed decisions about seed varieties

[111] Pretty & Bharucha, "Integrated Pest Management for Sustainable Intensification of Agriculture in Asia and Africa", 2015
[112] Vennila et al., "Success Stories of Integrated Pest Management in India", 2016
[113] Dhawan et al., "IPM Helps Reduce Pesticide Cost in Cotton", 2009
[114] Singh, Joginder, "Impact Assessment IPM Cotton", 2011
[115] Peshin et al., "Pesticide Use and Experiences with Integrated Pest Management Programs and Bt Cotton in India", 2014
[116] Pretty & Bharucha, "Integrated Pest Management for Sustainable Intensification of Agriculture in Asia and Africa", 2015
[117] Interview with Mr. Prikshit Pachkor, a cotton farmer from Akola district, 2018
[118] TechnoServe Focus Group Discussions, 2018
[119] Peshin, Rajinder, "Farmers Adoptability of Integrated Pest Management of Cotton Revealed by a New Methodology", 2013
[120] TechnoServe Expert Interviews, 2019
[121] Interview with Mr. Ashish Mudhwatkar of Tata Trust, 2018
[122] Interview with Dr. Vijay Waghmare, Director CICR, 2019
[123] Interview with Dr. TP Rajendran, 2018

Table 25: Supporting and Inhibiting Factors for Seed Optimization

Seed optimization is critical to all farmers regardless of their access to water.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Seed optimization can optimize yields within a given agronomic system (★★☆)	Use of the correct seeds can reduce water and pesticide requirements (★★☆)	Seed optimization requires no additional investment, as seed prices in India are set by the government (★★★★★)	Seed optimization requires expert knowledge and good information dissemination systems (★★☆☆☆)

Table 26: Scoring Results for Seed Optimization (see methodology section for scoring system)

Mechanical Harvesting

A mechanical cotton harvester is a machine that fully automates cotton picking. Harvesters exist in two types: stripper-type harvesters that destroy the cotton crop during the picking process, and picker-type harvesters that remove cotton from open bolls without unduly damaging the plant.

Supporting Factors	Inhibiting Factors
• As per TechnoServe survey results, cotton picking represents 20.5% of the total cost of cultivation (49.9% of labor costs)[124], making harvest optimization a key area • Agricultural labor availability has dropped. In 1961, 70.3% of labor was agricultural compared to 48.9% in 2010.[125] This labor shortage has pushed the cost of picking cotton to INR 10-12 /kg in 2018[125] from INR 4/kg in 2007. Shortages of labor during harvest season can also lead to untimely/inefficient operations resulting in poor yields. • Industrialized nations generally pick their cotton by harvester. Overall, 30% of the world cotton is machine harvested[126] • A research study estimated the cost of mechanical harvesting at around INR 2,500 /acre (45 USD/acre) with an additional cost of INR 2,750/acre (50 USD/acre) for defoliating agent use (total of about INR 5,250/acre). Mechanical harvesting was only recommended in combination with HDP[127]	• Trash content: Cotton picked by harvester has been reported to have higher trash content than manually-picked cotton • Higher trash content can be dealt by installation of pre-cleaners at ginneries; however these machines are expensive and may increase marketing costs for farmers • Mechanical harvesters are inaccessible to farmers for rent. Individual purchase is also not possible for most farmers due to high cost • Mechanical harvesters can be made available in collective-based interventions and through custom hiring models, given enough demand from farmers

Table 27: Supporting and Inhibiting Factors for Mechanical Harvesting

Mechanical harvesting makes sense for farmers with high yields. Rainfed farmers often have low yields, making harvesters a poor fit for the segment. Partially irrigated farmers with consistently high yields can consider using the mechanical harvester to reduce input costs. Saturated irrigation farmers often have high yields, making the mechanical harvester an interesting opportunity for reducing costs

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Fully mechanized harvesting has the potential to strongly reduce labor costs (★★★)	Mechanical harvesting frees up farmer and laborer time for alternative activities ((★★☆)	Mechanical harvesting needs machinery to be supplied through an FPO (★★★☆☆)	Mechanical harvesting is not complex and can be scaled easily through cooperatives. It is not yet applicable to all farmers, as it is only viable at high yields (★★★☆☆)

Table 28: Scoring Results for Mechanical Harvesting (see methodology section for scoring system)

Integrated Nutrient Management

[124] TechnoServe Farmer Survey, 2018
[125] Narula et al., "Farm Mechanization in Cotton", 2010
[126] CIAE, "Mechanical Picking of Cotton – A Review", 2007
[127] Konduru et al., A Study of Mechanization of Cotton Harvesting in India and Its Implications, 2013

Expenditure on fertilizers is one of the largest contributors to total cost of cultivation in cotton farming, but many farmers mismanage and apply excess fertilizer to their cotton crop, leading to poor soil health. Increasing awareness about soil testing-based application of fertilizers can bring down input expenditure and increase net farmer incomes while improving overall soil health.

Supporting Factors	Inhibiting Factors

• Our data analysis shows that farmers significantly overfertilize their fields, leaving room for fertilizer use reduction[128]
• Multiple studies support the idea of fertilizer use optimization and the benefits of soil health improvement:
  • An impact study on the national Soil Health Card Scheme reported a reduction in Diammonium phosphate (DAP) and Urea usage by 20 to 30% for using the SHC[129]
  • A study showed that overall fertilizer costs can be reduced by INR 565 per acre through use of cattle urine instead of chemical fertilizers[130]
  • Another study showed a reduction in chemical fertiliser use by 32%–53% through adoption of general best management practices[131]
• In drip-fertigation, nutrient use efficiency was found to be as high as 90% compared to 40-60% in conventional methods, implicating a concurrent decrease in fertilizer costs[132]
• A success story collected by TechnoServe shows that fertilizer usage can be reduced by INR 1,300 through optimization (see appendix)[133]
	• Farmers lack awareness on the recommended doses for specific fertilizers. Local traders are the main source of information for most farmers and their incentives are poorly aligned with farmer interests
	• Farmers fertilize for vegetative growth which would decrease with more judicious fertilizer application
	• Thorough education, e.g. through a collective-based intervention can help overcome these two mitigating factors

Table 29: Supporting and Inhibiting Factors for Integrated Nutrient Management

Reducing fertilizer usage is relevant to all farmers. Overuse is common among farmers and reducing it is very easy to implement. Drip irrigated farmers can switch to fertigation to realize both cost reductions and yields increases.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
INM fully addresses soil health constraints (★★★)	INM reduces dependency on chemical fertilizers (★★☆)	INM can be carried out by even poor small-holder farmers (★★★★★)	INM requires extensive training and long-term support, as benefits of good soil health take time to be realized (★★★☆☆)

Table 30: Scoring Results for Integrated Nutrient Management (see methodology section for scoring system)

Insurance Distribution

Crop insurance is a financial tool used to protect farmers against crop loss due to natural disasters (e.g., drought, floods and hail storms) and pests. An insurance premium (small fee) is paid by farmers, which enables them to claim compensation in the event of a natural disaster. This reduces risk and enables farmers to make investments in their farms without worrying that they will suffer sudden financial hardship.

Supporting Factors	Inhibiting Factors
• PMFBY is an insurance scheme that is the backbone of India's crop insurance. PMFBY provide security against	• Lack of education on the benefits of insurance schemes prevents farmers from joining and de-risking their crops

128 TechnoServe Farmer Survey, 2018
129 MANAGE, "Impact study of Soil health card scheme (SHC)", 2018
130 Vahanka et al., "Cow Urine as Biofertilizer", 2012
131 Yes Bank & WWF, "Cotton market and sustainability in India", 2012
132 CICR, "Technical Bulletin No. 1 - Low cost drip- cost effective and precision irrigation tool in Bt cotton", 2011
133 Interview with Mr. Nilesh Hande, a cotton farmer from Yavatmal district, 2018

several risks, varying from regular area-based weather dependent risks (e.g. drought, water) to pests (bollworm, whitefly, etc) to localized risks such as hail[134] • In Kharif 2017, 87.7 lakh farmers were covered under the PMFBY scheme in Maharashtra, paying a premium of INR 419 crore. They were paid claims of INR 2860 crore[135] This means that on an average, farmers got INR 670 in claims for every INR 100 paid in insurance • Cotton is classified as a cash crop under PMFBY. This means that it has a 5% premium for insured amounts[134] • A study in Burkina Faso showed that cotton famers with insurance were more likely to diversify into other crops and livestock[136]	• Claim payments can be delayed by situation assessments, which means that farmers only receive claim money with delays • Local situation assessments can be wrong or inaccurate. Most assessments are made regionally, which means that local conditions may not be reflected accurately. This means that farmers are sometimes not paid, even if they suffer a crop failure

Table 31: Supporting and Inhibiting Factors for Insurance Distribution

Insurance is well suited to all farmers. Premiums are heavily subsidized and easily within financial reach of farmers.

Impact		**Ease of Implementation**	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Crop insurance effectively de-risks farmers (★★★)	Insurance directly reduces farmer risk and prevents debt cycles (★★☆)	Crop insurance is cheap, due to heavy government subsidies (★★★★★★)	A well-designed government website allows easy sign-ups, but farmer acceptance can be limited due to past problems in claims processing (★★★☆☆)

Table 32: Scoring Results for Insurance Distribution (see methodology section for scoring system)

Diversification increases farmer income and diversifies risk

Goat Farming

Goat farming is the practice of rearing goats for harvesting milk, meat and fiber. It is a high-income, low-investment diversification option for farmers in both rainfed and irrigated areas

Supporting Factors	Inhibiting Factors

• Multiple studies have shown the positive impact of goat farming:
  ◦ Small herds of 5 goats were shown to increase net income by INR 19,000 [137]
  ◦ A Kerala study showed herd-size dependent net income increase of INR 1,748, INR 2,374 and INR 2,960/goat at herd sizes of 3, 10 and 27 respectively[138]
  ◦ Goat rearing contributed 10-40% to household income in different regions rearing small herds of 3-10 goats[139]
• A success story of a farmer from Sangli district illustrated a successful model for growing a goat business leading to a flock of 53 goats at a profit of INR 2,680/goat annually[140]
• The government supports goat farming as an agriculture allied activity through several subsidies. Please see the government context section for further details
	• Proper feed, breeding, housing management and protection from diseases are the key to maximize the profit per goat.
	• Selection of breeding stock, its management and care during pregnancy is a must to run business viably and sustainably
	• The above-mentioned factors can be managed by providing the capacity building training to goat rearing farmers.

Table 33: Supporting and Inhibiting Factors for Goat Farming

[134] Ministry of Agriculture and FW, "PMFBY Revised Operational Guideline", 2018
[135] Ministry of Agriculture and FW, "Kharif 2017 - State wise Farmer Details", Accessed 2019
[136] Stoeffler et al., "Indirect protection: the impact of cotton insurance on farmers' income portfolio in Burkina Faso", 2016
[137] Singh et al., "Goat Rearing: A Pathway for Sustainable Livelihood Security in Bundelkhand Region", 2013
[138] Bashir et al. "A Study on Annual Expenditure and Income from Goat Farming in Kerala", 2017
[139] Bill and Melinda Gates Foundation, "Building a vibrant goat sector - Approach paper for vision 2030", 2018
[140] Interview with Mr. Narayan Deshpande, a goat farmer from Sangli district, 2018

Goat farming is best suited to rainfed farmers. Goats can resist heat and need only low amounts of fodder, making it perfect for rainfed areas. Goat farming is also well suited to partially irrigated farmers and saturated irrigation farmers, but these farmers should also consider other high-profit activities like sericulture and dairy.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Goat farming diversifies income and increases it significantly (★★★)	Goatery holistically diversifies farmers and provides nutritional benefits (★★☆)	Even poor smallholders can purchase a small number of goats to start a herd (★★★★★)	Goats require little water and feed but maintaining animal health is non-trivial. Goatery is often perceived as a "lowly" activity, resulting in low farmer acceptance (★★★☆☆)

Table 34: Scoring Results for Goat Farming (see methodology section for scoring system)

Dairy Farming

Dairy farming is the practice of rearing cows or buffaloes to sell milk and milk products. Dairy is an all-season business that is an important source of income for small and marginal agricultural laborers. Cold chain and primary processing facilities can improve dairy income.

Supporting Factors	Inhibiting Factors
• A study conducted in Bangladesh showed that dairy farming, as an alternative income generating activity, can increase net household incomes by 23%[141]. Other experiences in India showed monthly net incomes from dairy alone at INR 3,000[142] and INR 1,569[143] • Dairy farming reduces chemical fertilizer and pesticide costs; cow dung is used as a biological fertilizer and cow urine is used as a biological pesticide[144] • Dairy farming is heavily subsidized under several government schemes which support setting-up of dairy farming, health maintenance and fodder generation for farmers (please reference the government support section of this document for more details) • A success story conducted by TechnoServe showed a farmer get a daily net income of INR 300 by selling milk. He made additional income through the sale of a bull calf at a price of about INR 5,000. A further INR 35,000 were earned through the sale of a cow (see appendix)[145]	• Farmer risk-aversion towards dairy adoption is prevalent, often due to fears of poor animal health • Lack of knowledge and skills can prevent new dairy entrepreneurs from increasing their net income • Lack of resources like cattle feed or water in rainfed areas • The above-mentioned factors can be mitigated by providing education about government support, good rearing practices and market linkages

Table 35: Supporting and Inhibiting Factors for Dairy Farming

Rainfed farmers can engage in dairy farming only if they get enough access to water and fodder for their cattle. Partially irrigated farmers are well suited to dairy farming, as they usually have enough access to water and fodder to rear their cows. Saturated irrigation farmers are well suited to doing dairy farming, as they have good access to water and fodder.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Dairy farming diversifies income and increases it significantly (★★★)	Dairy holistically diversifies farmers and provides nutritional benefits (★★☆)	Farmers with stable income can individually engage in dairy (★★★★☆)	Dairy is well supported by government programs, but requires water and good health maintenance to be successful (★★★☆☆)

Table 36: Scoring Results for Dairy Farming (see methodology section for scoring system)

141 Shamsuddoha, Mohammad, "Dairy Farming - An Alternative Income Generating Activity", 2009
142 SFAC, "Success stories of farmer producer organizations - Krishi Sutra 2", 2013
143 Reddy A., "Economic Analysis of Dairy Farms in Chittoor District", 2010
144 Maya Kilpadi, "An engineer's one-cow revolution is transforming Indian agriculture", 2016
145 Interview with Mr. Shivram Patil, a dairy farmer from Jalgaon district, 2018

Sericulture

Sericulture is the commercial mass cultivation of silkworms for silk. The worms are raised in a controlled environment and are fed mulberry leaves until they form a cocoon around themselves by secreting a protein known as silk fibre, which is then extracted to make silk.

Supporting Factors	Inhibiting Factors

• Farmers' Economics: Research has shown annual per acre net income of INR 53,900 [146], INR 52,900 [147] and INR 39,076 [148] in sericulture with an initial investment of INR 60,100[146] and INR 132,500[147]
  • Sericulture is low cost agri-allied activity which provides quick returns. Low water requirement makes it a good choice for water shortage areas
  • Higher investment of multiple lakhs is possible for farmers wishing to scale operations and increase profits
• The Maharashtra Sericulture and Central Silk Board provides aid and subsidies to farmers, e.g. initial worm purchases (75% subsidy) as well as sericulture shed construction (50% subsidy) are strongly supported[149]
• A success story collected by TechnoServe showed an increase in net annual farmer income from INR 30,000 to about INR 100,000 per acre via sericulture (see appendix)[150]
	• Lack of know-how and skills prevents many farmers from starting their own sericulture business
	• Risk of losses due to silk worm diseases is a legitimate concern for any farmer looking to diversify
	• Farmer education on the basics of sericulture and correct maintenance of sanitary conditions can address the above factors

Table 37: Supporting and Inhibiting Factors for Sericulture

Sericulture requires the cultivation of Mulberry, which requires some access to water, making it difficult for rainfed farmers. Partially irrigated farmers should pursue sericulture. Mulberry requires medium amounts of water, making it perfectly suited for these famers. Saturated irrigation farmers can pursue sericulture. These farmers should, however, consider using their land for other high-value crops.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Sericulture diversifies income and increases it significantly (★★★)	Sericulture diversifies farmer incomes away from cotton and offers a seasonally independent form of income (★★☆)	Farmers with stable income can individually engage in sericulture (★★★★☆)	Sericulture requires significant know-how, making it difficult to scale (★★★☆☆)

Table 38: Scoring Results for Sericulture (see methodology section for scoring system)

Horticulture

Horticulture is the practice of growing high-value, non-staple crops, such as nuts, fruits, vegetables and flowers. Horticulture can be practiced by farmers to diversify their income sources towards more high profiting crops.

Supporting Factors	Inhibiting Factors
• A case study covered by TechnoServe showed annual net incomes of INR 1,58 lakh per acre from orange cultivation (see appendix)[151]	• Water availability is key to the cultivation of many horticultural crops

[146] TNAU, Economics of Sericulture - Late Age Silkworm Rearing, Accessed 2019
[147] Trivedi and Sarkar, "Comparative study on income generation through agriculture crop and sericulture at farmer's level", 2015
[148] FAO, "Sericulture: An Alternative Source of Income to Enhance the Livelihoods of Small Farmers & Tribal Communities", 2009
[149] Maharashtra Sericulture Department, "Schemes and Grants for Farmers", Accessed 2019
[150] Interview with Mr. Aappasaheb Zunzar, a farmer from Kolhapur district, 2018
[151] Interview with Mr. Rahul Sahare, an orange farmer from Amravati district, 2019

• An impact study of the National Horticulture Mission Scheme showed per acre net profits from various fruits, vegetables, flower and other horticultural crops up to INR 26,000 [152] • At a spacing of 5x5 meter, Keshar mango farmers have generated net profits of INR 3.72 lakh per hectare per annum[153] • A study on rose cultivation showed average costs of INR 70,137 per acre and net returns of INR 54,749 [154] • A study on banana growers showed net incomes of INR 51,532 per acre[155]	• Lack of awareness regarding technical and financial government support holds farmers back from investing in horticulture • Infrastructure bottlenecks, absence of post-harvest marketing structures (e.g. cold storage) hinder farmers from engaging in horticulture • Financial risks pose a great barrier to many farmers, as horticulture crops often require large investments or are prone to crop losses

Table 39: Supporting and Inhibiting Factors for Horticulture

Rainfed farmers should consider carefully which horticulture crops to grow, as these crops are highly water dependent and only few fruit trees (e.g. custard apple) can survive droughts. Partially irrigated farmers should diversify by growing a small number of horticulture crops as per their land and water access. Saturated irrigation farmers should actively pursue horticulture to gain a more diversified crop portfolio including high-value crops.

Impact		**Ease of Implementation**	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
Horticulture diversifies income and increases it significantly (★★★)	Horticulture holistically diversifies farmers and provides nutritional benefits (★★☆)	Farmers with stable income can individually engage in horticulture (★★★★☆)	Horticulture is a well proven concept with strong government support and farmer acceptance (★★★★☆)

Table 40: Scoring Results for Horticulture (see methodology section for scoring system)

[152] Kumar P., "Impact Study of the National Horticulture Mission Scheme: A Consolidated Report", 2013
[153] Chalak S., "Effect of spacing on the growth, yield and quality of Mango", 2012
[154] Mathew et al., "Economic Analysis of Commercial Flower Cultivation in Sirmaur District of Himachal Pradesh", 2014
[155] Hamsakal S., "An Analysis of Banana Growers", 2009

Game changers can alter cotton fundamentals in India

High Density Planting

High Density Planting System is a practice of growing cotton in a short-dense-early system. In this system, plant population of 1-1.5 lakh per Ha is maintained as opposed to 12-24 thousand in conventional cotton cultivation in India, and the duration of the crop is shorted to 100-150 days. A deep-dive on HDP is provided in the strategy section of this document (see page 63).

Supporting Factors	Inhibiting Factors
• HDP was shown to produce an average yield increase of 29% in Indian field trials across multiple varieties[156]. Another ongoing study showed increases of 25-40%[157] • HDP has successfully been tested in the Vidarbha region on rainfed farmers. Seed cotton yield with AKH 081 was 28 quintals per hectare[158] • Implementation of HDP in cotton has strong synergies with several other interventions, such as promotion of mechanization[157] • HDP is a game changer in rainfed farming, as it is usually carried out with short duration cotton varieties, which reduce dependency on water outside of monsoon seasons. Short duration varieties are also less prone to bollworm infestation, due to early flowering[159] A farmer success story conducted by TechnoServe saw an 80% increase in yield, paired with only a 7% increase in cost of cultivation (see appendix)[160] • Studies in China show that farmers employing a "short-dense-early" system have average yields of >1900 kg/lint per hectare[161]	• Farmer risk-aversion towards HDP adoption is prevalent, due to its departure from traditional farming wisdoms • Lack of access to technique specific machinery like planters • Lack of appropriate seed varieties can prevent full realization of HDP benefits • Increase in plant population leads to rise in input material costs. Use of *Desi* cotton as an alternative was shown to have negative effects in a case study covered by TechnoServe (see appendix)[162] • The above-mentioned factors can be mitigated by providing education and technical assistance through an FPO-based intervention

Table 41: Supporting and Inhibiting Factors for HDP

HDP is well suited for rainfed, partially irrigated and saturated irrigation farmers, who all benefit from increased yields and cotton fiber quality. Rainfed farmers benefit from HDP especially well, as the short duration varieties used in HDP pass all important growing phases during the monsoon, reducing farmer water dependency.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
HDP can double net income from cotton (★★★)	HDP is a holistic approach that benefits health via lower pesticide usage (★★☆)	Even poor small-holders can do HDP (★★★★★)	HDP is complex to introduce and therefore poorly scalable. Innovation is still required around seed varieties (★★☆☆☆)

Table 42: Scoring Results for HDP (see methodology section for scoring system)

[156] Venugopalan et al., "High density planting system in cotton - The Brazil Experience and Indian Initiatives", 2014
[157] John Deere, Bayer and Bajaj Steel, "Cotton Mechanization in India", 2016
[158] Paslawar et al., "High Density Planting (HDP) in Cotton: An Option for Rainfed Region of Vidarbha", 2015
[159] Ficci, "Evaluation of the PPPIAD Project on COTTON", 2013
[160] Interview with Mr. Kishor Patokar, a cotton farmer from Akola, 2018
[161] Dai and Dong, "Intensive Cotton Farming Technologies in China", 2014
[162] Interview with Mr. Ashish Mudhwatkar of Tata Trust, 2018

Lint Based Marketing

Lint Based Marketing (LBM) refers to a game-changing shift in the pricing of cotton for farmers. Current mechanisms use expert judgment to price seed cotton based on weight and quality. Under LBM, fast, accurate and unbiased machine readings are used to price cotton lint for weight and quality. A deep-dive on LBM is provided in the strategy section of this document (see page 63).

Supporting Factors	Inhibiting Factors
• TechnoServe interviews indicated that ginners are willing to pay up to INR 200 per quintal for increased quality (e.g. staple length, micronaire) and that every 1% increase in ginning outturn can result in INR 90 per quintal increase in price[163] • LBM trials showed that every 1% increase in ginning outturn resulted in INR 125 per quintal increase in farmer price[164] • Grading machinery for LBM is key to success, and while full testing of cotton quality parameters is difficult at small scale at the moment, testing of a subset of parameters is possible. Ginning outturn in particular can easily be assessed with machines costing around INR 50,000. Early LBM efforts can therefore focus on ginning outturn as a first parameter[165] • LBM is the norm in developed cotton growing nations. The United States Department for Agriculture, for example, maintains laboratories that classify practically all cotton grown in the US for several quality parameters[166]	• Ginner cooperation is required, as ginners are ultimately processing seed cotton into cotton bales • Farmer education is needed to educate farmers about the benefits of LBM and to help them choose appropriate seed varieties • Ginner and farmer cooperation can likely be won through demos and LBM net income increase

Table 43: Supporting and Inhibiting Factors for LBM

LBM is well suited for rainfed, partially irrigated and saturated irrigation farmers, as it improves price finding mechanisms in the entire market for all farmers.

Impact		Ease of Implementation	
Financial Impact	**Secondary Benefits**	**Financial Viability**	**Feasibility**
LBM increases farmer price realization strongly (★★★)	LBM increases farmer market power and is a holistic system towards forward integration (★★☆)	Lint based marketing requires collective support (★★★☆☆)	LBM is highly scalable, universally applicable and should be well received by farmers (★★★★ ☆)

Table 44: Scoring Results for LBM (see methodology section for scoring system)

[163] TechnoServe Value Chain Interviews, 2018
[164] Interview with Mr. Govind Wairale of CITI-CDRA, 2019
[165] Interview with Mr. Govind Wairale of CITI-CDRA, 2019
[166] USDA, "The Classification of Cotton", 2018

A combination of interventions can double net cotton farmer incomes

A strategy for doubling cotton farmer incomes was devised

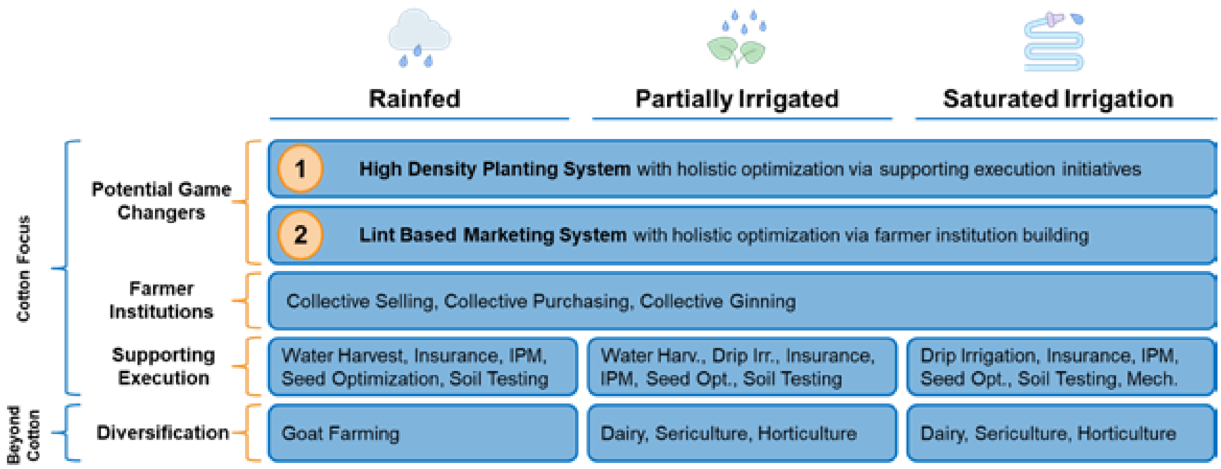


Figure 36: The recommended income growth strategy focuses on two potentially game changing approaches

The introduced categorization of shortlisted interventions into farmer institution, supporting execution, diversification and potentially game-changing interventions easily leads into a larger strategy proposal for doubling net cotton farmer incomes in Maharashtra (see Figure 36). This strategy can broadly be summarized in four points:

1. **Build farmer institutions:** Building farmer institutions enables purchase of inputs at lower prices while increasing marketing power of cotton to achieve higher selling prices. Collective power is used to enable a switch of cotton pricing towards LBM
2. **Selectively carry out supporting execution measures**: Supporting measures such as IPM and INM should be used to ensure the success of HDP, while other supporting solutions are offered to farmers in a segment-specific manner (e.g. water harvesting for rainfed farmers and drip irrigation for partially irrigated farmers)
3. **Selectively diversify farmers**: Diversification is introduced to farmers in a segment-specific manner to ensure maximum impact (e.g. goat farming is recommended to rainfed farmers because goats are not water intensive livestock).
4. **Focus on game changers**: HDP and LBM have the potential to create systematic changes in the way cotton is cultivated in India today. They are, therefore, placed at the core of efforts towards doubling net cotton farmer income in Maharashtra

High Density Planting transforms Indian cotton agronomy

High Density Planting refers to a game-changing shift in cotton agronomy from the current Indian paradigm of long-duration hybrid cultivation towards a short-dense-early cotton system, as it is commonly used in developed cotton growing nations. At the core of this system lies the idea of maximizing the number of cotton bolls per unit area, rather than the number of bolls per cotton plant[167]:

- **Plant Size**: While Indian hybrids grow large and bushy to allow for a very large number of bolls per plant, varieties used in HDP systems are small and compact with a lower number of bolls per plant, but with the benefit of allowing higher density cropping patterns

[167] Dai, J., & Dong, H, "Intensive cotton farming technologies in China: Achievements, challenges and countermeasures", 2014

- **Cropping Pattern**: Indian hybrids are grown in low-density spacings of roughly 50 cm by 110 cm[168], allowing for a total plant density of about 20,000 plants per hectare. In comparison, HDP systems use plant spacings such as 15 cm by 45 cm, leading to a total plant population of about 150,000 plants per hectare. This high plant density more than equalizes the loss in per plant boll yield
- **Crop Duration**: Cotton farmers in India usually plant their cotton crop in late June / early July at the onset of the Monsoon season and then leave their crop standing on their field for anywhere between 7 to 9 months. During this time, multiple pickings are made as each plant grows larger and produces more bolls. Later pickings suffer from strong yield and quality deterioration, largely due to increasing incident of pests and lack of water after the end of the Monsoons. While HDP systems are also initiated in late June / early July at the onset of the Monsoon period, they use early-flowering varieties grown for only 100 to 150 days and which pass all important growth phases while Monsoon rain is still available. Only one picking is carried out in HDP systems before the crop is terminated around November, which means that cotton quality remains high and many of the issues arising from long duration growing of cotton are eliminated

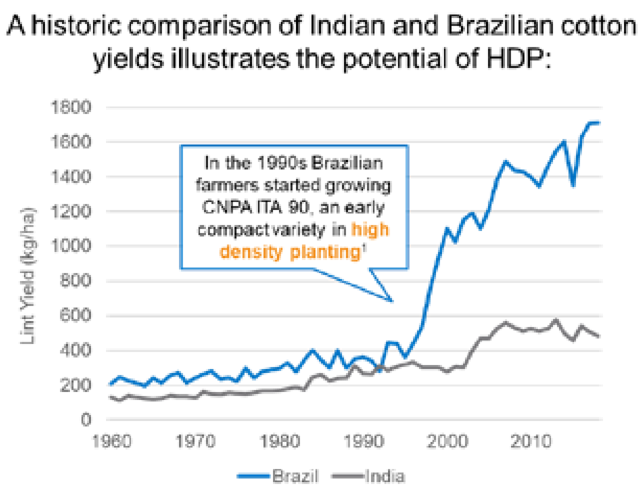


Figure 37: A historic comparison of Indian and Brazilian cotton yields illustrates the potential of HDP

The benefits of HDP systems become clear on comparing India to other nations. Australia (1,814 kg lint per hectare), Brazil (1,711 kg lint per hectare), China (1,755 kg lint per hectare) and the US (1,014 kg lint per hectare) all use HDP systems and have much higher yields than India (509 kg lint per hectare).[169,170] Brazil's recent cotton history illustrates this fact especially well. Where Brazilian and Indian cotton yields were both relatively low in the late 20th century (around 350 kg lint per hectare for Brazil and around 250 kg lint per hectare for India), a significant increase in Brazilian per hectare yield can be observed at the beginning of the 21st century. In this period, Indian cotton farmers switched to Bt hybrids for cultivation, while Brazilian farmers started growing a new compact variety called CNPA ITA 90 in HDP systems.[171] By 2010, Brazilian yields increased to 1,400 kg lint per hectare while Indian yields reached only 512 kg lint per hectare, where they are stagnated even today (see figure 37).[172] Recent field studies in India have further confirmed the potential of HDP on Indian farms: CICR field studies showed an average increase of 29% in per hectare yield from HDP,[173] and a study carried out by John Deere, Bayer and Bajaj Steel saw similar initial yield increases of 25-40%.[174]

[168] TechnoServe Farmer Survey, 2018
[169] USDA, Statistics Download from PSD Database, 2019
[170] Interview with Dr. Keshav Kranthi, Technical Head ICAC, 2019
[171] CICR, "High density planting system in cotton -The Brazil Experience and Indian Initiatives", 2014
[172] USDA, Statistics Download from PSD Database, 2019
[173] CICR, "High density planting system in cotton -The Brazil Experience and Indian Initiatives", 2014
[174] John Deere, Bayer and Bajaj Steel, "Cotton Mechanization in India", 2017

Going beyond yield benefits, several other factors speak for a shift of Indian cotton agronomy towards HDP systems:

- **Pest Resistance**: Since HDP systems mature early, pests have less time to multiply within cotton fields. This means that overall pesticide costs are reduced in HDP systems.
- **Water Independence**: Since HDP systems mature early, critical phases of cotton growth are all passed during the monsoon period. This means HDP cotton can be grown highly successfully under rainfed conditions. In fact, rainfed farmers may be more suited to HDP than irrigated farmers, as excess water can result in strong vegetative growth of cotton plants, which can require use of chemical growth retardants to maintain appropriate HDP plant size
- **Weed Suppression**: The high density of HDP systems results in early canopy closure of cotton crop, which prevents weeds from growing on fields and significantly reduces labor costs for cotton cultivation
- **Farmer Time Gains**: Harvesting of HDP after 100-150 days means that farmers gain significant time to invest in other activities

Like any new agronomy practice or technology, HDP does face several challenges in implementation, but all of these can be addressed through collaborative efforts by farmers, NGOs, industry and the government. Farmer education on new agronomic practices, for example, can be spearheaded by academic research institutions and NGOs in field schools and demonstration plots. Lack of farmer trust in the new technology can be alleviated by slowly increasing plant density in farmer systems rather than proposing an immediate shift from 20,000 plants per hectare to 150,000 plants per hectare. The choice of seeds and cultivation practices is complex but implementing partners can consider engaging with central institutes, like the CICR, to partner on best practices. New machinery (HDP requires mechanical sowing machinery to achieve accurate plant spacing at high density) and input requirements (HDP sometimes needs the use of growth regulators if vegetative growth is too strong on a given field) can be addressed by partnering with industry to deliver affordable products and services to farmers

Overall, HDP is a revolutionary technology that has the potential to revolutionize Indian cotton while especially benefitting poor rainfed farmers. This report proposes it as one of the high impact agronomic measure towards doubling net cotton farmer income in Maharashtra.

Lint Based Marketing systematically improves cotton pricing

In the current Indian cotton scenario, farmers are incentivized to grow large amounts of seed cotton with little regards to their cotton's quality: pricing of seed cotton on local markets is almost exclusively determined by local domestic supply and demand as well as trash content. Further quality factors, such as ginning outturn, staple length, fiber strength and color grade, are usually not assessed beyond a cursory expert judgment that may result in a small to moderate discount on the per quintal seed cotton price. This practice not only negatively affects farmers, who could be fetching higher prices for high quality cotton if their marketing systems rewarded them for it, but it also negatively affects ginners, who suffer from low ginning outturns, and downstream actors such as spinners, whose highly automated and specialized equipment is negatively affected by inefficiencies arising from poor quality cotton.

Lint Based Marketing refers to a shift away from the weighing and pricing of seed cotton towards the weighing and pricing of cotton lint, and it has the potential to improve margins of players at every stage of the Indian cotton value chain. In an LBM system, buyers of cotton (ginners and aggregators) assess cotton quality for several parameters (e.g. ginning outturn, staple length, fiber strength and color gradient) using fast, accurate and unbiased machinery. Cotton prices are then determined by the amount of cotton lint gained (as determined by an assessment of ginning outturn) and based on clearly communicated pricing schemes for other quality parameters (e.g. "staple length of 32 mm fetches INR 5500 per quintal" and "staple length of 30 mm fetches INR 5,200 per quintal”). In an LBM system, farmers are positively affected, as they actively select for high quality cotton varieties (e.g. high ginning outturn varieties), which fetch them higher prices than they can realize in the current Indian paradigm. Ginners are also positively affected, as they receive higher quality seed cotton, which not only yields them a larger amount of cotton lint (due to higher ginning outturn), but also has better quality. In other words, ginners are enabled to produce more cotton lint of higher quality without making any additional investments beyond an increased price of raw seed cotton. Even downstream players such as spinners benefit from an increase in cotton quality, which leaves fewer inefficiencies in their production cycle.

Implementing LBM requires cooperation of farmers, ginners and/or the government. Multiple models can be pursued to aid the implementation of an LBM system, several of which are outlined in Table 45.

Type	Approach	Description	Pros	Cons
Collective Based	**FPO Facilitation**	FPO to negotiates favorable conditions with local ginner (e.g. 100% grading). Members cover transport to ginner and avail benefits	ow capital requirement :an lead to more capital- itensive models later	Farmer needs to organize transport Ginners prefer bulk purchase
	FPO Credit Purchasing	FPO that collects cotton at farmgate on credit sells to ginning partner, who grades in bulk. Payment is done within 1-5 days digitally	ow capital requirement armgate purchase :an do collective ginning with me	Farmer prefers cash on hand
	FPO Cash Purchasing	FPO that collects cotton at farmgate for cash to sell to ginning partner, who grades in bulk	armgate purchase :ash purchase :an do collective ginning with me	High capital requirement
Government Action	**Full Grading Mandate**	Government mandate for all cotton deliveries at ginners to be graded by machine reading	nmediate large-scale effect	Requires significant policy change
	Mandi Grading Mandate	Government mandate for all cotton deliveries at APMCs to be graded by machine reading	arge-scale effect ets precedent for local inners	Capital intensive
	Grading Subsidy	E.g. large government subsidies on grading equipment for ginners	arge-scale effect ncourages ginners to urchase equipment	Capital intensive

Table 45: LBM can be encouraged through local collective based interventions and government policy

In an effort to create further transparency around the potential benefits of an LBM system for Indian cotton farmers, this report carries out an estimation of the potential price increases due to a collective-based LBM intervention. Overall, four sources of price increase were assessed, leading to a total potential price increase of INR 850 per quintal of seed cotton:

1. **Aggregator Profit Capture**: In an FPO-based LBM approach, aggregator margin is captured by the FPO and returned in part to its members, leading to potential per quintal farmer benefit of INR 90[175]
2. **Ginning Outturn Increase**: Increases in ginning outturn are the single largest source of initial farmer benefit in LBM models. While current ginning outturn in Maharashtra lies at around 35%, varieties with around 40% return are common across the world and have been introduced to India.[176] According to the value chain calculations carried out for this report, a one percentage point increase in ginning outturn (e.g. from 33% to 34%) yields a benefit of around INR 85 per quintal to the farmer. When assuming a conservative increase of ginning outturn by 4% (e.g. from 33% to 37%), this leads to a potential price increase of INR 340 per quintal[177]
3. **Lint Quality Increase**: Increases in lint quality parameters (e.g. staple length, fiber strength, etc) can lead to a benefit of INR 200 per quintal[178]
4. **Collective Ginning Benefits**: Collective ginning refers to the practice of a farmer collective pooling cotton for ginning at a local ginnery against a fixed ginning fee, after which ginning products (cotton lint and cotton seed) are sold in domestic markets. This allows farmers to capture ginner margins, leading to a farmer benefit of INR 220 per quintal (assumes ginning fees of INR 810 per quintal).[179] Further benefits can be realized by farmers carrying out toll ginning if they time markets to realize benefits from seasonal price variations, but these benefits were not assessed, as they are highly unpredictable and depend strongly on market movements.

Like any marketing intervention, LBM does face several challenges in implementation, but all of these can be addressed through collaborative efforts by farmers, NGOs, industry and the government. Farmer education on the benefits of LBM practices, for example, can be spearheaded by NGOs in collaboration with local ginning partners. Lack of farmer trust in the new system can be alleviated by carrying out non-binding cotton gradings at the beginning of any intervention (grading results can be shared with the farmer without any result on his final price realization). Finding local ginning partners can be seen as a challenge, but this can be overcome by explicitly fixing terms with ginners that allow them to profit share the new benefits generated from LBM. Questions around finding appropriate grading machinery are relevant, but initial LBM interventions can focus on determining ginning outturn only, as opposed to more advanced models that also assess cotton quality parameters. Small machines for assessing ginning outturn in a fast, accurate and unbiased manner already exist and can be procured for around INR 50,000.[180] For FPOs interested in more advanced LBM interventions, e.g. collective ginning, technical know-how and support can be supplied by NGOs, while seed-funding can be obtained through government programs that support FPO formation and development.

In summary, Lint Based Marketing allows farmers to improve the price they get for their cotton, by providing additional transparency on quality parameters, such as ginning outturn. LBM can be scaled effectively with appropriate government support and has the potential to significantly improve net cotton farmers' incomes. This report endorses LBM as a high potential approach for improving cotton marketing systems for farmers across Maharashtra.

[175] TechnoServe Value Chain Interview, 2018 – Assumes 50% of the calculated aggregator margin is captured as profit by the FPO
[176] Cotton Association of India, "Higher Ginning Percentage Cotton Successful", 2017
[177] TechnoServe Value Chain Interviews, 2018
[178] TechnoServe Value Chain Interviews, 2018
[179] TechnoServe Value Chain Interviews, 2018 - Ginner margin after deduction of INR 810 ginning fee per bale
[180] Interview with Mr. Govind Wairale, Project Coordinator CITI-CDRA, 2019

Net farmer income can be doubled for all farmer segments

This report seeks to assess whether the prioritized interventions identified in the above have the potential to double net cotton farmer incomes in Maharashtra. For this purpose, three example intervention portfolios were created – one for each of the identified farmers segments (see Table 46).

Farmer Segment	Strategy Dimension	Suggested Interventions
Rainfed	**Farmer Institutions**	Farmer Institutions in the form of collective purchasing and selling are initiated
	Supporting Execution	Supporting implementation focuses on enabling HDP agronomy (IPM, INM) and gaining access to water (water harvesting)
	Diversification	Diversification into goat farming is recommended
	Possible Game Changers	High Density Planting is implemented with improved seeds and Lint Based Marketing is introduced with farmers receiving benefits of higher ginning outturn
Partially Irrigated	**Farmer Institutions**	Farmer Institutions in the form of collective purchasing and selling are initiated
	Supporting Execution	Supporting execution focuses on enabling HDP agronomy (IPM, INM) and improving water use efficiency (drip irrigation)
	Diversification	Diversification into sericulture can be pursued. Some horticulture can be pursued to improve net incomes
	Possible Game Changers	High Density Planting is implemented with improved seeds and Lint Based Marketing is introduced with farmers receiving benefits of higher ginning outturn
Saturated Irrigation	**Farmer Institutions**	Farmer institutions in the form of collective purchasing and selling are initiated. Collective ginning can be carried out
	Supporting Execution	Supporting execution focuses on enabling HDP agronomy (IPM, INM) and improving water use efficiency (drip irrigation)
	Diversification	Diversification into dairy can be pursued and farmers should engage in horticulture to further diversify
	Possible Game Changers	High Density Planting is implemented with improved seeds and Lint Based Marketing is introduced with farmers receiving benefits of higher ginning outturn

Table 46: Example intervention packages were created for each identified farmer segment

As outlined in the methodology section of this report, impact quantification was then carried out by analyzing secondary data on the prioritized interventions and applying the results found therein to the baseline given by the conducted farmer survey. Overall, this shows that farmers from each of the identified farmer segments can more than double their net household income if the suggested intervention portfolios are implemented. The example intervention portfolio for rainfed farmers resulted in a 2.8-fold increase in net cotton farmer household income. The example intervention portfolio for partially irrigated farmers resulted in a 2.7-fold increase in net cotton farmer household income, and the same for saturated irrigation farmers resulted in a 2.3-fold increase in net cotton farmer household income (see Figure 38: Cotton farmer incomes in Maharashtra can be doubled in each identified segment).

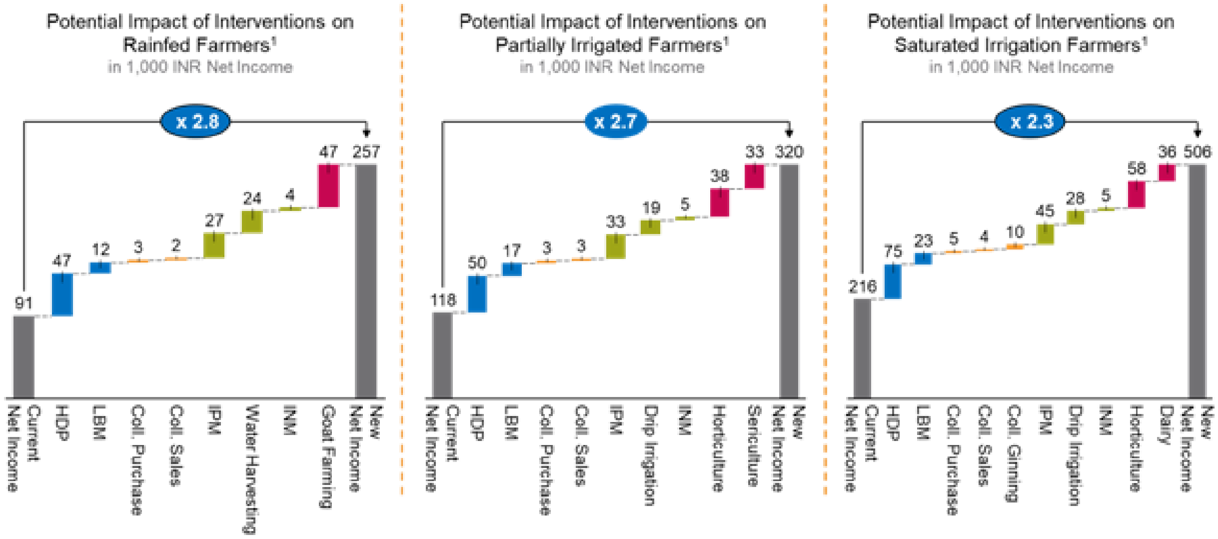


Figure 38: Cotton farmer incomes in Maharashtra can be doubled in each identified segment

While the field research conducted for this report was purely carried out in Maharashtra, the findings presented in the above are generally applicable to a much wider set of farmers across India and even internationally. It is the hope of the authors that the described results help NGOs, industry, policy makers and other cotton stakeholders in devising bold and impactful programs towards increasing the livelihoods of all cotton farmers suffering from poor yields and low incomes. With regards to Maharashtra, it is clear that a combined effort by farmers, NGOs, industry and the government can both increase and diversify farmer livelihoods, achieving the desired results of doubling cotton farmer income in Maharashtra.

Appendix

The appendix gives additional information on content discussed in the main section of this report; it is split into three sections:

1) **Value Chain:** Additional district-wise details on the results of the conducted value chain analysis
2) **Farmer Stories**: Farmer stories created for this report (includes both success stories and cautionary tales)
3) **Scoring**: Details on the scoring system used for filtering the core section of the report as well as scores for each intervention on the long-list

District-wise Value Chain Information

As outlined in the key constraints section of this document, the pre-processing value chain in Maharashtra is overall dominated by aggregators. Table 47 outlines the cotton flows from the indicated sources to the indicated targets for each of the four districts in which a value chain analysis was carried out. All units are in percentage of total cotton sold by farmers in the district (see Figure 19 for a visualization of the average cotton flows for all districts).

Flow Source	Flow Target	All Districts (Average)	Akola	Amravati	Jalna	Yavatmal
Farmer	Government (MSP)	1%	0%	5%	0%	0%
	Farmgate Intermediary	38%	48%	34%	70%	1%
	Village Intermediary	21%	34%	24%	7%	0%
	Local Market	5%	0%	18%	17%	1%
	APMC	12%	4%	1%	1%	36%
	Ginner	20%	13%	14%	3%	62%
Government	Ginner	1%	0%	5%	0%	0%
Aggregator	Ginner	47%	74%	72%	81%	0%
	APMC	18%	8%	4%	14%	2%
APMC	Ginner	30%	12%	5%	16%	36%
All values are given as % of the total cotton sold by farmers in the given district in the 2017-18 cotton season						

Table 47: Cotton flows through the pre-processing value chain vary by district

Furthermore, farmer margins are relatively large, but realized at a small volume, while aggregator and ginner margins while small, benefit from the volumes of transaction. Table 48 outlines the costs and margins of farmers, aggregators and ginners in the cotton value chain (see Figure 20 for a visualization of the early cotton value for all districts).

Value Chain Player	Value Gain	All Districts (Average)	Akola	Amravati	Jalna	Yavatmal
Farmer	Land Lease	434	338	729	284	386
	Irrigation	464	394	443	782	236
	Seed	1164	1472	860	1126	1199
	Chemical Fertilizer	2172	1941	1403	3389	1955
	Organic Fertilizer	427	222	415	209	860
	Chemical Pesticide	1147	1300	649	1743	896
	Organic Pesticide	46	48	51	46	40
	Labor	5255	5590	4666	4570	6192

	Mechanization	1136	1567	707	1420	849
	Selling Fees	208	78	154	68	533
	Loans	1143	1168	672	2508	223
	Margin	11015	10495	13203	8939	11424
	Farmgate Price	24610	24615	23952	25082	24792
Aggregator	Loading	256	245	228	289	264
	Transportation	291	245	257	390	272
	Unloading	58	45	44	70	73
	Margin	836	821	811	884	826
	Price to Ginner	26051	25970	25292	26716	26226
Ginner	APMC Fee	197	177	182	156	273
	Ginning & Pressing	428	475	413	480	344
	Packaging	32	37	27	31	34
	Brokerage	72	75	76	70	69
	Margin	1123	876	1599	661	1354
	Price to Spinner	27903	27610	27589	28114	28300
All values are scaled to reflect the production of one bale of cotton in the indicated district						

Table 48: Farmer, aggregator and ginner margins vary by district

Farmer Stories

Several case studies were collected to support the prioritized interventions recommended in this report (see Table 49 for an overview).

Type	Intervention
Collective Action	Collective selling allows farmers to reap the benefits of improved quality
	Collective purchasing of farming inputs allows farmers to reduce selected input costs by 10-30%
	Collective ginning opens a profitable avenue to marketing cotton for farmer groups
Supporting Execution	In-situ soil & water conservation with “bunds” leads to higher yields and returns from cotton cultivation
	Drip irrigation provides multiple benefits such as water conservation, enhancing yields and reducing labor costs
	Integrated Pest Management (IPM) results in monetary benefits as well as significant positive side-effects
	Use of soil testing helps in reducing fertilizer costs and improve soil health
	Tractor operated cotton picking reduces labor costs, but issues need to be resolved for large-scale adoption
	Handheld cotton-picking machines demonstrated less harvesting efficiency in trials
Diversification	Goat rearing can contribute additional income to cotton farmers at low initial capital expenditure
	Dairy Farming can be a good source of secondary income along with mainstream cotton farming
	Sericulture is a profitable and seasonally independent form of farmer diversification
	Horticulture, such as orange cultivation, is a high-profit diversification activity that provides long-term income
Possible Game changers	High Density Cotton Planting can almost double cotton yields
	HDPS-grown *desi* cotton can suffer from lack of boll formation, and crop failure

Table 49: 15 case studies were created to inform prioritized interventions

The remainder of this chapter consists of one-pagers for the above-listed farmer stories.

High Density Cotton Planting can almost double cotton yields

Context

- **Controlling plant population plays a vital role** in optimizing yields in cotton
- Indian cotton farmers currently plant their crop at a **traditional density of 12,000 to 24,000 plants per hectare**, realizing average yields around 15 quintals / hectare
- Mr. Kishore Shrikrishna Patokar, a rainfed farmer from Akola, started implementing High Density Planting with support from Tata Trusts, starting in Kharif 2017

Intervention

- **Used a seed planter** to plant hybrid cotton seeds on 14 acres of land at INR 1700 per acre
- **Increased seed use** from 0.9 kg to 2.25 kg per acre
- **Applied growth retardants** (two rounds of Lihosin spray) to restrict crop's vegetative growth
- Maintained a plant population of **75,000 plants per hectare**

Achievements

- **80% increase in yield**, moving from 5 quintals under traditional method to 9 quintals of cotton per acre in HDP
- **7% increase in costs of cultivation**, moving from INR 18,600 to 19,900 / acre (higher seed and harvesting costs were partially offset by reduced weeding and fertilizer application costs)
- **More than tripled cotton profits** in a jump from INR 8,400 to 28,700 / acre

Lessons Learned

- High Density Planting **can significantly increase yields**
- **Hybrid plants can be used in HDP** in combination with growth retardants
- **Mechanization support is required** for efficient HDP

Definition & Visuals

HDP refers to an agronomic system that plants cotton at a **closer spacing** using with the objective of obtaining **maximum productivity per unit area without sacrificing quality**

Source: Interview with Mr. Kishor Patokar, a cotton farmer from Akola, 2018

HDPS-grown *Desi* cotton can suffer from lack of boll formation, and crop failure

Context

- In recent years, **Bt hybrids have failed to live up to the promise of high yields** and reduced pesticide use, prompting farmers to search for alternatives
- Straight *Desi* cotton varieties in high density planting were estimated to have lower input costs of INR 4,525 per acre compared to at least INR 10,000 for growing regular Bt hybrids.
- **In 2014, Tata Trusts introduced HDPS with the *Desi* variety "Suraj"** in Akola district

Intervention

- **Sowing was done at 0.7 x 0.5 feet distance** by hand on a total of 12 acres (plant population of 125,000 plants per acre)
- All other practices (pesticides, fertilizers, weeding, etc) were **followed as recommended by CICR**

Achievements

- **Farmers experience a full crop failure on their *Desi* crop**. Vegetative growth and flowering proceeded as expected, but boll formation never took place
- Farmers ultimately ended up giving up their crop for animal grazing

Lessons Learned

- ***Desi* cotton was shown to be susceptible to crop failure under certain conditions**
- In the following year, **HDPS was continued with Bt hybrids, and 10 quintals yield were obtained** under rain-fed condition. The same trend continued from 2015 to 2018
- *Desi* cotton needs further research for successful implementation

Definition & Visuals

HDP refers to an agronomic system that plants cotton at a **closer spacing** with the objective of obtaining **maximum productivity per unit area without sacrificing quality**

Source: Interview with Mr. Ashish Mudhwatkar of Tata Trust, 2018

Collective purchasing of farming inputs allows farmers to reduce selected input costs by 10-30%

Context

- Usage of good quality inputs like seeds, fertilizers and pesticides is critical in cotton cultivation. Farmers rely on local input dealers' say on selection of input and pricing
- In general, **farmers purchase inputs individually and** pay relatively high prices. Collective buying increases farmers' bargaining power and **ensures high quality inputs at comparatively lower prices**
- Deola Agro Producer Company Limited, a farmer collective formed in 2014 and supported by MSAMB, decided to arrange quality inputs at low costs for farmers

Intervention

- Producer company opened an agri-input shop within the local APMC market yard in Nashik after acquiring necessary licenses for input sales
- Ensured **supply of quality seed** of onion, wheat, gram, maize tomato and sorghum to its member as well as non-member farmers
- Supplied **inputs to members and non-members alike,** but only members were given discounted rates

Achievements

- **25% - 30% reduction on urea prices paid during the crop season;** farmers saved INR 50 to 110 per 50 kg bag
- **INR 40-50 per kg saving on purchase of seed** and **10% discount availed on pesticides** as compared to prevailing market rates
- The company is **financially sustainable** and is planning to scale its operations

Lessons Learned

- **Collective purchasing provides financial benefits** to farmers and can be carried out sustainably
- Cost reductions were possible in the case of fertilizers and seeds
- Wholesalers can **gain high margins on pesticide sales**
- **Price negotiations** with retailers and wholesalers played a pivotal role in lowering prices

Definition & Visuals

Collective buying is a group of farmers coming together as a group to **leverage their combined purchasing power to negotiate discounts** from suppliers

Source: Interview with Mr. Karbhari Jadhav of Deola Agro Producer Company Limited, 2019

Collective selling of cotton can lead to a 12 - 15% increase in cotton price

Context

- Collective selling of farm produce allows farmers to bundle their marketing power to negotiate better prices for their products
- **Chetna Organics Producer Company Ltd.** has successfully been running a collecting business since its establishment in 2004. Today it supports more than 15,000 farmers, helping them increase the sustainability and profitability of their farming systems

Intervention

- **Farmers were organized** in SHGs at village level. SHGs were federated at district level
- Obtained **collective organic and fair trade certification** in compliance with NPOP-APEDA and Fairtrade International
- **Purchased certified seed cotton from society farmers** at market price (but no lower than MSP) at farm gate/door
- Arranged and paid **transportation, loading, unloading, transit insurance and certification charges**
- **Distributed organic and fair-trade premium** to farmers

Achievements

- **Procured 42,000 quintals in 2017-18 and** 2018-19 target is 45,000 quintals.
- Farmers received **7-8% ethical sourcing benefit,** i.e. about INR 400 per quintal in 2018 and **5-7% organic premium benefit,** i.e. about INR 350 per quintal
- **Community benefits** of INR 250-300 per quintal were distributed to SHGs (fair trade premium)

Lessons Learned

- **Collective selling can be beneficial. Farmers** are getting a 12 - 15 % higher price on organic cotton than they would get for regular cotton
- Farmers can earn **5 - 8 % more from collective selling of non-organic cotton** through ethical sourcing
- When forming cooperatives, several challenges need to be resolved, e.g. like **lack of trust among farmers, initial lack of cooperation among farmers, need for farmer education and know-how development**

Definition & Visuals

Collective selling is basically **pooling up of farm produce of different farmers** to enhance their **bargaining power and get better price**

Source: Interview with, R. Nand Kumar, CEO Chetna Organic Producer Company Limited, 2018 the sustainable trade initiative

TECHNOSERVE
BUSINESS SOLUTIONS TO POVERTY

Collective ginning opens a profitable avenue to marketing cotton for farmer groups

Context

- Cotton prices, in general, remain low during the peak harvesting season
- Value addition provides more market visibility and attracts various buyers offering competitive prices
- Farmers are often unable to establish forward linkages as they lack key skills like aggregating, processing and marketing
- The CAIM project in the Vidarbha region supported farmers in establishing the Samanvit farmer company at Wardha district in 2015. The **company worked to facilitate forward linkages for farmers**

Intervention

- **Toll ginning started in 2015** with 32 farmers
- **Farmers transported cotton to the ginning mill**. The gin issued them a weighing receipt for deposited cotton.
- **Cotton was processed, baled and stored** at the gin for INR 30 per bale per month.
- **Bales were sold to Sanskar Agro**, a local spinner and trader, in the off-season (March-Aug.)
- **Administrative and operational tasks were carried out by the PC** (e.g. shifting of bales, storage and selling)

Achievements

- In 2015-16, price realisation was **INR 47 per kg compared to average market price of INR 42.6 (10% higher)**
- In 2016-17, a price of **INR 52 per kg was realised, compared to INR 49.5 per kg average market prices (5% high)**
- In 2017-18, **INR 54 per kg** was the realisation to the farmers as compared to **market prices of 41.8 respectively (29% higher)**

Lessons Learned

- **Toll ginning can increase farmers price realisation,** especially when taking advantage of seasonal differences in produce price
- **Very few farmers are capable** of providing raw material on credit basis (number of farmers in the program ranged from 32 to 46)

Definition & Visuals

The process of removing cotton seeds from raw cotton is called **ginning. Toll ginning is the collective processing of raw cotton** which aims to increase producer share in consumer Rupee by selling bales

Source: Interview with Mr. Satish Hiwarkar, CEO of Samanvit Farmer Producer Company Limited, 2018

In-situ soil and water conservation with "bunds" leads to higher yields and returns from cotton cultivation

Context

- In India agricultural lands are poorly protected against water loss and soil erosion
- On unprotected fields, soil nutrients are swept away with the flow of rainwater
- Top soil degradation **significantly reduces cotton yields**
- With the aim of improving in-situ soil and water conservation, Ms. Shalinitai Kairnar from Wardha district prepared a graded bund in her field with support from the **M. S. Swaminathan Research Foundation**

Intervention

- The field slope was determined by using simple measures (e.g. string, pipe, scale)
- **A bullock was used to create a bund** of 30 cm in height and 100 cm in base width
- **The bund was slightly graded longitudinally** by about 7.5 cm per running 33 m for safe disposal of water
- **Ploughing, harrowing, sowing and Intercultural** were carried out across the land slope

Achievements

- **Increased cotton yield by 150% -** from 2 to 4.5 quintals per acre
- **Increased red gram yield by 100% -** from 1 to 2 quintals per acre rom
- **Net profit from cotton increased** from INR 1,500 to INR 12,300 per acre

Lessons Learned

- **Bunds needs to be renewed periodically**. As the bund deteriorated in rainfall, yield also decreased (from 4.5 to 3.5 quintals per acre for cotton, and from 2 to 1.5 quintals per acre for red gram)
- **Soil fertility improved, and erosion reduced** significantly
- Water conservation **ensured availability of water for the crop duration**

Definition & Visuals

In-situ soil and water conservation through bunding **is a technique that prevents water-runoff and linked soil erosion,** thereby improving soil fertility and conserving water

Source: Interview with Ms. Shalinitai Kairnar, a farmer in Maharashtra's Wardha region, 2018

Drip irrigation provides multiple benefits such as water conservation, yield enhancement, and reduction of labor costs

Context

- **Irrigation plays a crucial role in cotton** cultivation by boosting and stabilizing yield
- Flood and sprinkler-type irrigation requires close supervision and labour (e.g. to move pipes from one place to another) for efficient management
- With support from the Agriculture Department of Maharashtra, Mr. Ganesh Nanawate from Akola district started using drip irrigation in 2016

Intervention

- **Drip irrigation equipment was installed on five acres** at a total investment of INR 25,000 per acre (after subsidy of INR 36000 per acre)
- **Fertigation** (application of water-soluble fertilizers through drip irrigation) was initiated
- Crop-protection measures were recommended after proper identification of pests

Achievements

- **Reduction of the labor cost** associated with fertilizer and water application. Drip irrigation system usually only needs to be turned on and off
- **Tripling of yields**, as the farmer was able to achieve 12 quintals per acre from 4 quintals previously without drip irrigation
- **30% savings on water required** for the crop before installing the drip system

Lessons Learned

- Drip irrigation **can significantly increase in cotton yields**
- **Water usage is minimized**
- Fertigation enhances **fertilizer utilization efficiency**

Definition & Visuals

Drip irrigation is a form of **precision irrigation wherein water is uniformly distributed to plant roots directly**. It requires **minimum supervision and no labor**

Source: Interview with Mr. Ganesh Nanawate, a cotton farmer from Akola, 2018

Integrated Pest Management (IPM) results in monetary benefits as well as significant positive side-effects

Context

- **Chemical pesticides efficiently combat pests in the short term, yet cause long-term damage,** as they weaken crop resistance (e.g. by killing natural predators) as well as harm the farmer's health
- **Chemical pesticides are heavily used in Maharashtra**. Farmers usually spray two to four distinct pesticides in a total of seven to nine applications[2]
- Mr. Prikshit Pachkor from Akola district initiated integrated pest management practices in his field in 2010 with positive results

Intervention

- D**eep summer ploughing** was practiced very alternate year
- **Crop rotation with soybean and intercropping with sesame were initiated** to reduce pest susceptibility
- **Innovative pest monitoring measures were initiated,** e.g. yellow sticky traps for white fly and sucking pest, and pheromone traps for pink bollworms
- **Organic pesticides were added** to reduce chemical sprayings (three neem seed sprays and two chemical pesticide sprays)

Achievements

- **~ 30% decrease in expenditure on plant protection chemicals** (INR 3000 to INR 2000 per acre) by reducing chemical pesticide applications (from five to three sprayings)
- **80% yield increase** (from five to nine quintals per acre) due to improved crop health and **reduced pest infestation** (field has been free of boll worm)
- A **net profit of INR 26,800 per acre** in 2018
- **Additional net income earned** from intercropping

Lessons Learned

- IPM is an improved **alternative to traditional chemical pest management**
- It provides an efficient crop protection method and **reduces chemical pesticide costs**
- **Improved farmer health** is a significant side benefit
- Effective pest management increases and stabilizes yields

Definition & Visuals

Integrated Pest Management is an ecosystem-based strategy that **aims for long-term prevention of pests and pest damage** through a combination of techniques



Source: 1) Interview with Mr. Prikshit Pachkor, a farmer from Akola, 2018
2) TechnoServe Farmer Survey, 2018

the sustainable trade initiative

TECHNOSERVE
BUSINESS SOLUTIONS TO POVERTY

Use of soil testing helps in reducing fertilizer costs and improve soil health

Context

- Soil testing helps farmers adjust fertilizer application to optimal levels
- **Due to lack of knowledge of scientific crop management, farmers use fertilizers indiscriminately**
- Supported by the NGO Vikas Ganga, Nilesh Hande from Yavatmal district **conducted a soil test, which helped him adjust his fertilizer application** and reduce input costs

Intervention

- **Conducted soil testing** following the **Soil Sample Collection** recommended at a capacity-building training at Ghatangi Yavatmal.
- Soil sample given to **Vikas Ganga for testing**
- Recommended types of **fertilizers were applied rather** conventional mix of nitrogen , phosphorus and potassium (NPK)
- Applied **full dose** of phosphorus during land preparation
- Used a rotavator for mixing phosphorus in soil

Achievements

- **Fertilizer quantity decreased significantly -** from 34:29:46 kg NPK per acre to 21:11:16 kg NPK per acre
- **Fertilizer expenditure reduced by INR 1,300/acre**
- **Number of fertilizer doses decreased** from four times to two time after reading soil test result
- Increased crop production by one quintal per acre

Lessons Learned

- Applying **only those fertilizers which are required by the soil**
- **Balanced fertilizer use** not only **reduced costs but also increased yield**
- **Pest infestation was decreased** by limiting fertilizer use
- Improvements in soil condition - soil is softer than earlier

Definition & Visuals

A **soil test** commonly refers to the **analysis of a soil sample** to determine nutrient content, composition, and other characteristics such as the acidity or pH level

Source: Interview with Mr. Nilesh Hande, a cotton farmer from Yavatmal, 2018

Tractor-operated cotton picking reduces labor costs, but multiple issues need resolving for large-scale adaption

Context

- Cotton picking is a laborious job; **workers take a full day to pick 30-50 kg of seed cotton manually**
- Most cotton is ready for harvest by November, which leads to high short-term demand for labor. **Labor shortage causes wastage and yield loss**
- Tata Trust and John Deere conducted **a project in Akola to test the efficiency of a tractor-operated cotton picker** between 2015 and 2017 with mixed results[1,2]. Similar tests were carried out in Guntur and Warangal in Andhra Pradesh[3]

Intervention

- **Cotton crop spacing was adjusted** to allow **tractor operated** mechanized cotton harvesting
- The cotton crop was **defoliated** with a defoliation agent provided by Bayer India to reduce trash
- **Defoliation, mechanized picking, and pre-cleaning were given to farmers free of charge**
- To further deal with the high trash content of machine-harvested cotton, **a pre-cleaner was installed at a local ginnery** at a cost of INR 6 crore

Achievements

- **Two acres of cotton crop are harvested in one hour** by mechanized harvesting, regardless of the amount of cotton bolls on the field
- **Labor cost for harvesting was reduced significantly;** a small amount of labor was required to pick low-hanging and immature cotton bolls lefts behind

Lessons Learned

- Use of tractor operated cotton-picking machines is an **efficient and fast method of harvesting cotton**
- **Additional investments are required** to make mechanization work (e.g. defoliation agent, ginning pre-cleaner)
- Costs for defoliation, mechanized picking and pre-cleaning were estimated at INR 1000, 2000 and 1000 respectively
- **Maturity synchronization and trash management** need to be resolved for full adaptation of mechanization

Definition & Visuals

The **cotton picker machine** is a single-drum machine that can be mounted on a tractor.
It **automates cotton harvesting** in a way that reduces harvest-time, maximizing efficiency

Source: 1) Interview with Mr. Ashish Mudhwatkar of Tata Trust 2) Interview with Mr. Nitin Chaudhary of Ankur Seeds 3) ETV Annadata, Demonstration of Cotton Harvester, Guntur and Warangal Districts, 2015

Handheld cotton-picking machines demonstrated less harvesting efficiency in trials

Context

- **Cotton harvesting cost is a major component of the total cotton production cost in India**. It is almost exclusively carried out manually at a cost of INR 6-10/kg
- In addition, farmers face labor shortage issues during picking season. Lack of sufficient labor during this period results in **harvest losses and quality deterioration**
- We interviewed representatives from research institutes and NGOs who had tested handheld cotton pickers, but **no positive results were recorded**[1,2,3,4]

Intervention

- **Handheld cotton pickers were demonstrated in open-field trials** by a number of agents
- **Farm workers tested the machine**

Achievements

- **Farm workers were not able to harvest faster** in demonstration trials, a core limiting factor being that handheld pickers still need to access every boll individually
- Dr. D. R. Rathod at PDVK Akola; Dr. Paalve at CICR Nagpur; Mr. Swami of ETV Hyderabad; and Mr. Rajesh of BCI in Bhatinda all reported **frequent machine clogging, high trash content, and low worker acceptance**
- **Only well-opened bolls** were picked easily
- The current design of the machine places significant stress on users' wrists

Lessons Learned

- **Multiple demonstrations of handheld cotton-picking machines did not yield successful outturns**. Full-scale field studies may yield more positive results, but initial results are indicative of current issues with the technology
- **Tested models may need a more ergonomic design** to reduce hand-strain and increase worker acceptance
- **Machine clogging and high-trash content** emerged as major issues

Definition & Visuals

The hand operated **cotton-picker machine** is a labor-operated harvesting tool that runs on battery power. It gathers seed cotton in bags that are attached to the machine via a suction pipe

Source: 1) Interview with Dr. D.R. Rathod of PDKV Akola, 2019 2) Interview with Dr. Paalve of CICR Nagpur 3) Interview with Mr. Swami of ETV Hyderabad, 2019 4) Interview with Mr. Rajesh of BCI, 2019

Goat rearing can contribute additional net income to cotton farmers at low initial capital expenditure

Context

- Goat-rearing is an agri-allied activity that helps small and marginal farmers who want to **diversify in farming**
- While goat-rearing is suited for even rainfed areas, it can also be challenging, as **nutrition, sanitation, breeding and marketing require significant experience**
- Mr. Narayan Deshpande from Sangli began goat-rearing in 1976 without external support, and saw positive results

Intervention

- Purchased **one doe and one buck as an initial investment**
- 2 acres of land were allocated for **fodder farming** (jowar, maize, stylohemata and lucerne)
- **Sheds constructed** on dry and raised ground
- Adopted regular health check-up and began following de-worming and vaccination schedules

Achievements

- **Grew flock from 253 goats within six years** and maintained that size sustainably thereafter
- Achieved **low mortality rate** of 5% for adult goats and 10% for kids
- Managed to earn a **profit of INR 1,34,000 per year** (INR 2680 per goat per year). Seven does and one buck are sold each year

Lessons Learned

- Goat-rearing is an important agri-allied diversification activity. It can provide a consistent secondary income to experienced farmers
- Farmers can start goat-rearing with **low initial investment**
- **Maintaining good animal health and sanitation** is key to success in goat farming

Definition & Visuals

Goat farming is an animal husbandry activity where **goats are raised and bred for production of milk, meat and fibre.**

Source: Interview with Mr. Narayan Deshpande, a goatery farmer from Sangli, 2018

Sericulture is a profitable and seasonally independent form of farmer diversification

Context

- Silk-farming is an option for farm diversification that can give high per acre profits. However, silk farmers must overcome several hurdles like **poor quality of seed (eggs) supply, poor knowledge of farm diseases and supply chain to** become successful silk entrepreneurs
- Despite these hurdles, **Aappsaheb Zunzar from Kolhapur district** has successfully been running a sericulture business since its establishment in 2005, and he is satisfied with the sustainability and profitability of his silk production

Intervention

- **Planted mulberry on 5 acres** – three in 2005 & two more in 2015
- **Constructed two sheds** – a 100 x 30 feet shed in 2005 and a 72 x 41 feet shed in 2015 costing a total INR 7.5 lakh
- **Cultivates eight batches of silkworm per year** – one batch takes around 40 days to pass through all four developmental stages (egg, larva, pupa and adult)
- **Used lime, bleaching powder and salt for floor cleaning. Disinfectants** were used for rakes and other rearing material

Achievements

- Earned INR **100,000 per acre** every year.
- Achieved yield of **70, 80, and 90 kg silk per 100 egg beans** (one egg bean contains 350 – 400 eggs) in summer, rainy and winter season respectively
- Succeeded at synchronizing Mulberry leaf production with silkworm feeding time
- **Successfully reared eight batches per year** (about 600 egg beans per batch)

Lessons Learned

- Silkworm rearing gives **assured income** in all seasons (summer, rainy and winter)
- Only 5% silk goes to market as final output. The remaining 95% are **recycled in the field leading to an improvement in soil fertility**
- Sericulture has intermediate requirements for water access for Mulberry cultivation

Definition & Visuals

Sericulture is the production of **raw silk** by raising caterpillars of the domesticated silkworm.
Silk production involves **two core processes:** care of the silkworm and cultivation of Mulberry for fodder

Source: Interview with Mr. Aappasaheb Zunzar, a farmer from Kolhapur district, 2018

Dairy farming can be good source of secondary income along with mainstream cotton farming

Context

- Dairy as an agriculture allied activity is extensively **supported by the government** through a number of schemes.
- **Dairy cooperatives allow farmers to access local know-how**, quickly providing a good base for farmers wishing to start their own dairy production
- Mr. Shivram Patil from Jalgaon successfully started diversifying his net farm income by taking up dairy alongside his cotton farming in 2002 through self-effort.

Intervention

- After initially purchasing a jersey cow at INR 12,000, he grew a herd with a **stable size of four cows and two calves.**
- Followed artificial insemination to obtain good breed
- **Daily feeding of concentrated feed** along with dried stalks of crops and green grass as supplement feeding
- Prepared temporary cattle shade in the field
- **Maintained hygiene and cleanness f**or clean milk production.
- Sold milk and milk products to local vendors

Achievements

- **Average daily net income of INR 300 from cattle,** by selling milk and dairy products
- Additional income generated through the **sale of a bull calf** at a price of about **INR 5,000**
- A further INR 35,000 were earned through the sale of a cow
- Constructed **permanent shade** from only dairy income

Lessons Learned

- Dairy farming can be a good source of **diversified income for cotton farmers**
- **Assured availability of less-expensive manure at the farm**
- **Soil fertility is improving** due to application of green manure

Definition & Visuals

Dairy farming: The business of farming to produce milk and milk products for home consumption and income generation to meet the family's requirement.

Source: Interview with Mr. Shivram Patil, a cotton farmer from Jalgaon, 2018

Horticulture, such as orange cultivation, is a high-profit diversification activity that provides long-term income

Context

- **Orange-tree cultivation requires extensive knowledge** of soil fertility management, plantation, pruning of trees, intercultural operation, irrigation, fertilizer and pesticides application
- Regular attention is essential, otherwise chances of crop failure increase, deterring many farmers from this **horticulture activity**
- But **a farmer, Mr. Rahul Sahare from Amravati district,** dared to establish an orange orchard on his farm in 2010. He has been earning an assured income from his orchard since 2014-15.

Intervention

- Dug **two tube** wells to ensure sufficient water supply
- Planted **900 orange trees on six acres** in 2010
- Installed **drip irrigation system**, with government subsidy
- **Intercropped during initial four years** of growth phase with soya, red gram, wheat, watermelon and cotton
- Attended **training on pruning and staking**
- Initial investment of INR 7,15,000 in first year, followed by INR 2,00,000 maintenance costs per year

Achievements

- First harvesting took place four years after planting, and **investment was paid back in the eighth year after planting**
- In 2017-18, the revenue from the full six-acre orchard was INR 11.5 lakh and expenses were 2 lakhs, leading to a **net per-acre income of about INR 1,58,0000**

Lessons Learned

- Orange production is a **highly profitable horticulture activity, but it requires high initial investments** and financial stability to endure a number of years without income
- Net returns from orange orchard **increases with increasing age of trees.**
- **Additional income** can be obtained in initial years through intercropping

Definition & Visuals

Horticulture is the practice of farming high-value crops such as fruits, flowers, nuts and vegetables.

Orange cultivation is an example of this intervention

Source: Interview with Mr. Rahul Sahare, a farmer from Amravati, 2019

Longlist of interventions reviewed by TechnoServe

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
1	**Fully Mechanized Cotton Picking**	Labor for harvesting cotton makes up a large share of farmer input costs. Therefore, fully mechanized harvesting solutions have a large potential impact on farmer incomes (3 - financial impact). At the moment, only a few farmers in India have sufficiently high yields to justify the use of mechanical harvesting (1 - financial impact). This intervention holistically removes the constraint posed around harvesting labor (1- holistic) and removes drudgery from farmers' lives (1 - social). This intervention does not help farmers in gaining market power (0 - market power).	3	2	Purchase of a tractor-mounted cotton harvester is possible for a cooperative with limited funds (3 - financial viability). Implementation is scalable (1 - scalability) and only limited training is required for implementation (1 - complexity). Farmer acceptance will likely be low, as manual picking is cheaper than mechanized harvesting at low yields (0 - acceptance). Cotton pickers can already be purchased on the open market (1 - policy & innovation) and can be used by all cotton farmers (1 - universality).	3	3
2	**Handheld Cotton-Picking Machine**	The handheld-cotton picker was shown to have little impact in several field demonstrations. The problems of the machine are that the machine-harvesting of bolls is not significantly faster than handheld picking, as farmers still need to direct the machine at every boll individually (0 - financial impact). In theory, this intervention holistically addresses the costs of cotton harvesting (1- holistic), but it does not have any health or environment benefits (0 - social). This intervention does not help farmers in gaining market power (0 - market power).	0	1	Individual farmers or collectives can invest in this machine, and multiple cotton pickers can be bought and provided as a service. (4 - financial viability). This intervention would be easy to implement and scale (1 - scalability); very limited training is required to use the machine as it is not complex to use (1 - complexity). Farmer acceptability will be low as the cotton harvested through this machine has very high trash content (0 - acceptance). Hand-held cotton pickers can be easily purchased online (1 - policy & innovation) and can be used universally by all cotton farmers (1 - universality).	4	4
3	**Mechanized Cotton Sowing**	Mechanized cotton sowing has a low impact in traditional hybrid-cotton planting in India. With current cropping density, manual planting is possible without excessive labor requirements. Mechanized cotton sowing does become interesting in combination with High-Density Planting (HDP) schemes, as HDP requires very accurate spacing of plants, and the planting of a significantly higher number of cotton plants. The use of this machine reduces labor requirements to minimally reduce the cost of cultivation (1 - financial impact). This intervention holistically addresses the process of sowing in cotton (1 - holistic) but does not have any health or environment benefits (0 - social). This intervention does not help farmers in gaining market power (0 - market power).	1	1	Getting farmers access to mechanized cotton sowing machines is easy to implement. Sowing machines can be purchased individually or collectively from many international equipment manufacturers at a variety of prices (4 - financial viability). The mechanized planter is gaining popularity (1 - farmer acceptance),is easy to operate, and does not require any training (1 - complexity). The planters are readily available in the market making it easily scalable and universally usable (1 - scalability) (1- policy & innovation) (1 - universality).	4	5

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
4	**Growing Re-sowable Cotton**	Use of re-sowable (straight, open-pollinating) variants has the benefit of significantly reducing seed costs for cotton farmers. Seeds no longer need to be bought every year, but only every few years to renew stock and maintain high germination rates. This is expected to result in significant income benefit by way of reducing cost of cultivation for cotton farmer (2 - financial impact). Use of re-sowable seeds, does not holistically address the issue of seed optimization (0 - holistic). Use of re-sowable seeds has no secondary social benefits (0 - social) and farmers do not gain market power through the intervention (0 - market power).	2	0	Growing re-sowable cotton is difficult to implement. Farmers today know how to grow hybrid varieties and a shift back would require an adjustment of many agronomic practices (1 - complexity). Acceptance amongst farmers will likely be low, given that most straight varieties have lower yields than modern Indian hybrids (1 - acceptance). The public sector needs to focus on developing high-yielding re-sowable varieties and take some policy-level decisions to ensure that new re-sowable seeds are introduced in the market (0 - policy and innovation). Market availability of high-yielding re-sowable varieties will reduce cultivation costs. These varieties will be in high demand across the country (5 - financial viability) (1-universality) (1 - scalable).	5	3
5	**Use of Organic Pesticides**	Usage of organic pesticides for plant protection is a practice of using non-chemical measures and biological pesticides. Usage of organic pesticides reduces the cost of cultivation by decreasing the use of chemical pesticides (2 - financial impact). The intervention does not holistically address the issue of pest management (0 - holistic), and does not help farmers improve market power (0 - market power). This practice provides health benefits to farmers (1 - social) as it doesn't involve use of chemical pesticides.	2	1	Use of organic pesticides brings down plant protection costs significantly, making them a popular alternative to chemical pesticides (5 - financial viability) (1- farmer acceptance). Organic pesticides can be made from local ingredients and can be easily scaled through FPO based education (1 - complexity) (1 - scalability) (1 - universality). Use of organic pesticides does not need any policy change or innovation. (1 - policy & innovation).	5	5
6	**Window Based Pest Management**	Window Based Pest Management refers to the process of applying pesticides at optimal periods or windows in optimal doses to maximize crop protection against pests. It is explicitly a practice that works against reactive spraying. Optimal spraying is highly effective and a part of IPM. Please see the entry for 'Integrated Pest Management' for more details. On its own, optimal spraying offers only a limited benefit to farmers (1 - financial impact). The intervention does not holistically address the issue of pest management (0 - holistic) and does not help farmers improve market power (0 - market power), but it does allow farmers to reduce pesticide use, enabling secondary health benefits (1 - social)	1	1	Window-based pest management is difficult to adopt and requires detailed farmer education on the optimal pesticide spraying windows for their crops, which makes it difficult to scale (0 - complexity). Farmer acceptance should be high, given reduction in cost pesticide use (1 - farmer acceptance). Window based pest management can be practiced by all cotton farmers (1 - universality) and can be scaled through only intensive FPO-based education (0 - scalability) Judicious, targeted application of pesticides results in reduction of plant protection costs (5 - financial viability). Targeted and time-based application of pesticides does not require any innovation or policy change (1- policy & innovation)	5	3

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
7	**Soil Health Card**	Maharashtra farmers significantly over-fertilize their fields, especially with regard to fertilizers for vegetative growth (urea, DAP). This means there is a large potential to improve soil health while reducing input costs. While it is possible for farmers to reduce fertilizer use by following the standard procedures given by CICR, the most accurate option is to reduce costs by following the recommendations laid out in a Soil Health Card. Use of soil health cards could significantly reduce cultivation costs for farmers (2 - financial impact). Though this intervention addresses the issue of soil health and fertilizer usage, it needs a package of practices to surround it to be fully effective (0 - holistic). However, it does not increase the market power (0 - market power). Soil test-based chemical fertilizer use reduces the percentage of chemical fertilizers used, providing environmental benefits (1 - social).	2	1	Farmers need to be made aware about their Soil Health Card, after which they can reduce their fertilizer costs easily (1 - farmer acceptance). The Central government is promoting soil health by running a Soil Health Card scheme which makes it free for all farmers to access their soil health data (5 - financial viability) (1 - universality). Education of farmers on the use of their soil health data has already been initiated by government agencies, and further training should require only moderate efforts, making interventions in this area scalable (1 - scalable) (1- complex). No innovations or further policy changes are required to make use of Soil Health Cards (1 - policy and innovation).	5	5
8	**Composting**	Composting can improve soil health at low costs and replace high-cost chemical fertilizers, thereby reducing the overall cost of cultivation (2 - financial impact) while also bringing in environmental benefits from reduced use of fertilizers (1 - social). Composting alone however cannot fully address soil health needs of cotton farmers and should be considered as a part of a larger package of practices (0 - holistic). The intervention doesn't directly address any of the market constraints associated with cotton farmers (0 - market power)	2	1	Composting requires only a limited amount of farmer education (1 - complex) and can be adopted by all farmers on a large scale (1-universality) (1 - scalable). It requires very low investment on basic equipment (5 - financial viability), and is generally well received by farmers (1 - acceptance). Composting is already being practiced and does not require any policy-level change (1- policy & innovation).	5	5
9	**Composting of Cotton Stalks**	This intervention is focused on rapid composting of cotton stalks. Additional benefit is gained from increased crop protection, as cotton stalks are a common refuge for pests between seasons (2 - financial impact), The intervention is expected to have strong environmental benefits, as it prevents stalk burning after the end of the season (1 - social). The intervention should be considered as part of a larger package of practices around soil health (0 - holistic). Also, it does not address any of the market constraints associated with cotton (0 - market power)	2	1	Composting requires only a limited amount of farmer education (1 - complex) and can be adopted by all farmers on a large scale (1-universality) (1 - scalable). Vermicomposting can be carried out easily by individual farmers, even if they have limited financial power (5 - financial viability). It is slowly gaining popularity among farmers and does not require any policy level intervention (1- farmer acceptance) (1 - policy & innovation).	5	5

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
10	**Synthetic Mulching**	Mulching is the practice of applying a layer of natural or synthetic materials to the surface of a field to contain moisture. In our research, studies on mulching showed mixed results. Two issues were identified around use of pest control: mulch gives an additional habitat to pests, and danger also arises when using infested plant parts to make mulch. The intervention is expected to also drive up cost of cultivation with additional effort and investment (0 - financial impact). Use of synthetics in mulching additionally creates environmental damage, and was also shown to reduce soil fertility in some examples (0 - social). The intervention, if carried out, should be considered as part of a larger package of practices (0 - holistic). It does not improve farmer market power (0 - market power)	0	0	Like many interventions, mulching needs education and training. For synthetic mulching, materials need to be provided to farmers. The government is already promoting mulching by providing subsidy for its use (5 - financial viability) (1 - policy & innovation). Mulching, if not carried out properly, can lead to pest infestation making it more difficult for farmers to adopt (0 - complexity). Synthetic mulching is easily scalable (1 - scalable) even though farmer acceptance can be moderate, as immediate benefits are not readily observed and introduction of synthetics is not always readily accepted on farmer fields (0 - acceptance)	5	3
11	**Green Manuring**	Green manuring is an organic form of mulching (i.e. with no use of synthetic mulching measures). The interventions provide a relative boost to the moisture content of the soil at a very low investment, and thus achieving minor economic gains (1 - financial impact). Since the intervention does not require use of any synthetic materials, it is a useful environment-friendly option to boost soil moisture and reduce need for water usage (1 - social). This intervention should be considered as part of a larger package of practices for improving soil health (0 - holistic), and has little effect on the farmer's overall bargaining power (0 - market power)	1	1	Green manuring is a form of living mulch. Farmers need to correctly select mulching plants to carry out the intervention. Usually, leguminous plants are easy to maintain (1 - complexity) and require very low investment (5 - financial viability). Low investment and ease of implementation helps in farmer acceptance (1 - acceptance). Green manuring is easy to scale and does not require any form of innovations. (1 - scalability) (1 - policy & innovation). Green manuring is more efficient for farmers with enough rainfall as leguminous plants also need irrigation (0 - universality).	5	4
12	**Integrated Nutrient Management**	Integrated Nutrient Management refers to a holistic approach that includes mulching, composting, manuring and use of chemical fertilizers in a balanced and effective nutrient management approach. INM synergizes well with the use of soil health cards in India, as these allow measured and targeted application of fertilizers. The intervention has strong financial impact, as it reduces fertilizer costs and increases yields, (3 - financial impact) and holistically addresses soil health and fertilizer usage issues (1 - holistic). INM also has positive effects on the environment, as it enables farmers to reduce the amount of chemical fertilizers (1 - social), but does not affect farmers market power (0 - market power)	3	2	INM can be carried out by individual farmers with poor finance (5 - financial viability). Overall, INM is relatively complex to carry out effectively, as it requires multiple conjoining practices to be carried out in a holistic fashion (0 - complexity). The practice can and should be carried out by all farmers universally (1 - universality), and no policy change or innovation is required to make it viable (1 - policy & innovation). INM is relatively difficult to scale, as farmers need to be educated about the multiple practices that make up this holistic intervention (0 - scalable). Farmer acceptance of INM can be a challenge, as soil health cannot immediately be visibly linked to improved yields (0 - acceptance).	5	3

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
13	**Growing ELS cotton varieties**	Growth of extra-long staple varieties of cotton can fetch significantly higher market prices than long or medium-long cotton. However, ELS varieties in India (predominantly 'Suvin' cotton) are plagued by low yields, making financial benefit at scale questionable (1 - financial viability). Growing ELS varieties does not holistically address the issue of seed optimization (0. holistic) and does not improve farmer market power significantly (0 - market power). Growing ELS cotton varieties does not result in health or environment benefits (0 - social).	1	0	Growing ELS varieties requires no significant additional knowledge in agronomy (1 - complexity), although varieties are fickle and should only be planted in suitable climates (0 - universality). In our research, Suvin was found to be the only ELS variety commercially grown in India, but this cultivation is mostly carried out in southern regions. Suvin cultivation is also plagued by low yields, making farmer acceptance and large-scale adoption questionable (0 - scalability) (0 - acceptance). Currently available varieties are mostly cultivated by well-to-do farmers (4 - financial viability). Research and innovation are required to make growing ELS varieties more sustainable (0 - policy & innovation).	4	1
14	**Switching to higher staple length varieties**	Higher staple-length varieties realize better prices on global and national cotton markets. If possible, farmers should be growing long varieties instead of short or medium-length varieties. Selling longer staple-length cotton can result in financial gains for farmers (2 - financial impact). Use of longer staples has no effect on farmer market power (0 - market power) and it does not holistically address the issue of seed optimization (0 - holistic). Growing long staple length cotton varieties does not have health or environment benefits (0 - social).	2	0	Switching to longer staple varieties is a part of seed optimization. Farmers require increased awareness on the benefits of growing long staple varieties, optimum varieties and package of practices (0 - complexity), which is difficult to disseminate at scale without knowing the specifics of local conditions (0 - scalability). Long-staple varieties are readily available in the market (1- policy & innovation) and can be grown by all categories of farmers (1 - universality). Farmer acceptance is high (1 - acceptance), and the intervention is in no way financially prohibitive for farmers (5 - financial viability).	5	3
15	**Collective Selling**	Collective selling is a forward integration activity which allows farmers to cut out middlemen, while connecting farmers' prices to the quality of their cotton. This has a significant effect on the final price per-unit of produce for the farmer, and can provide a real boost to incomes (2 - financial impact). Collective selling does not provide significant social benefits (0 - social). The approach also addresses the issue of low bargaining power for small-farmers who have low volumes and limited holding or bargaining capacity (1 - market power). Collective selling as a process does not address the issue of value-chain integration for farmers holistically (0 - holistic).	2	1	Collective selling requires farmers to be collectivized and organized (3 - financial viability) after which procurement and joint-selling of cotton can begin. Collective selling is easily accepted by farmers, as it allows them to increase their prices for cotton sold (1 - farmer acceptance); however, sale of cotton requires know-how, cooperative unity, and strong leadership (0 - complexity). Though difficult, collectivization is possible for farmers everywhere (1- universality), and it is scalable to include more farmers (1- scalability). Collective selling is being practiced successfully and does not require any policy-level intervention (1 - policy & innovation).	3	4
16	**Hedging**		1	2	Hedging is difficult to execute and requires significant technical know-how (0 - complexity) and experience to	3	1

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
		Hedging allows farmers to reduce the risk of price fluctuation on their cotton crop. It can be suitable for educated farmers or cooperatives supporting farmers in collective ginning or collective selling interventions. It is used primarily as a tool for risk-reduction rather than as a tool for income increase (1 - financial impact). Hedging allows farmers to effectively address the issue of market risk associated with commodity prices (1 - holistic) and removes the need for farmers to engage in further marketing (1 - market power). The approach has little social or environmental benefit (0 - social).			be carried out efficiently and successfully. Such complexities do not make it very popular with farmers (0 - acceptance). This means that individual farmers will have a very difficult time in implementation (0 - universality). Hedging requires strong NGO support with technical experts (0 - scalability) (3 - financial viability). No government policy change or innovation is required for farmers or NGOs to engage in hedging (1 - policy & innovation)		
17	**Collective Ginning**	Collective ginning is a forward integration activity that allows farmers to capture value usually won by aggregators and ginners and that connects farmers' prices directly to the quality of their cotton. In collective ginning, farmers take their raw cotton directly to a ginner (or through a cooperative to the ginner) where the cotton is turned into bales for a nominal fee. The bales of the farmers' own cotton can then be sold on national markets (either directly to spinners or through exchanges such as eNAM or MCX). Collective ginning undoubtedly has a positive impact on farmer incomes, and it has the important side-effect of incentivizing farmers to plant high-quality cotton (3 - financial impact). The intervention does effectively address the issue of market integration (1 - holistic), and it helps farmers improve market power (1 - market power). Collective ginning does not give any secondary health or environmental benefits (0 - social).	3	2	Collective ginning is difficult to carry out for individual farmers, as ginning is carried out at large volumes (100-500 quintals), which are usually not attainable by individual farmers. Groups of farmers and collectives can however effectively engage in collective ginning if they are sufficiently funded (2 - financial viability). Collective ginning requires a good understanding of the ginning process and the management of a gin (0 - complexity). Collective ginning results in better remuneration for the farmers making it a better choice than prevalent market systems (1 - acceptance). The collective ginning model is already being carried out on a limited scale and does not need any intervention from policymakers (1 - policy & innovation). Collective ginning, when carried out as a collective, is easily scalable and can include all categories of farmers (1 - scalability) (1 - universality).	2	4
18	**High Density Planting**	High density planting (HDP) is the practice of planting more cotton plants on a single hectare of land. HDP is commonly used in developed cotton growing nations (e.g. USA, Australia, Brazil), aiding these countries in achieving two-fold or five-fold cotton yields when compared with India. HDP seed usually allows early harvest, which synergizes well with weather conditions in India, as a short duration crop will usually go through its core growing cycles during the wet monsoon months, making farmers less reliant on post-monsoon irrigation. Short duration crops also reduce the prevalence of crop infestation, as	3	2	The major challenge of HDP lies in the complex change in cultivation practices that comes with this new cotton cultivation approach (e.g. sowing should be carried out with mechanized sowing machines to get equidistant spacing between plants) (0 - complexity). HDP is universally applicable to farmers, although rainfed farmers stand to gain most from the practice (1 - universality). HDP is usually carried out with short-duration straight varieties which already exist even though further research is recommended (0 - policy & innovation). HDP can be practiced by smallholder	5	1

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		pests have a shorter time window to multiply during the cotton season. Lastly, high density planting of short duration varieties significantly improves the quality of cotton, as cotton is collected only in the first picking, in which lint quality is highest. All these are significant drivers of income growth for cotton farmers (3 - financial impact). HDP provides environmental benefits, as it reduces the need for pesticide application and multiple post-monsoon irrigations (1 - social). HDP systems holistically improve cotton cultivation in a package of practices that is suited to all farmers (1 - holistic). HDP has no direct effect on farmer market power (0 - market power)			farmers (5 - financial viability), but scaling needs to be closely monitored to ensure correct practices are employed by farmers (0 - scalability). Farmer acceptance of HDP should be high as soon as initial results are observed, as yields under HDP are significantly higher than those under current hybrid-based cultivation (1 - acceptance)		
19	**Growing Desi cotton**	Desi cottons are straight, open pollinating local varieties of the Arboreum species. Please see the 'Growing Re-sowable Cotton' entry for details on growing open-pollinating variants. Seeds no longer need to be bought every year, but only every few years to renew stock and maintain high germination rates. This practice significantly reduces input costs. However, currently available Desi varieties have lower yields than their hybrid counterparts, making the overall impact of Desi cotton questionable (1 - financial impact). Growing Desi cotton has no positive social, environmental or health benefits (0 - social) and it does not improve farmer market power (0 - market power). The intervention also does not holistically address constraints around seeds in cotton cultivation (0 - holistic).	1	0	Growing Desi cotton is complex, as extensive knowledge of traditional growing methods is required to make cultivation successful (0 - complexity) With introduction of hybrid varieties, farmers have lowly shifted to hybrid. In the current scenario they do not want to go back to low yielding re-sowable seeds (0 - acceptance). Although efforts are already underway, the public sector needs to continue focusing on developing high yielding Desi varieties (0 - policy and innovation). Appropriate varieties of Desi cotton can be grown by farmers across the country (1 - universality) and their cultivation does not require expensive Bt hybrid seeds, meaning that a Desi intervention could be afforded by every farmer (5 - financial viability). Scaling Desi cotton is difficult, since it requires a shift of agronomic practices that needs close farmer guidance (0 - scalability)	5	1
20	**Growing organic cotton**	Growing organic cotton also ensures that no chemical pesticides and fertilizers are used. This practice significantly reduces input costs, but field experience indicates that organic cotton suffers from significantly lower yields than currently grown hybrids (0 - financial impact). The approach has significant environmental benefit owing to reduced use of chemicals (1 - social). Organic cotton cultivation is a holistic approach to cotton cultivation (1 - holistic), but it does not improve farmer market power (0 - market power).	0	2	Growing organic cotton requires extensive knowledge of agricultural practices, which can be difficult to obtain for farmers (0 - complexity). Although well managed organic cotton cultivation projects can be successfully adopted by all farmers (1 - universality), most farmers prefer to rely on chemical options (0 - acceptance). Organic farming significantly reduces input costs and can be practiced by small farmers too (5- financial viability). The complexity of organic cotton, and the decreased yields obtained by most farmers makes organic growing poorly scalable (0 - scalability). Organic farming is being	5	2

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
					practiced and does not require policy change (1- policy & innovation).		
21	**Growing non-Bt cotton**	Non-Bt variants are generally more prone to crop losses than their Bt cousins. This means non-Bt cotton faces increased risks which cannot fully be counterbalanced by reduced seed costs (1 - financial impact). Growing non-Bt variants has negative impacts on the environment, as they increases the need for chemical pesticide usage (0 - social). Growing non-Bt cotton alone does not holistically address the issue of seed optimization (0 - holistic), and has no effect on farmer market power (0 - market power).	1	0	Growing non-Bt cotton is difficult to implement. While seeds for non-Bt hybrids can be procured at non-local markets for distribution to farmers, farmer uptake of these seeds will likely be modest, as farmers have come to rely on Bt as a quality indicator in cotton seeds (0 - acceptance). Cultivation practices with non-Bt cotton would remain the same, although more care needs to be given to pest control (1- complexity). Growing non-Bt seeds can be carried out by all farmers (1- universality), even by smallholder farmers (5-financial viability) and scaling is only constrained by farmer acceptance (1- scalability). Growing non-Bt cotton does not require any policy change or innovation (1- policy & innovation).	5	4
22	**Water harvesting**	Water harvesting refers to the highly beneficial collection of technologies that allow farmers to collect rainwater. In most cases, water harvesting should not be seen as a source of full-scale irrigation: rather, it allows farmers to apply between one and three protective irrigations in dry spells between rains. Allowing farmers to protect and nurture their crops (3 - financial impact), water harvesting has clear positive benefits for farmers. Multiple systems for water harvesting exist, which will be analyzed separately in the following sections. These can meet the needs farmers from several different geographies of effectively (1 - holistic). Water harvesting does not improve market power (0 - market power), but has the social benefit of reducing use of deep aquifer groundwater when used correctly (1 - social).	3	2	Water harvesting techniques have a medium implementation difficulty, their main limiting factor being financial (2 - financial viability). Placement and construction of water harvesting structures need expert knowledge, but this knowledge is readily available in the market (1-complexity). Structures are very popular amongst farmers (1 - acceptance) and the government is promoting water harvesting by providing various subsidies (1 - policy & innovation). Water harvesting is poorly scalable, as it needs to be carried out for farmers (or small groups of farmers) individually (0 - scalability) (1 - universality).	2	4

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
23	**Doha**	Building a Doha is a water harvesting technique that makes use of local streams and rivers: river beds are deepened and broadened in a section of choice, allowing water to collect and be available even after the river runs dry. Dohas can be very impactful if used correctly, and farmers and NGOs should push to use them where appropriate. For more details on general water harvesting, see the 'Water Harvesting' intervention entry. Dohas are open water structures, meaning that water gathered in them evaporates in hot conditions. They, therefore, have only limited impact on water availability for farmers (2 - financial impact). The intervention does not holistically address the issue of water harvesting, as optimal water harvesting solutions should be chosen on the basis of local geography from a wide portfolio of solutions (0 - holistic). It also does not help farmers improve market power (0 - market power). It does have the positive social benefit of reducing usage of deep aquifer groundwater (1 - social).	2	1	Dohas are water harvesting structures which are relatively easy to build and implement (1 - complexity), their major challenging being financing (2 - financial viability). Once built, they are easy to maintain and are widely accepted by farmers (1 - acceptance). The government is promoting water harvesting by providing various subsidies (1 - policy & innovation). Dohas can be practiced by all categories of farmers (1 - universality), but they are poorly scalable given construction cost and the limited number of farmers that can be affected by a single harvesting structure (0 - scalability).	2	4
24	**Malguzari Tanks**	Malguzari tanks are traditional water tanks/ponds that were used by farmers in Maharashtra as far back as the 19th century. In practice, they are very similar to farm ponds. Please see the 'Farm Ponds' entry for more detail. Recharge pits are open water structures, meaning that water gathered in them evaporates in hot conditions. They, therefore, have only limited impact on water availability for farmers (2 - financial impact). The intervention does not holistically address the issue of water harvesting, as optimal water harvesting solutions should be chosen on the basis of local geography from a wide portfolio of solutions (0 - holistic). It also does not help farmers improve market power (0 - market power). It does have the positive social benefit of reducing usage of deep aquifer groundwater (1 - social).	2	1	Malguzari tanks require no policy change or innovation for implementation (1-policy & innovation), and are affordable for farmers with support (2 - financial viability). Farmers like the idea of Malguzari tanks as they help them gain increased access to water (1-acceptance). Tank construction and maintenance do not require much knowledge for usage (1 - complexity) but the technology should not be employed in very hot areas, as stored surface water will evaporate very quickly under tropic conditions (0 - universality). Malguzari tanks are poorly scalable due to their construction cost and the limited number of farmers that can be affected by a single harvesting structure (0 - scalability).	2	3

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
25	**Farm Ponds**	Farm ponds are open structures that are built strategically to catch run-off water from farmer fields and the surrounding environment. They are a quintessential water harvesting structure (for more details on general water harvesting, see 'Water Harvesting' intervention entry). Recharge pits are open water structures, meaning that water gathered in them evaporates in hot conditions. They therefore have only limited impact on water availability for farmers (2 - financial impact). The intervention does not holistically address the issue of water harvesting, as optimal water harvesting solutions should be chosen on the basis of local geography from a wide portfolio of solutions (0 - holistic). They do not help farmers improve market power (0 - market power). Care should be taken with the common practice of feeding farm ponds from borewells. While this practice can enable year-round irrigation from the farm pond and allows for fishery, keeping standing water in the open in Maharashtra in summer results in large amounts of water loss through evaporation. This injudicious use of water depletes groundwater and can result in long-term water scarcity (0 - social)	2	0	Farm ponds have been supported heavily by the Maharashtra government through subsidies and schemes in previous years (1-policy & innovation), making them financially viable for farmers and implementing partners (3 - financial viability). Farmers like the idea of farm ponds as they help them gain increased access to water (1- acceptance). Farm pond construction and maintenance do not require much knowledge for usage (1 - complexity) but the technology should not be employed in very hot areas, as stored surface water will evaporate very quickly under tropic conditions (0 - universality). Farm ponds are poorly scalable given construction cost and the limited number of farmers that can be affected by a single harvesting structure (0 - scalability).	3	3
26	**Bhungroo**	Bhungroos are water harvesting structures that have great potential in Maharashtra. This structure enables underground storage of rainwater in what can be seen as an "inverse bore-well procedure". Here, a catchment basin is built at a strategically placed location. Then a pipe is drilled into the ground until a high-level water reservoir is reached. During the monsoon season, water can thereby directly flow into the reservoir and recharge water levels there for later use. Bhungroos have the great advantage of not losing water to evaporation during the dry season. Significantly improved access to water enhances farmer incomes (3 - financial impact). The intervention does not holistically address the issue of water harvesting, as optimal water harvesting solutions should be chosen on basis of local geography from a wide portfolio of solutions (0 - holistic). It does not help farmers improve market power (0 - market power). It does have the positive social benefit of reducing usage of deep aquifer groundwater (1 - social).	3	1	Bhungroos need special drilling equipment to be built, but this equipment is readily available given appropriate financing. Costs are comparable to the costs of building farm ponds or other water harvesting structures (2 - financial viability). Since the Bhungroo is a technology that is not yet widely practiced and requires knowledge of underground strata and reservoirs, it is more complex in execution than other water harvesting solutions (0 - complexity). Bhungroos are widely accepted by farmers as it grants farmers access to water (1 - acceptance) and the technology can be employed throughout Maharashtra for all farmers (1 - universality). They do not need any policy level change for implementation (1- policy & innovation). Bhungroos are poorly scalable given construction cost and the limited number of farmers that can be affected by a single harvesting structure (0 - scalability).	2	3

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
27	**Canal Extension and Fortification**	As part of large-scale irrigation development programs, canal extension and fortification undoubtedly benefit farmers across Maharashtra, delivering strong financial impact (3 - financial impact). Canal extension is a holistic method to provide long-term, large-scale access to water (1 - holistic), but it does not increase farmer market power (0 - market power) or have clear secondary social benefits (0 - social).	3	1	Canal extension and fortification are large, expensive projects that benefit thousands to millions of farmers. Farmers strongly support irrigation development (1 - acceptance), and improved irrigation is universally beneficial to them (1 - universality). Canal extension requires experts to do planning and execution (0 - complexity) and is done at scale by definition (1 - scalability) The government is currently engaged in several large-scale irrigation projects, so no further policy change or innovation is required (1 - policy & innovation). Canal fortification is very expensive and requires resources at government scale (1 - financial viability).	1	4
28	**Recharge Pits**	Recharge pits are small pits 3-4m across and 3m in depth which are topped with a 3 feet silt trap filled filter media such as rubble, sand and gravel, which prevent sediment from falling into the pit. For more details on general water harvesting see the 'Water Harvesting' intervention entry. Recharge pits are open water structures, meaning that water gathered in them evaporates in hot conditions. They therefore have only limited impact on water availability for farmers (2 - financial impact. The intervention does not holistically address the issue of water harvesting, as optimal water harvesting solutions should be chosen on the basis of local geography from a wide portfolio of solutions (0 - holistic), It does not help farmers improve market power (0 - market power). It does have the social benefit of reducing use of groundwater (1 - social).	2	1	This intervention has a medium implementation difficulty, the main limiting factor being financial support for building this water harvesting structure (3 - financial viability). Once the infrastructure is built, it is easily implemented (1-complexity) and is especially popular amongst rainfed farmers (1 - acceptance). The government is already promoting water harvesting by providing various subsidies (1 - policy & innovation). Recharge pits can be practiced by all categories of farmers (1 - universality). They are poorly scalable given their construction cost and the limited number of farmers that can be affected by a single harvesting structure (0 - scalability).	3	4
29	**Bunding**	Bunds are small dams made of earth, stone or other materials that help catch water in a field. Building a bund on a field allows water to seep into soil locally and not run-off. At the same time, it improves soil health by preventing the erosion of top soil. Bunds have clear positive impacts on farmer yields (2 - financial impact). Bunding does not fully address the issue of soil health maintenance (0 - holistic), and has no effect on farmer market power. It does, however, have the positive side-effect of reducing chemical fertilizer use on cotton farms, thereby providing a positive social benefit (1 - social).	2	1	Bunds are very cheap to build and can be made by farmers individually with an ox-drawn cart (5 - financial viability) (1 - complexity). They can and should be used by farmers everywhere (1- universality) as a common best practice. Bunding can be done at a large scale (1 - scalability) and faces no resistance from farmers (1 - acceptance). Bunding does not require any policy change or innovation to be functional (1- policy & innovation).	5	5

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30	**SMS based information systems**	In general, SMS-based information systems can help farmers make smart decisions about farm management and crop cultivation. Previous attempts at the intervention have not been highly successful, but CICR Nagpur has recently initiated the e-Kapas network as a new attempt. As the project is relatively recent, benefits need to be assessed before scale-up can be considered (2 - financial impact). This intervention has the potential to significantly increase the availability of agronomic information in rural settings (1 - holistic), but it does not increase farmer market power (0 - market power). No secondary social benefits are derived from the intervention (0 - social).	2	1	Implementing an SMS-based advisory system is technically challenging, as it needs to consider local soil and weather conditions to be efficient (0 - complexity). Full and efficient implementation of an adequate system is therefore very expensive (1 - financial viability). Considering the outreach of the SMS-based advisory system, it is scalable (1- scalability) and can be practiced in all geographies (1 - universality). It does not require much effort from the farmer's end, and is readily gaining traction (1- acceptance). Implementing an SMS-based information system does not require any policy level intervention, but it does require innovation in messaging services and tailoring of automated advisory (0 - policy & innovation).	1	3
31	**Optimal Spraying**	Optimal spraying refers to the process of applying pesticides at optimal periods or windows in optimal doses to maximize crop protection against pests. It is explicitly a practice that works against reactive spraying. Optimal spraying is highly effective and a part of IPM. Please see the entry for 'Integrated Pest Management' for more details. On its own, optimal spraying has only a limited benefit to farmers (1 - financial impact). The intervention does not holistically address the issue of pest management (0 - holistic), and does not improve farmer market power (0 - market power). However, it allows pesticide reduction, giving health benefits (1 - social).	1	1	Optimal spraying requires significant farmer education and training (0 - complexity). Otherwise it can be implemented without major issues, as input costs decrease with targeted application of pesticides (5 - financial viability). IPM is scalable through field schools and community-based implementation (1 - scalability) and is usually well received by farmers due to decreased costs (1 - acceptance). No new policy requirements are required for IPM (1 - policy & innovation), which can be carried out by all farmers universally (1 - universality).	5	4
32	**Scouting & Early Detection**	Scouting and early detection aim to catch pest attacks before they happen and destroy crops. Scouting and early detection have a high impact on farmer livelihoods, as they can reduce the prevalence of crop losses significantly. Scouting and early detection are part of part of Integrated Pest Management. Please see the entry for 'Integrated Pest Management' for more details. On its own, optimal spraying has only a limited benefit to farmers (1 - financial impact). The intervention does not holistically address the issue of pest management (0 - holistic) and does not help farmers improve market power (0 - market power), but it does allow farmers to reduce pesticide usage, giving secondary health benefits (1 - social)	1	1	Scouting and early detection require farmer education and training. Otherwise they can be implemented without major issues. Practicing this results in reduced expenditure on chemical pesticides, enabling it to be carried out by all farmers easily (5 - financial viability). Significant education and training are required (0 - complexity). IPM is scalable through field schools and community-based implementation (1 - scalability), and is usually well received by farmers due to decreased costs (1 - acceptance). No new policy requirements are required for IPM (1 - policy & innovation). IPM should be carried out by all farmers universally (1 - universality).	5	4

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33	**Timely Termination**	Timely termination refers to the practice of growing short-duration cotton varieties and then cutting down these varieties quickly after harvest. Timely termination has a strong positive impact on farmer livelihoods, as it ensures that harvesting is completed before pests such as pink bollworm have time to multiply. Timely termination is a part of part of Integrated Pest Management. Please see the entry for 'Integrated Pest Management' for more details. On its own, optimal spraying has only a limited benefit to farmers (1 - financial impact). The intervention does not holistically address the issue of pest management (0 - holistic) and does not help farmers improve market power (0 - market power), but it does allow farmers to reduce pesticide use, giving secondary health benefits (1 - social)	1	1	Timely termination of crops places no financial burden on farmers if the correct varieties and cultivation practices are selected (5 - financial viability). Introduction of timely termination mostly requires good education. It needs to be considered as part of a larger, well-educated decision on seed choices and integrated pest management practices. If a good seed is found, the implementation is very easy (0 - complexity). Timely termination will likely face farmer resistance, as current cotton cultivation practices usually focus on long-duration hybrids and allow multiple pickings, which would be reduced in short duration varieties (0 - acceptance). Currently, there is a lack of high-yield short duration hybrids on the market, and straight varieties are hardly used, making innovation necessary (0 - innovation). Scaling efforts will likely be hindered by lack of farmer acceptance and are likely to need implementation in a more holistic pest resistance strategy such as IPM (0 - scalability). Timely termination is relevant to all farmers (1 - universality)	5	1
34	**Integrated Pest Management**	Integrated Pest Management (IPM) describes a series of measures taken to reduce pest damage through non-chemical measures, e.g. optimal spraying; scouting and early detection; timely termination; cultural and mechanical control measures for minimizing the carryover of pink bollworm; and use of biological pesticides. IPM as a practice is highly impactful, as it not only reduces the cost of cultivation by decreasing the use of chemical pesticides, but also increases the yields of cotton farmers by preventing crop losses due to pest infestation (3 - financial impact). The intervention holistically addresses the issue of pest management (1 - holistic) but does not help farmers improve market power (0 - market power). IPM reduces the amount of pesticides used, thereby providing health benefits to farmers (1 - social).	3	2	IPM reduces expenditure on chemical pesticides, enabling it to be carried out by all farmers easily (5 - financial viability). Significant education and training are required (0 - complexity). IPM's complexity makes it difficult to scale (0 - scalability). It is usually well received by farmers due to decreased costs (1 - acceptance). No new policy requirements are required for IPM (1 - policy & innovation). IPM which should be carried out by all farmers universally (1 - universality)	5	3

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35	**Commercial Dry Storage Solutions**	Dry storage of cotton is important, although it generally does not require commercial solutions as is common for other crops (1 - financial impact). Cotton does not spoil under regular conditions, although extended storage can result in quality degradation. Farmers should find a safe place for storage outside their main living area to prevent wetting of cotton and cotton fires (seed cotton is highly flammable, so storage near kitchen fires is dangerous). The intervention holistically addresses the issue of post-harvest storage (1 - holistic) but does not help farmers improve market power (0 - market power). It does not provide any social benefits (0 - social)	1	1	Commercial options for cotton storage can be purchased for implementation by well-off farmers (4 - financial viability). Set-up of commercial solutions is easy (1 - complexity), but farmers usually prefer to keep cotton in small sheds or in their homes (0 - acceptance), but the set-up of commercial dry-storage solutions are scalable if farmers are willing to spend money on the solution (1 - scalability). No government policy or innovation is required for implementation (1 - policy & innovation). These options can be used by all cotton farmers universally (1 - universality)	4	4
36	**Crop Insurance**	Crop insurance under PMFBY forms the core of India's agricultural insurance. Crop insurance has a highly positive impact on farmers because it allows them to de-risk crop failure. While an individual farmer may not benefit every year, the overall impact of insurance on farmers is significant in stabilizing income and protecting farmer livelihoods (3 - financial impact). Any intervention carried out by NGOs in Maharashtra should aim to enroll farmers wherever possible. The intervention holistically addresses the issue of risk in cotton cropping (1 - holistic) but does not help farmers improve market power (0 - market power). Insurance helps farmers drop out of debt spirals, thereby providing clear social benefits (1 - social).	3	2	Getting farmers access to crop insurance is easy and can be afforded even by poor individual farmers, since agricultural insurance is heavily subsidized by the government (5 - financial viability). A well-designed website by the ministry allows quick sign-ups (1 - policy & innovation) (1 - complexity). Nonetheless, farmer acceptance of insurance is often low, as problems with receiving claims disincentivize farmers from purchasing insurance (0 - acceptance), hampering scalability (0 - scalability). Insurance is relevant to all farmers and can be purchased by all farmers easily (1 - universality).	5	3
37	**Group Lending**	Group lending refers to the practice of lending money to a group of farmers, who then encourage each other to repay their loans. Group lending can help companies gain confidence in giving loans to farmers who otherwise would not be deemed creditworthy. Overall, the impact of group lending is positive, although group lending usually only sees small loan amounts which many farmers are likely to also be able to access through banks and KCC loans (2 - financial impact). The intervention therefore does not holistically address the issue of access to finance (0 - holistic). It also does not help farmers improve market power (0 - market power). Collective lending does help farmers with no access to finance get at least a limited amount of loan, thereby giving social benefits (1 - social).	2	1	Collective lending requires funding from government or a larger cooperative society (2 - financial viability). Farmer acceptance is high due to low interest rates (1 - acceptance), and collective lending can be scaled to hundreds or thousands of farmers relatively quickly, given enough capital inputs (1 - scalability). Collective lending applies to all farmers (1 - universality) and no new government policy is required for implementation (1 - policy & innovation). Collective lending is, however, quite complex and requires experienced management and good farmer engagement (0 - complexity)	2	4

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38	**Loan Waivers**	Loan waivers waive farmer debt. While this intervention improves farmer livelihoods, it should be seen very critically. Loan waivers incentivize farmers to make poor financial decisions (a moral hazard), as farmers come to expect that future debts will likewise be waived. Loan waivers are also non-targeted, meaning that money is simply given to farmers as a lump sum as opposed to methods such as subsidies on drip irrigation, where specific, beneficial behavior is encouraged. Overall, loan waivers provide a short-term benefit to farmers, but they do not have the financial impact that other interventions with a more long-term focus can provide (1 - financial impact). The intervention does not holistically address the issue of access to finance, as it only gives short-term relief to farmers (0 - holistic), and does not help farmers improve market power (0 - market power). However, as it allows some farmers to escape debt spirals, it has some social benefits (1 - social)	1	1	Loan waivers can only be decided by senior government officials (1 - financial viability). They are highly popular with farmers (1 - acceptance), always carried out at scale (1 - scalability), and are universally applicable to farmers (1 - universality). Delays with payment of claims under loan waivers have been reported (1 - complexity) and government action is needed for better implementation (0 - policy & innovation)	1	3
39	**Poultry**	While poultry can be a profitable business, chicken farming is poorly suited to Maharashtra's climate. Birds can die in extreme heat, leading to large losses in a poultry farming (0 - impact). The intervention effectively addresses the issue of diversification (1 - holistic), but it does not help farmers improve market power (0 - market power). Poultry gives secondary health benefits, as farmers' households can consume some of the poultry produce (1 - social).	0	2	While keeping a small number of chickens for private meat and egg consumption can be done without great difficulty by farmers, commercial and semi-commercial poultry operations require significant seed capital that only wealthy farmers can afford (4 - financial viability). Good know-how on sufficient cooling, fodder, and water are required for success (0 - complexity). Poultry is poorly suited to the hot climate of Maharashtra's summers, as chickens can easily die due to overheating (0 - universality). Poultry can be poorly received by farmers, due to its risks in Maharashtra's climate (0 - acceptance). It is already supported by multiple government schemes (1 - policy & innovation) and can be scaled relatively efficiently, e.g. through a poultry cooperative (1 - scalability)	4	2
40	**Dairy**	Dairy is a traditional means of income generation in large portions of India. In Maharashtra, dairy farming is particularly suited to farmers with saturated irrigation, as they are able to supply cows with a sufficient amount of water and fodder. Keeping dairy provides a seasonally independent source of farm income that can be very large if cows are managed well (3 - financial impact. The	3	2	Purchase of cows for dairy business can be carried out by farmers with stable incomes (4 - financial viability). Poor management of dairy can result in death of cows or low milk yields (0 - complexity) There is extensive market and government support (1 - policy & innovation) for farmers wishing to start their own dairy business, making dairy farming scalable in the current context (1 -	4	3

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
		intervention effectively addresses the issue of diversification (1 - holistic), but does not help farmers improve market power (0 - market power). Dairy gives secondary health benefits, as farmers' households can consume some of their dairy produce (1 - social).			scalability). Farmer acceptance for dairy is high, as the success of past schemes has shown the benefit of dairy to farmers (1 - acceptance). Cows, however, require good amounts of water and fodder to stay healthy, which rainfed farmers are not always able to provide (0 - universality).		
41	**Goat Farming**	Goat farming is well suited for farmers in Maharashtra, especially for rained and partially irrigated farmers. Goats have smaller water and fodder requirements than dairy, and a higher innate resistance to heat, making them well suited for Maharashtra's climate. Goat farming was shown to have a high-income impact for marginal farmers in several studies (3 - financial impact). The intervention effectively addresses the issue of diversification (1 - holistic), but does not help farmers improve market power (0 - market power). Goat farming does give secondary health benefits, as farmers can consume some of the goatery produce within the household (1 - social).	3	2	Goat farming requires a small amount of seed funding that cotton farmers with stable incomes can afford (4 - financial viability). Poor management of goats can result in low milk yields or death of goats (0 - complexity). There is extensive government support for farmers wishing to start their own goat farming business (1 - policy and innovation). Goat farming can face low farmer acceptance, as it is usually carried out by low-cast, landless farmers (0 - acceptance), but can be carried out by even rainfed farmers (1 - universality) and is scalable due to relatively low investment costs (1 - scalability).	4	3
42	**Sericulture**	Sericulture refers to the domestication of silk worms for the harvesting of silk worms. It is a highly profitable business that has moderate water and fodder requirements. Multiple studies have shown the benefits of diversification into sericulture, making it a viable and impactful solution for Maharashtra farmers (3 - financial impact). The intervention effectively addresses the issue of diversification (1 - holistic), but does not help farmers improve market power (0 - market power). Sericulture has the benefit of diversifying farmers strongly away from agriculture, providing a stable year-round income that farmers can access to maintain their livelihoods (1 - social)	3	1	Sericulture needs significant investments in the set-up phase. These set-up costs can be carried by wealthy farmers (4 financial viability). Farmers need to follow strict sanitary guidelines to prevent silkworms from contracting disease (0 - complexity). Silkworm cultivation also requires the cultivation of Mulberry for fodder, which in turn requires at least partial irrigation. Mulberry can only be grown in areas with enough access to water (0 - universality). However, several government subsidies exist to help farmers set up their sericulture operation (1 - policy & innovation). Sericulture is difficult to scale, given the high investment and training input required (0 - scalability)	4	3
43	**Fishery**	While fishery is a lucrative business, it is poorly suited to Maharashtra's climate. When fish ponds are exposed to hot weather and strong sunlight, they lose water rapidly and heat up quickly, making living conditions for fish difficult and the practice of fishery risky (1 - financial impact) Maintaining high-water requirement for fisheries requires water to be pumped up from borewells, which depletes deep water reservoirs. The intervention does	1	2	Fisheries are expensive to set up, requiring well-off farmers for implementation (4 - financial viability). Fishery is already supported by the Maharashtra government through the 'Blue Revolution' schemes (1 - policy & innovation). Farmers wishing to engage in this diversification practice need proper training (0 - complexity). Fish farms should only be grown in areas with enough access to water (0 - complexity), and high	4	2

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
		effectively address the issue of diversification (1 - holistic), but does not help farmers improve market power (0 - market power). Fishery gives secondary health benefits, as farmers can consume some of the fish within the household (1 - social).			investment costs make them difficult to scale (0 - scalability). Fisheries are accepted by farmers if local conditions allow use of the practice (1 - acceptance)		
44	**Crop Rotation**	Field rotation in appropriate ordering also improves soil health, as crop nutrient requirements and nutrient creation vary. While crop rotation usually doesn't provide a significant secondary source of income, it does result in better soil health and higher yields (1 - financial impact). The intervention in itself is not sufficient to fully diversify a farmer or shift soil health to fully productive levels (0 - holistic), and it does not help farmers improve market power (0 - market power). Crop rotation does give secondary environmental benefits, as farmers can reduce chemical fertilizer usage on their land due to increased soil health (1 - social).	1	1	Crop rotation does not result in any additional costs for farmers if cash crops are grown on the cropped land during the main growing season of kharif (5 - financial viability). Crop rotation has a certain degree of complexity, as proper rotation needs explanation and training (0 - complexity). Also, many farmers in Maharashtra are fully reliant on cotton as a cash crop, and thus have little opportunity to grow legumes on their plot during kharif (0 - universality). Scaling crop rotation is difficult, as farmers need to be educated individually (0 - scalability). Farmer acceptance of intercropping is limited, as visibility of its immediate effects can be low after initial implementation, making retention difficult (1 - acceptance). No new policy or innovation is required for implementing of crop rotation (1 - policy & innovation)	5	3
45	**Seed optimization**	Seed optimization refers to the process of picking the correct cotton seed for farmers. Picking the right seed for any cotton intervention is critical and needs to be chosen in consideration of agronomic practices and other planned interventions. The impact of seed optimization within a given system is high (2 - financial impact) although the largest benefits can usually be reaped by combining system change with seed optimization in a dual intervention. The intervention is enough to address the correct choice of seeds (1 - holistic), but it does not help farmers improve market power (0 - market power). Seed optimization does give secondary environmental benefits as farmers can reduce use of water for drought-resistant seeds; can reduce fertilizer usage if seeds are optimized for local soils; and can reduce pesticides if seeds are resistant to certain pests (1 - social).	2	2	Seed optimization requires no additional costs, only additional information to pick the right seeds (5 - financial viability). Picking the right seed for cotton cultivation is a difficult process requiring a very detailed understanding of seed choices and their characteristics. Seeds can be selected for yield; drought resistance; size; pest resistance; cotton quality including staple length; harvest index; and crop duration (0 - complexity). Seed optimization is however difficult to scale, as a lot of analysis needs to be conducted to choose optimal seeds for individual farmers (0 - scalability). Farmer acceptance to seed optimization is moderate, as farmers prefer to grow what they have experience in growing. Similarly, retention of optimized seeds in the following seasons without selection support can be an issue (0 - acceptance). No policy requirement or innovation is required for seed optimization (1 - policy & innovation) and the practice can be carried out by all farmers (1 - universality)	5	2

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
46	**Intercropping**	Intercropping has a positive impact on cotton farmers' incomes, as it diversifies farmer incomes and improves soil health (2 - financial impact). Most intercropping for Maharashtra cotton farmers is carried out with pigeon pea and grams. Since intercropping is already so prevalent, the need for further interventions can be debated. The intervention in itself is not sufficient to fully diversify a farmer's earnings or shift soil health to fully productive levels (0 - holistic), and it does not help farmers improve market power (0 - market power). Intercropping does give secondary environmental benefits, as farmers can reduce chemical fertilizer usage on their land due to their increased soil health (1 - social)	2	1	Intercropping is easy and cheap to implement, and many Maharashtra farmers are already actively engaging in the practice (5 - financial viability). Intercropping is not complex (1 - complexity), has already been scaled (1 - scalability), is widely accepted by farmers (1 - acceptance), needs no policy change or innovation for viability (1 - policy & innovation), and can be universally used by farmers (1 - universality)	5	5
47	**Kitchen Garden**	Kitchen gardens are grown by farmers to supply additional nutritional value for household consumption. Since household consumption has no significant impact on overall income, kitchen gardens were not analyzed in detail in this study (1 - financial impact). The intervention in itself is not sufficient to fully diversify a farmer or shift soil health to fully productive levels (0 - holistic), and it does not help farmers improve market power (0 - market power). Kitchen gardens do give secondary health benefits, as farmer households get access to better nutrition (1 - social).	1	1	Kitchen gardens are relatively easy to implement for even poor farmer households, given sufficient access to water and availability of family labor (5 - financial viability). Kitchen gardens are low in complexity as they require minimal training (1 - complexity) and are scalable (1 - scalability). They are usually maintained by women, meaning they are only applicable to households in which women are not fully engaged in other domestic or economic activities (0 - universality). Farmer acceptance for kitchen gardens is high, as they are low in costs and provide nutritional benefits (1 - acceptance). No policy change or innovation is required for their implementation (1 - policy & innovation)	5	4
48	**Horticulture**	Horticulture refers to the cultivation of high-value crops such as nuts, vegetables, berries and flowers. Horticulture can allow farmers to significantly increase their incomes (3 - financial impact). The intervention in itself is sufficient to strongly diversify a farmer's earnings (1 - holistic), but does not help farmers improve market power (0 - market power). Horticulture often gives secondary social benefits, as farmers can access improved nutrition by eating some of their horticulture crops (1 - social)	3	2	Horticulture is an activity usually requiring a limited amount of seed funding, making it affordable for farmers with stable incomes (4 - financial viability). However, horticulture is risky, as the crops grown are usually less stable and more easily spoilt than other crops, and require high amounts of water (0 - universality). Horticulture has a manageable level of complexity, as it means farmers will continue doing agriculture, but with a new crop (1 - complexity). Horticulture is scalable (1 - scalability) and farmer acceptance is high, given the high returns from the practice (1 - acceptance). No government policy changes are required (1 - policy & innovation)	4	4

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49	**Agro-Forestry**	Agro-forestry is agriculture incorporating the cultivation of trees, e.g. along field-borders or as a source of fruit crops. Agro-forestry is beneficial in areas where water is sufficiently available to sustain trees. Agro-forestry can even be beneficial to rainfed farmers if it is carried out with dryland agriculture trees such as *sitaphal* or lime. Overall, dryland agriculture helps diversify farm incomes slightly but does not act as a game-changer in farming incomes (2 - financial impact). The intervention in itself is not sufficient to strongly diversify a farmer's earnings (0 - holistic), and it does not help farmers improve market power (0 - market power). Agro-forestry does give secondary social benefits, as farmers can access improved nutrition by eating some of their agro-forestry crops (1 - social).	2	1	Even poor farmers can afford to purchase a small number of trees to be planted at the border of their fields (5 - financial viability). Agro-forestry is not complex (1 - complexity), and is also scalable (1 - scalability). It has high farmer acceptance, as returns from investment tend to be high (1 - acceptance). Agro-forestry can be carried out even in rainfed regions if drought resistant trees are used (1- universal) and no policy changes or innovation is needed for implementation (1 - policy & innovation)	5	5
50	**Hand Looms**	Handlooms as a vertical diversification alternative allows farmers to process their cotton into a higher-value product. However, our research has shown mixed results on the impact of handlooms as an activity. Handlooms work best when connected well with urban markets, considering that rural farmers have suffered from poor market linkages, especially considering ever-increasing competition from machine-spun garments (1 - financial impact). The intervention in itself is not sufficient to strongly diversify a farmer's household (0 - holistic), and it does not help farmers improve market power (0 - market power). Handlooms do give secondary benefit, as they empower women within households (1 - social).	1	1	Running a handloom operation can easily be carried out by a single farmer (5 - financial viability). Creating a handloom intervention to diversify farmer income requires training, but this training is readily available (1 - complexity). Handlooms are scalable (1 - scalability) and farmer acceptance is high, as handlooms are a traditional income activity in India (1 - acceptance) and multiple policies already exist to support khadi and other hand loom interventions (1 - policy & innovation). Handloom interventions can be done for all farmers (1 - universal).	5	5
51	**Micro Ginnery**	Micro-ginning refers to the practice of using a small-volume ginning machine to allow farmers to gin their own cotton. It is also referred to as community ginning. Micro-ginning is practiced in some parts of Maharashtra at small scale successfully, but micro-ginneries do not contain a bale pressing machine, which means micro-ginneries continue to be reliant on larger gins to press their cotton. This limits financial impact (1 - financial impact). Micro-ginneries do not address the issue of ginning holistically (0 - holistic), although they do allow farmers to move up the value chain (1 - market power). No direct social benefits are obtained from micro-ginning facilities (0 - social).	1	1	Micro-ginneries require multiple crores in seed funding (2 - financial viability). Running a micro-ginnery is complex (0 - complexity) and poorly scalable due to high seed funding requirements and strong local competition (0 - scalability). Farmer acceptance is likely, as long as the micro-ginnery gives good prices (1 - acceptance). However, innovation is required to create micro-ginning units with efficiency levels compared to those of larger ginneries (0 - policy & innovation). Micro-ginning interventions can be done for all farmers (1 - universal)	2	2

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
52	**Bricket Packaging**	Bricket packaging refers to the process of compressing cotton stalks into cylindrical cotton brickets, which can then be sold as firewood. Bricket packaging helps reduce pest infestation, as it removes cotton stalks, a natural reservoir for pests. Overall, the financial impact of bricket packaging on cotton farmers is small when considered alone (farmers receive about INR 200 per acre when they allow bricketing companies to cut cotton stalks on their field) (1 - financial impact). Bricket packaging also has positive environmental benefits (1 - social) as it reduces the burning of cotton stubble at the end of the growing season. The intervention does not holistically address the issue of pest management (0 - holistic), and also does not help farmers improve market power (0 - market power)	1	1	Bricket–packing requires sufficient seed funding to purchase machinery for the creation of brickets (2 - financial viability). The intervention is complex, as it requires significant training (0 - complexity) and is poorly scalable due to high investment costs (0 - scalability). Bricket-packaging is readily adopted by all, and participants can even get paid to allow the service provider access to their fields (1 - farmer acceptance). It requires no policy change or innovation (1 - policy & innovation). Bricketing can be done for all farmers (1 - universal)	2	4
53	**Drip Irrigation**	Drip irrigation is high in financial impact, as it allows farmers to grow more water intensive crops. It also allows farmers to increase the yields of their existing crops (3 - financial impact). Drip irrigation does not increase farmer market power (0 - market power), but reduces water usage, providing environmental benefits (1 - social). Drip irrigation is a holistic method for increasing water efficiency on farms (1 - holistic).	3	2	Drip irrigation is a very efficient method of irrigation that provides high yields, and can be afforded by farmers with stable finances (4 - financial viability). It can only be used by farmers with access to water (0 - universality) but is not complex to use (1 - complexity). Drip irrigation is well accepted by farmers (1 - acceptance), but is poorly scalable, as farmers need to be upgraded one by one (0 - scalability). No policy change or innovation is required for the implementation of drip systems (1 - policy & innovation).	4	3
54	**Collective Purchasing**	Purchasing inputs and other materials as a collective/group of people provides farmers with better negotiating power. Collective purchasing has a high financial impact (3 - financial impact) as it helps in reduction of costs and increase incomes with high-quality produce. This intervention does not provide environmental or social benefits (0 - social), but increases farmers market power (1 - market power), and effectively addresses input procurement for farmers (1 - holistic).	3	2	Collective purchasing can be carried out by collectives with small financial input (3 - financial viability). It can be used by all farmers (1 - universality) and is not complex to use for individual farmers (1 - complexity). Collective purchasing is scalable through the collective (1 - scalability) and does not require policy changes or innovation for implementation (1 - policy & innovation). Collective purchasing is well accepted by farmers due to its cost savings (1 - acceptance).	3	5
55	**Lint Based Marketing**	Lint Based Marketing (LBM) refers to a combination of measures to shift farmers from paying for cotton based on seed cotton weight and quality to paying for cotton based on cotton lint weight and quality. Lint Based Marketing can potentially create lasting increase in farmer price realization (3 - financial impact). It improves farmer	3	2	Lint-based marketing (LBM) can be pushed by collectives with limited financial input (3 - financial viability). It can be used by all farmers (1 - universality), and scaled through government action or FPO-based interventions (1 - scalability). No government action is required to enable LBM, but government action can	3	4

S. no	Intervention	Impact Assessment	Financial Impact	Secondary Benefits	Ease of Implementation and financial viability assessment	Financial Viability	Feasibility
		marketing power, by connecting lint quality with farmer income (1 - market power). LBM holistically addresses issues in the cotton value chain (1 - holistic), but it does not provide any additional social benefits (0 - social).			significantly hasten the process of a shift from current marketing procedures towards LBM (1 - policy & innovation). LBM is likely to be widely accepted by farmers, as it increases price transparency in the value chain (1 - acceptance). LBM is, however, somewhat complicated to implement, as it requires a shift in current pricing norms (0 - complexity).		
56	**Watershed Development**	Watershed development refers to a holistic approach to preserving local water resources through water harvesting, improvement of water use efficiency and other sustainable agriculture practices (1 – holistic). Watershed development has strong financial impact in the long-term (3 – financial impact), although immediate effects can be small. It has significant positive effects on the environment and long-term climate resilience of local communities (1 – social), but has no effect on farmer marketing power (0 – market power)	3	2	Although individual farmers can contribute to watershed development on their own, significant benefits of watershed development interventions require working at scale with significant government or institutional support (1 – financial viability). Watershed development can and should be carried out by farmers universally (1 – universality), but is difficult to scale without significant support (0 – scalability). No policy change or innovation is required to carry out watershed development (0 – policy & innovation), which is generally well received by farmers due to the increased water access that it provides (1 – acceptance). Watershed development is complex, requiring extensive training for execution.	1	3

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