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Baseline Scenario of Postrainy Season Sorghum Economy in Western Maharashtra

N Nagaraj, Vasanth Pokharkar, Surajit Haldar, Cynthia Bantilan and MG Chandrakanth

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Abstract

Postrainy season sorghum is one of the major dietary staple cereal crops in the western Maharashtra region supporting food and fodder security. Currently, the productivity levels are extremely low because of limited adoption of dryland technologies by the poor. Thus, the HOPE project aimed at increasing the productivity of sorghum and pearl millet by 35-40% over the base level in South Asia. This was done through introduction of on-shelf technology and improved management practices in the targeted clusters over a period of four years. In this regard, the baseline survey was conducted in the primary project intervention area (HOPE) where improved technologies have been introduced, and in matching control villages with comparable agro-ecological and market conditions in non-intervention areas (non-HOPE), where improved technologies have not been made. The objective of this baseline survey was to appraise the existing situation of the targeted cluster villages with respect to adoption of technologies, productivity, income, yield gaps and other socioeconomic issues. The coverage area of improved rabi sorghum varieties were around 29% in HOPE and 13% in non-HOPE areas, where the yield gap was estimated at 51% as compared to the potential yield for the improved varieties. The productivity of rabi sorghum in the HOPE area was 1.06 t/ha and in non-Hope area 1.05 t/ha. Considering the variable costs, HOPE farmers are receiving a net return of ₹ 3988 per ha and non-Hope farmers as ₹ 5158 per ha. The annual per capita income in HOPE area is ₹ 38,118, while in the non-HOPE area it is ₹ 25,000, of which 65% is derived from crop enterprises only. Involvement of women in activities such as land preparation, intercultural operations, harvesting and threshing are very significant. Moisture stress, especially during sowing and/or terminal drought, shortage of labor especially during harvesting and threshing were some of the key critical constraints expressed by the farmers in adoption of improved *rabi* sorghum technologies.

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This work has been undertaken as part of the CGIAR Research Program on Dryland Cereals

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Summary

The Harnessing Opportunities for Productivity Enhancement of Sorghum and Millet (HOPE) project aimed at increasing the productivity of sorghum and pearl millet by 35-40% over the base level in South Asia through introduction of on-shelf-technology and improved management practices in the targeted clusters over a period of four years. One of the objectives of the project is aimed at targeting the opportunities for technology development and delivery to maximize adoption and impacts of innovations on livelihoods. In this regard, a baseline survey was carried out to review the existing situation of the targeted cluster villages with respect to the status of resource endowments, socio-economic profile of farmers, cropping pattern, improved varieties and practices adopted, yield gaps, input-output levels and the profitability of crop production, technology and trait preferences of farmers, income and consumption levels, labour participation and earnings, marketing channels and costs and gender participation.

The baseline survey was conducted in the primary project intervention area (HOPE) where improved technologies have been introduced, and in matching control villages with comparable agro-ecological and market conditions in non-intervention areas (non-HOPE), where improved technologies have not been made. This enabled collection of baseline data from participating and non-participating farmers that help identify comparable and counterfactual for impact evaluation.

The average size of the holding is around 4.5 ha indicating medium sized holdings in both HOPE and non-HOPE areas. Agriculture provides the major source of income in both areas. More than 55 percent of the sample farmers are middle aged (35-55 years), with the proportion of literate farmers in the sample being at least 75 percent. With respect to resource endowments, around 40 percent of the farmers in the HOPE project area owned less than 2 ha land (ie marginal and smallholders) as against 32 percent in the non-HOPE area. On an average, more than 50 percent of the farmers owned two draft animals (valued ₹ 36,000) and around 30-40 percent of the farmers owned various milch animals valued ₹ 18,000. Around 13 percent of the farmers in the HOPE area and 10 percent in the non-HOPE areas owned tractors valued at ₹ 410,000.

In both the areas, agriculture is the major source of income. In addition, around 65 percent of the farmers in HOPE and around 75 percent of the farmers in non-HOPE areas earned an annual income of around ₹ 43,000 and ₹ 35,000 respectively from dairy farming. Around 12 to 16 percent of the farmers in both areas indicated that they are in formal salaried jobs. Around 10 percent of the farmers in the HOPE area and 23 percent In the non-HOPE area earned around ₹ 13,000 from hiring bullock labour. Thus, a majority of the rainfed farmers are practicing integrated farming systems with synergies of crops with livestock. Most of the respondent farmers are middle aged, indicating the interest of middle aged towards agriculture. Most of the fodder produced is retained at home for feeding livestock. The annual per capita income of farmers in HOPE area is ₹ 38,118, while in non-HOPE area it is ₹ 25,000. Thus, the per capita incomes in HOPE and non-HOPE area are far below the national level (India's per capita income is around ₹ 53,000).

There is a great diversity of crops cultivated by rainfed farmers in both HOPE and non-HOPE areas, indicating diffusion of risk by farmers through crop pattern. In the *rabi* (postrainy) season, the largest proportion of area is under sorghum (49%) followed by bengal gram (18%) and wheat (15%). In the non-HOPE area, sorghum occupies 59% of the total *rabi* area followed by bengal gram (17%) and wheat (16%).

The productivity level of *rabi* sorghum in HOPE and non-HOPE areas was around 12 q/ha in a normal year. The productivity differential between normal and below normal years is around 7.3 q/ha. However, in the above normal years, the productivity has greatly improved from 12 to 17 q/ha, as stated by the farmers. The proportion of area under improved varieties of *rabi* sorghum is around 29% in the HOPE area as against 13% in the non-HOPE area. The yield gap of improved varieties of *rabi* sorghum was estimated as 51% as compared to the potential yield, which shows further immense scope for improvement in the productivity level by introduction of the recommended package of practices along with improved varieties.

On an average, the paid out cost of production per ha of *rabi* sorghum is ₹ 12,959 in HOPE and ₹ 10,835 in the non-HOPE area, which yields a net return of ₹ 4753 in the HOPE area and ₹ 5780 in the non-HOPE area. Considering the the cost of cultivation in *rabi* sorghum, the labor component forms around 50% of the total cost in both HOPE and non-HOPE areas. The productivity of sorghum between HOPE and non-HOPE areas is comparable. The relative profitability of competing crops in HOPE area in that year indicated that onion (₹ 68,835) is more profitable than gram (₹ 3312), wheat (₹ 4537) and *rabi* sorghum (₹ 3977), yet the majority of farmers in the HOPE and non-HOPE areas preferred to sell sorghum in the regulated market.

The *rabi* sorghum (Maldandi) farmers in both HOPE and non-HOPE areas have indicated low productivity, pest and disease incidence and long duration as the major constraints to technology adoption. With regard to improved varieties, pest and disease incidence and long duration are the constraints opined by both HOPE and non-HOPE area farmers. Farmers prefer high productivity, short duration, drought, pest and disease resistance. In both HOPE and non-HOPE areas, farmers as consumers prefer to have tasty sorghum with less cooking time and high shelf quality in both local and improved varieties. Since livestock forms a strong component of farming activity, quantitatively and qualitatively, it is crucial to maintain sorghum cultivation for fodder demand. Therefore, preference for high productive fodder with more palatability and storability is vital. Relating to marketing of grain and fodder, assured demand, remunerative price and price stability are the traits preferred by farmers in addition to bigger grain size with white lustre, which fetch higher market price.

In HOPE and non-HOPE areas, the consumption of sorghum is around 40%, pearl millet is around 12% and other cereals is around 48%. While considering demand forecast for sorghum and other millets, it is crucial not to ignore the feed demands from the livestock sector, which is sustainable with proven and wide market for livestock fodder. More than 50 percent of the farm families are continuing the consumption of *rabi* sorghum as their staple food for its palatability, ease of availability at farm and health benefits.

About 95 percent of the farmers indicated that harvesting was a woman's role, and 75 percent of the farmers indicated their role in weeding, signifying the inevitable contribution of women in *rabi* sorghum cultivation wherever bending operations are involved.

Some of the key critical constraints expressed by the farmers are moisture stress, especially during sowing and/or terminal drought, economic scarcity of labour, shortage of fertilizer and FYM, lack of credit, lack of quality seed and lack of appropriate machineries.

I. Significance of the Study

To cope with the harsh agro-climatic conditions, smallholder and marginal farmers tend to grow dryland cereals such as sorghum and millet, which are the hardiest crops and less risky to produce. Sorghum is predominately grown in semi-arid regions of India and it continues to play a prominent role in the dryland economy considering the limited scope for expansion of irrigated areas. *Rabi* (postrainy season) sorghum is a staple crop, nutritionally superior, mostly consumed at the farm level and providing both food and fodder security.

The productivity of *rabi* sorghum is extremely low in South Asia, as it is subjected to moisture stress. Further, most of the smallholder and marginal farmers deter from investing in improved technologies due to the risk and uncertainty associated with biotic and abiotic stresses. Hence, with a view to increase the productivity of dryland sorghum, household incomes and food security, the HOPE project has been implemented in South Asia. In order to achieve increase in productivity, six specific objectives were chosen that attend to market chain and delivery constraints/opportunities, genetic and production systems specific to these crops and for better targeting. In an endeavour to achieve better targeting, the baseline study was undertaken in predominantly *rabi* sorghum-growing village clusters of Maharashtra state. Thus, the overall objective of this study is to provide critical baseline information inventory of the existing scenario in the targeted clusters and develop a database to track the changes in adoption and impact of crop management, improvement and market access on food, fodder, and income security.

In India, sorghum is cultivated on 7.38 million ha (2010-11), with annual production of 7.00 million tons and productivity of 949 kg per hectare. Maharashtra is the largest producer of sorghum in India (4.06 million tons representing 55% in 2010-11) followed by Karnataka (16.8%), Rajasthan (9.89%), Madhya Pradesh (5.83%), Andhra Pradesh (3.39%), Tamil Nadu (3.23%), Uttar Pradesh (2.71%), Gujarat (1.76%), Haryana (0.98%) and Orissa (0.09%). Maharashtra also ranked first in area with 4.18 million hectares (54%), followed by Karnataka (18%), Rajasthan (9.23 %), Madhya Pradesh (5.73 %), Andhra Pradesh (4.94%), Tamil Nadu (3.06%), Uttar Pradesh (2.45%), Gujarat (2.09%), Haryana (0.92%) and Orissa (0.12%).

II. Importance of *rabi* (postrainy season) sorghum in Maharashtra

In Maharashtra, *rabi* sorghum is a vital food and fodder crop cultivated in 4.06 million ha producing 3.45 million tons realizing 850 kg per hectare (2010-11). In Maharashtra, Pune, Ahmednagar and Solapur districts cultivate 52% of *rabi* sorghum. Solapur district leads the state in *rabi* sorghum area followed by Ahmednagar and Pune. For the past few decades, the area under *rabi* sorghum is stagnant in Maharashtra state as well as at district levels.

As a vital staple diet, sorghum has a crucial role in the food and feed basket of the rural poor in the semi-arid areas of Maharashtra. Although, sorghum is nutritionally rich, its consumption is declining significantly for the past three decades due to the laborious and time consuming process of food preparation, and the policy to supply wheat and rice at highly subsidized prices

to the poor, who are the main consumers of sorghum. While on the one hand this policy has improved physical access of superior cereals such as rice and wheat to the rural poor, on the other hand, it has hampered the cultivation of sorghum largely consumed by the rural poor, and consequently the availability of sorghum fodder. Sorghum is also a climate change crop meeting both food and fodder requirements with its wide adaptability to extremes of hot temperatures. There are no alternative crops to *rabi* sorghum in these areas since in the post-*kharif* season, the crops need to survive only on residual moisture. During periods of droughts and/or floods, while the Government may rely on the buffer stock of rice and paddy, there is no buffer stock of fodder. Hence it is evident that sorghum needs to be promoted essentially to meet both food and feed requirements of vast stretches of semi-arid tropics spread over Andhra Pradesh, Karnataka, Maharashtra, Rajasthan and Gujarat. In addition, in order to boost the consumption of sorghum in urban areas, it is essential that processing for value-addition leading to affordable, healthy and palatable food items, at least on home-industrial scale, is facilitated. This requires the policy to develop technology of processing sorghum increasing its shelf life before and after processing, converting those to palatable consumable products and dissemination as health foods in urban areas, and as staple foods in semi-arid tropical areas.

III. Sorghum in Western Maharashtra

Rabi sorghum is one of the major food and fodder crops in the Western Maharashtra region with an area of 20.68 lakh hectare and production of 14.16 lakh tons with a grain productivity of 6.84 q/ha and fodder productivity of 1368 kg/ha. Though *rabi* sorghum is largely for food and *kharif* sorghum is largely for feed, the ability of sorghum to meet the needs of both food and feed in any growing season is immense. The prominent *rabi* sorghum growing districts are Solapur, Pune and Ahmednagar districts of Western Maharashtra cultivating 79% of the sorghum area and producing 73% of production.

Sorghum is cultivated on 19% of the gross cropped area as the main dryland crop with no perfect substitute in the region. Due to the policy of distributing wheat and rice, the sorghum area is affected and farmers restrict cultivation of sorghum largely to meet their home food and fodder requirements and not for the market. Among the dry fodders, sorghum fodder is much preferred as it is palatable for all types of livestock with no perfect substitute available.

IV. Sampling

The target area of sorghum under the HOPE project was earmarked on the basis of secondary data on area, production and productivity levels, biological features, soil type, and climate. Western Maharashtra covers 10 districts of Maharashtra and the districts are arranged in descending order of area under *rabi* sorghum. Accordingly, the top three districts are Solapur, Pune and Ahmednagar, which have been sampled. In Ahmednagar district, five villages (Jakhangaon, Pimpagaon-Kauga, Bhire-Pather, Hivere Bazar and Taki-Khatagaon), six villages from Pune district (Padavi, Jiregaon, Khar, Hinganigada, Borkawadi and Vasunde) and six villages from Solapur district (Hinjagi, Sarola, Wadachi Wadi, Honemurgi, Araliand and Aurad) were selected under the HOPE project.

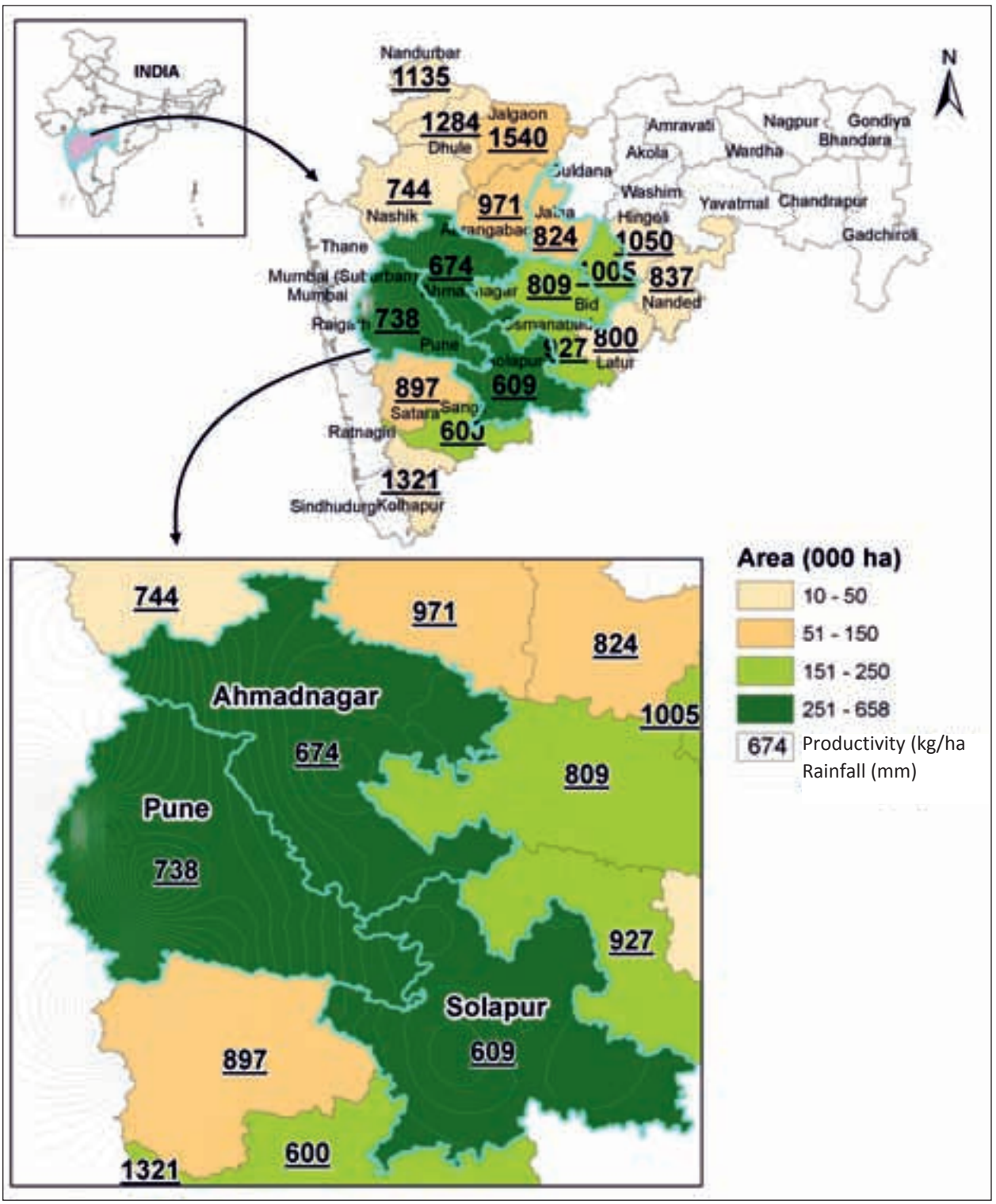


Figure 1. Map of the study area.

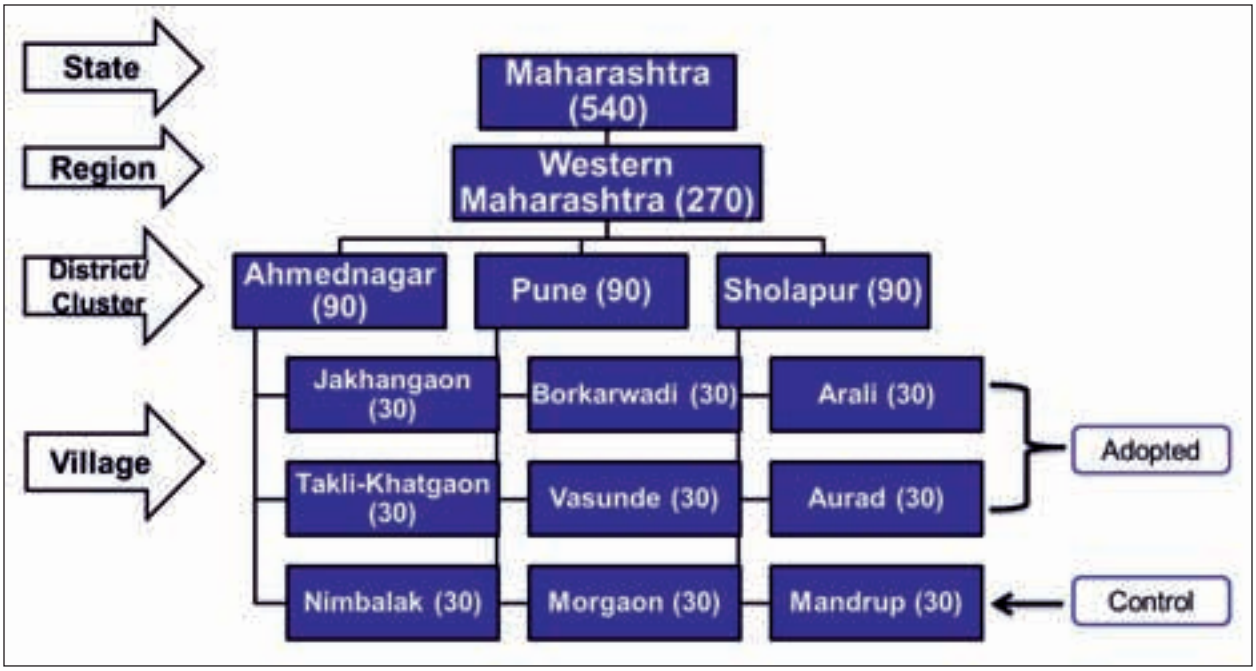


Figure 2. Sampling Framework of the HOPE project in Maharashtra. (Figures in parentheses are the numbers of sampled farmers)

The baseline survey was conducted in both the regions of Maharashtra (Western Maharashtra and Marathwada) with the total sample size of 540. From Western Maharashtra, 270 sample farmers were chosen from three districts—Solapur, Ahmednagar and Pune. Three villages were sub-sampled from each district, two villages as project beneficiary (60 samples) and one village as non-beneficiary (30 samples). Therefore the total number of farmers from the HOPE area (180) and non-HOPE area (90) were chosen considering stratified random sampling based on probability, and proportional to size (PPS) of the holding. Figures 1 and 2 show the sampling framework.

V. Results and Discussion

General characteristics of sample farmer

The average size of the holding is around 4.5 ha and indicates that the farmers possess medium sized holdings, in both HOPE and non-HOPE areas, where the size of land holdings range from 2.1 ha to 18.2 ha. Agriculture provides the major source of income in both the areas. More than 55 percent of the sample farmers are middle-aged (35-55 years). The proportion of literacy is more than 75 percent (Table1).

Table 1. Characteristics of sample households in Western Maharashtra in 2010.

Characteristics	Farmer beneficiary in HOPE project	Farmer in non-HOPE project area
Family size (No.)	6.6	7.3
Male (%)	2.4 (50%)	2.7 (52%)
Female (%)	2.4 (50%)	2.5 (48%)
Average Literacy (years of schooling)	7.3	6.3
Proportion of literate farmers in the sample	87	78
Social classification (% of farmers)		
SCs + STs	4.4	6.7
Backward classes	25.0	45.6
Others	70.6	47.8
Size Class of holdings		
Small and Marginal : <2 ha (%)	40	32
Average size(ha)	1.47	1.45
Medium & large: >2.01 ha (%)	60	68
Average size (ha)	4.82	4.69
Agriculture as Primary occupation (% of holdings)	98.93	100
Age cohort of farmers		
1. Youth (< 35 years)	8.3%	3.3%
Average age in years	27.4	24.67
2. Middle-aged (35-55 years)	55.0%	66.7%
Average age in years	44.42	45.35
3. Aged farmers (> 55 years)	36.7%	30.0%
Average age in years	64.97	63.41

Land holding pattern

The striking feature in the sample is the proportion of rainfed land, which is around 45% in the HOPE area and 67% in the non-HOPE area. A cause of concern is that 30 to 40% of the holdings belong to marginal and smallholder farmers in the HOPE and non-HOPE areas.

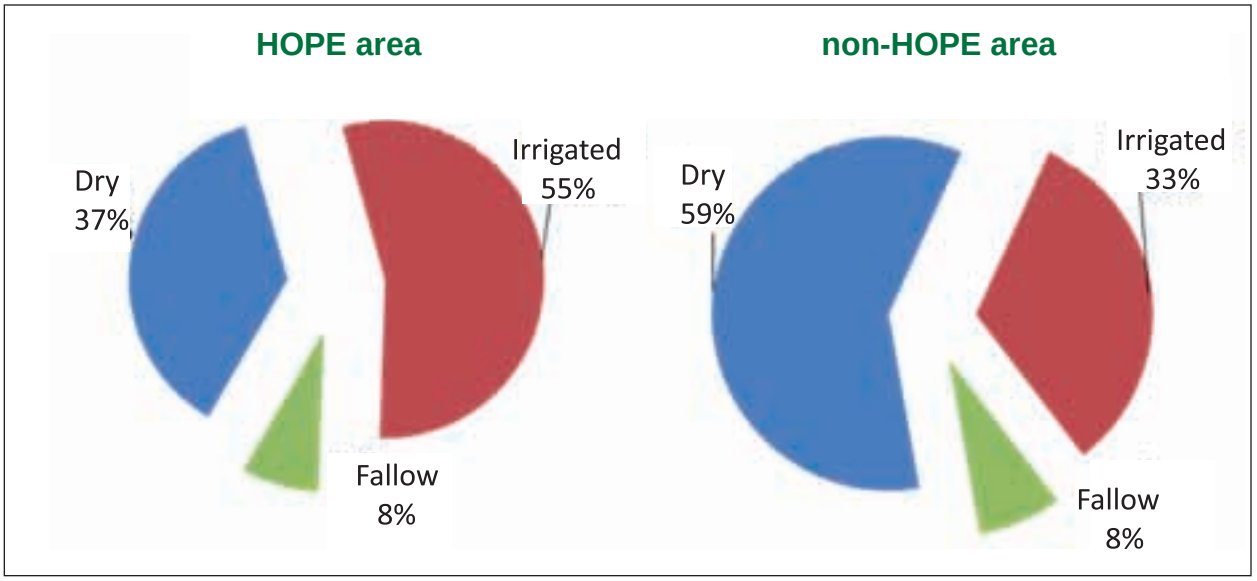


Figure 3. Land holding pattern among sample farmers in Western Mahatashtra.

This feature will be the motivating factor for the adoption of new technologies in both HOPE and non-HOPE areas (Table 2). In the HOPE area, the irrigated area forms 55% of the holding, while in the non-HOPE area, it forms 32%. In the HOPE area, there is wider scope for diversification of enterprises due to availability of irrigation.

Table 2. Pattern of Land holdings among sample farmers in Western Maharashtra.

	HOPE project area (N=180)		non-HOPE project area (N=90)	
	Area (ha)	Proportionate to total operating land	Area (ha)	Proportionate to total operating land
Owned land				
Dry	1.30	36	2.12	60
Irrigated	1.97	55	1.17	32
Fallow	0.28	8	0.27	8
Leased in land				
Dry	0.04	1	-	-
Operating land				
Dry	1.34	37	2.12	60
Irrigated	1.97	55	1.17	32
Fallow	0.28	8	0.27	8
Total	3.59	100	3.56	100

Pattern of livestock holding

The animal husbandry component is the dominant feature among farmers in both HOPE and non-HOPE areas, since 60 percent of the farmers owned cows, around 35 to 56 percent owned she buffaloes, and around 50 percent of the farmers owned small ruminants (sheep and goats). This also implies that the potential for family labor employment is higher due to the strong livestock component. This also demonstrates the integrated farming system among rainfed farmers, with access to the rich source of on-farm organic manure. The strong livestock component also implies that it checks out-migration, since livestock needs constant attention of the farm family. Thus, in Maharashtra, *prima facie* it is expected that wherever there is a strong livestock component, there will be relatively low migration compared with other situations (Table 3).

Table 3. Pattern of Livestock holding among sample farmers in Western Maharashtra.

	HOPE project area (N=180)			non-HOPE project area (N=90)		
Particulars	No. Per farm family	% of farmers owning	Value of livestock ₹	No. Per farm family	% of farmers owning	Value of livestock ₹
Draft animals	2.06	52	36396	1.97	63	37641
Local cows	1.21	28	12388	1.21	42	8275
Crossbred cows	1.17	42	18357	1.29	41	23545
She buffaloes	1.44	35	28917	1.48	56	24080
Sheep and goats	2.23	48	4361	3.2	44	6400
Others	1.47	60	4995	1.58	56	5555

Pattern of farm machinery and household items

Around 55% of the farmers' cropped area is irrigated by groundwater in the HOPE area, with around 75 percent of the HOPE farmers possessing irrigation pump sets (Table 5). In the non-HOPE area, 33% of the farmers' cropped area is irrigated by groundwater, and around 60 percent of the sample farmers possess irrigation pump sets.

Table 4. Pattern of farm machinery and equipment holding among sample farmers in Western Maharashtra.

	HOPE project area (N=180)			non-HOPE project area (N-90)		
Particulars	No. Per family	% of farmers owning	Current value (₹)	No. Per family	% of farmers owning	Current value (₹)
Agro-processing equipment	-	-	-	1	1	4000
Farm house	1	56	28245	1	62	34179
Harvester/thresher	1	1	200000	1	7	17714
Irrigation pump set	1	75	13137	1	59	10392
Bollock cart	1	37	12221	1	49	9500
Wooden Plough	1	40	1926	1	44	2098
TV	1	63	7940	1	74	8373
Residential house	1	100	162806	1	99	173258
Tractor	1	13	369587	1	10	418889
Bicycle	1	37	12221	1	49	9500
Two wheeler	1	70	44448	1	68	34966
Mobile Phone	2	78	4085	1	86	4122
Radio	1	33	1643	1	29	1410
Other farm assets	10	73	7552	8	76	7980

Though, the area irrigated per farm is relatively small, irrigation has paved the way for greater asset formation in both the areas – for example, 80 percent of the farmers own mobile phone, 70 percent own two wheelers, and between 37 to 49 percent own bullock carts. In drought prone SAT areas, the value of irrigation water is immense when compared with relatively well-endowed areas where irrigation water in high temperature, low rainfall dryland regions has immense value Thus, the value of water for irrigation widely differs across agro-climatic situations. Making one protective irrigation available for a rainfed millet crop will boost the productivity immensely (by 20-30%).Thus, water for irrigation will have different marginal productivities in different crops, in different seasons, in different scenarios, for different farmers depending upon their managerial ability (in semi-arid tropical, transitional, hilly, coastal regions).

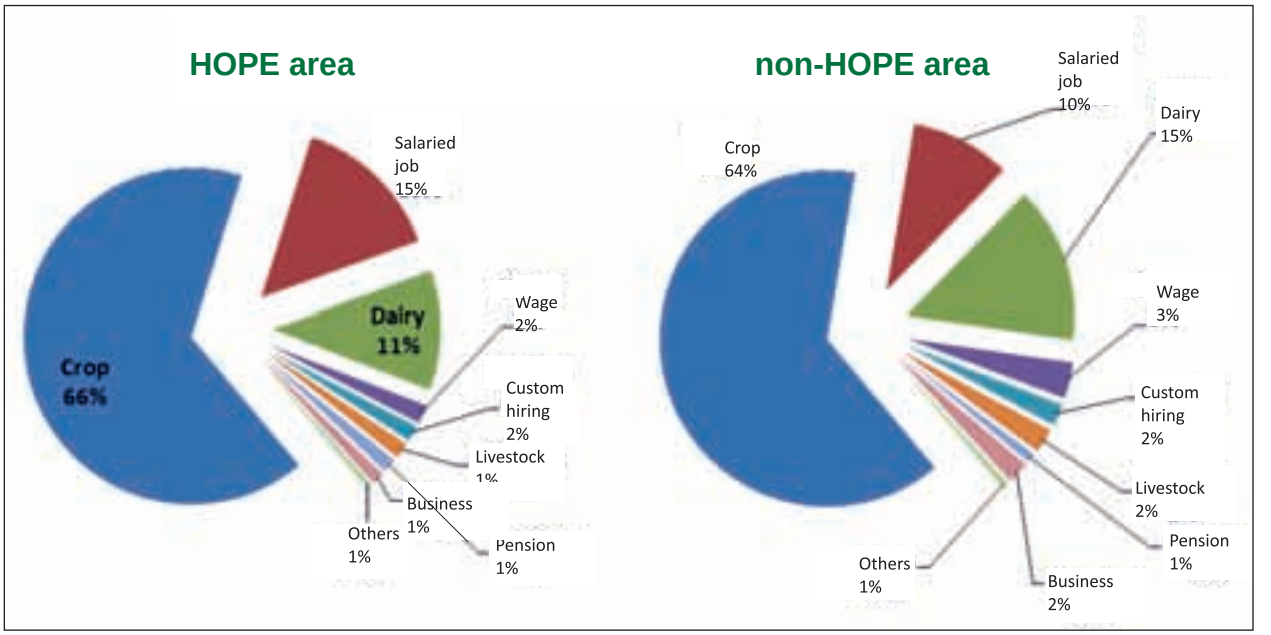


Figure 4. Different sources of income among sample farmers in Western Maharasthra.

Assessment of various sources of income

Apart from heavy dependence on crop incomes, access to irrigation has led a majority of the farmers (65% to 75% of the farmers) to buy dairy animals, providing around 17 to 19% of the total income in HOPE and non-HOPE areas (Table 6). The livestock component is present in around 30% of the farms in both the areas. The third common component of total income in both the areas is from wages and non-farm incomes, which support 27 percent of the farmers in HOPE areas and 41 percent of the farmers in the non-HOPE areas.

Since income is accrued from land and non-land activities, the common denominator can be the family size or the number of workers per family. However, in agriculture, since children are also involved in farm activities as a routine, the common denominator can be the family size.

Table 5. Sources of income for sample farmers in Western Maharashtra.

	HOPE project area (Average family size=6.6)		non-HOPE project area (Average family size=7.3)	
Particulars	Income (₹)	% of farmers responded	Income (₹)	% of farmers responded
Income from crops	166050	100.0	116396	100.00
Wage income and non-farm income	16365	27.2	15324	41.10
Income from dairy	43772	65.0	35500	76.70
Wage income from hiring bullock labour	13395	10.6	13048	23.30
Income from livestock	7460	31.7	3300	37.80
Income from water market for irrigation	2000	0.6	2000	1.10
Income from gathering NTFPs	5000	0.6	-	-
Income from custom hiring	50571	7.8	68400	5.60
Rent from land, building, machinery	10000	1.1	-	-
Caste occupations	31250	2.2	17500	2.20
Business	59667	5.0	58333	6.70
Regular salaried jobs (Govt.)	179467	16.7	137182	12.20
Regular salaried jobs (Private)	114182	6.1	42000	2.20
Remittances	20167	3.3	37500	2.20
Pension from employer	109000	3.3	150000	1.10
Total Income from all sources	251578	100.0	182504	100.00
Per capita income	38118		25000	

Accordingly the annual per capita income in HOPE area is ₹ 38,118, while in non-HOPE area it is ₹ 25,000. Thus, even with access to irrigation for 65 to 80% of the land, and including possession of dairy livestock and contribution of non-farm income, the per capita income in HOPE area, still falls short by 30% of India's per capita income, while in non-HOPE area, the per capita income falls short by 56% of India's per capita income.

Crop production, cropping pattern and yields

The diversity of crops cultivated by rainfed farmers in both HOPE and non-HOPE areas is a prima facie indicator of the diffusion of risk by farmers through crop patterns. Protective irrigation has an immense role in this regard. In HOPE areas, in *Kharif*, the crop with the largest proportion of area is onion (29% of cropped area) followed by pearl millet (23%). In non-HOPE areas, pearl millet occupied the largest proportion of area occupying 28%, followed by green gram (18%), onion (15%), and red gram (12%) (Table 7).

In the *rabi* season, the largest proportion of area is covered by sorghum (50%) followed by bengal gram (17%) and wheat (17%) in HOPE areas. In non-HOPE area, sorghum occupies 59% of total *rabi* area followed by bengal gram (18%) and wheat (15%).

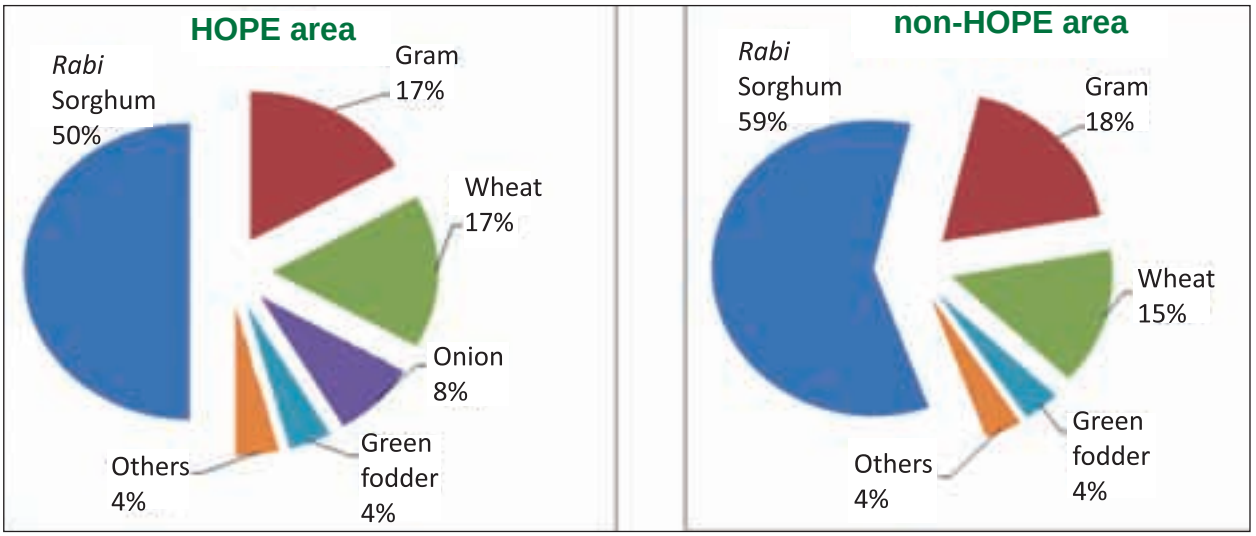


Figure 5. Choice of crop varieties during rabi season in Western Maharasthra.

Table 6. Choice of crop varieties among sample farmers in Western Maharashtra.

		HOPE project area				non-HOPE project area			
Sl. No.	Crops including fodder	Area (ha)	% of GCA	% of season area	Yield (ton/ha)	Area (ha)	% of GCA	% of season area	Yield (ton/ha)
A	***Kharif* Season**								
1	Onion	0.5	11.1	28.7	7.7	0.2	5.2	14.9	8.5
2	Pearl millet	0.4	8.9	23.0	1.4	0.5	9.7	28.0	1.5
3	Green gram	0.2	4.8	12.4	0.7	0.3	6.3	18.0	1.0
4	Red gram	0.2	4.1	10.7	1.2	0.2	4.3	12.4	0.9
5	Maize	0.1	2.2	5.6	3.5	0.1	2.8	8.1	4.2
6	Fodder (green)	0.1	1.7	4.5	23.1	0.1	2.4	6.8	25.7
7	Black gram	0.1	1.5	3.9	0.3	0.02	0.4	1.2	0.3
8	Sunflower	0.1	1.1	2.8	0.9	0.03	0.6	1.9	0.8
9	Others	0.2	3.3	8.4		0.1	3.0	8.7	
Total *Kharif* crops		**1.8**	**38.7**	**100.0**		**1.6**	**34.7**	**100.0**	

Continued

Table 6 contd. **Choice of crop varieties among sample farmers in Western Maharashtra.**

Sl. No.	Crops including fodder	HOPE project area				non-HOPE project area			
		Area (ha)	% of GCA	% of season area	Yield (ton/ha)	Area (ha)	% of GCA	% of season area	Yield (ton/ha)
B	***Rabi* Season**								
1	Sorghum	1.2	25.4	49.0	1.0	1.6	34.3	58.5	1.0
2	Gram	0.4	9.3	18.0	0.9	0.5	10.3	17.6	0.8
3	Wheat	0.4	7.8	15.1	1.7	0.4	9.5	16.2	1.6
6	Onion	0.2	4.3	8.4	13.8	0.01	0.9	1.5	15.3
8	Fodder green	0.1	2.4	4.6	16.7	0.1	1.3	2.2	21.7
	Others	0.1	2.6	5.0		0.1	2.4	4.0	
Total *rabi* crops		**2.4**	**52.0**	**100.0**		**2.7**	**58.6**	**100.0**	
C	**Pre-*kharif*/Summer season**								
1	Groundnut	0.037	0.7	37.5	1.5	0.03	0.2	33.3	0.8
2	Maize	0.012	0.2	12.5	3.8	0.03	0.2	33.3	5.2
3	Pearl millet		0.0	0.0	0	0.03	0.2	33.3	1.2
4	Fodder green	0.025	0.4	25.0	30.3		0.0	0.0	
5	Others	0.025	0.4	25.0		0.0	0.0	0.0	
Total summer season		**0.1**	**1.7**	**100.0**		**0.09**	**0.6**	**100.0**	
D	**Annual crops**								
1	Sugarcane	0.2	3.5	88.9	98.1	0.2	3.2	93.8	109.1
2	Tuberose	0.01	0.4	11.1	7.7	0.012	0.2	6.3	2.0
Total annual crops		**0.2**	**3.9**	**100.0**		**0.2**	**3.4**	**100.0**	
E	**Perennial crops**								
1	Grape	0.04	0.7	18	9.3	0.0	0.0	0.0	
2	Custard apple	0.02	0.4	12	1.3	0.01	0.2	8.3	5.0
3	Lucerne	0.02	0.4	12	70.4	0.02	0.6	25.0	67.0
4	Lemon	0.02	0.4	12	4.3	0.0	0.0	0.0	
5	Sweet orange	0.01	0.2	6		0.0	0.2	8.3	1.3
6	Others	0.1	1.5	41		0.1	1.5	58.3	
Total perennial crops		**0.2**	**3.7**	**100**		**0.06**	**2.6**	**100.0**	
Gross cropped area		**4.6**	**100.0**			**4.6**	**100.0**		

It must be noted that farmers are cultivating fodder crops in a considerable area to rear their owned livestock. Thus, sorghum, onion and green gram dominate the crop pattern and are not as soil exhausting as maize. Also, farmers in both the areas seem to be using groundwater in a relatively sustainable manner, resulting in wise use of water rather than in beneficial use since they are cultivating low water high value crops rather than high water high value crops.

During the baseline survey the adoption of improved varieties was low in HOPE as well as non-HOPE regions. The proportion of area under improved varieties of sorghum was around 29 % in HOPE area (yield of 1.26 t/ha), against 13 % in non-HOPE area (yield of 1.25 t/ha). Around 45 % of increase in yield is observed compared to local varieties in improved varieties (Table 7). The yield gap was estimated at 51% as compared to the potential yield (grain yield is 1.4-1.6 t/ha as per recommendation) for the improved varieties.

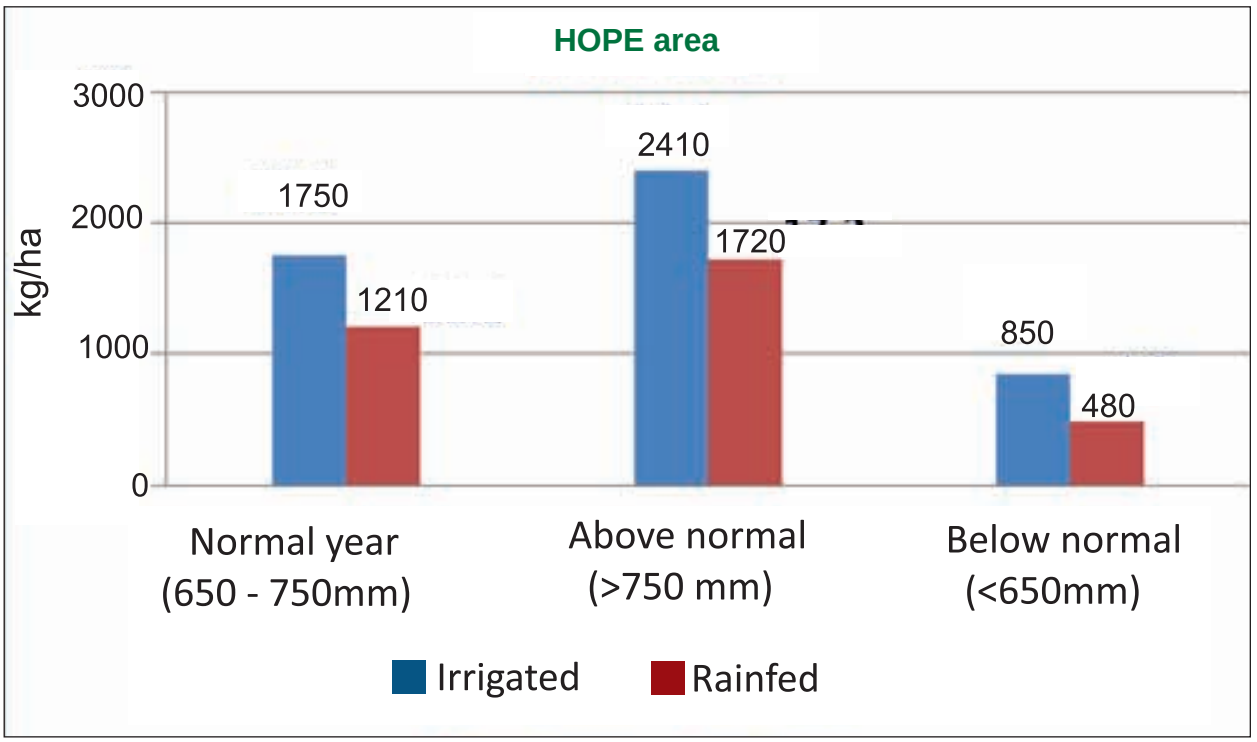
Table 7, Area adoption of improved and local *rabi* sorghum varieties in Western Maharashtra (ha).

	HOPE	Yield (t)	non-HOPE	Yield (t)
Improved variety	137 (29%)	1.26	47 (13%)	1.25
Local variety	332 (71%)	0.86	307 (87%)	0.85

Note: figure in parentheses are % of totals

In HOPE areas, productivity of irrigated sorghum in a normal year is higher by 11% over irrigated sorghum in the non-HOPE area. However in years that are above normal, the productivity of irrigated sorghum is higher in the non-HOPE area by 6%. In below normal years, the productivity of irrigated sorghum in HOPE areas is higher by 3% over non-HOPE areas. The productivity of irrigated *rabi* sorghum during subnormal years falls by more than 300% compared with normal years, but the cost of cultivation remains the same. The probable reason is the depletion of groundwater levels during subnormal or drought years. Irrespective of irrigation facility, the farthest depletion of groundwater offsets the yield level up to 300% less as realized during a normal year. Moreover, comparing HOPE and non-HOPE areas, there were no apparent differences in yield levels realized by *rabi* sorghum farmers in different rainfall situations (Table 8).

The access to irrigation matters a great deal during subnormal years. For instance during the normal year, the difference in the productivity between rainfed and irrigated in HOPE and non-HOPE areas ranges from 40 to 60%; in the above normal years from 40 to 45%, while in the sub-normal years, from 77 to 80%. The productivity in subnormal years is lower than that of normal years by around 150% in rainfed situations and by 100 to 137% in irrigated situations. During sub-normal years, the productivity of sorghum falls by 150 to 160% despite irrigation provision, since the farmers prefer to irrigate cash crops rather than food crops.



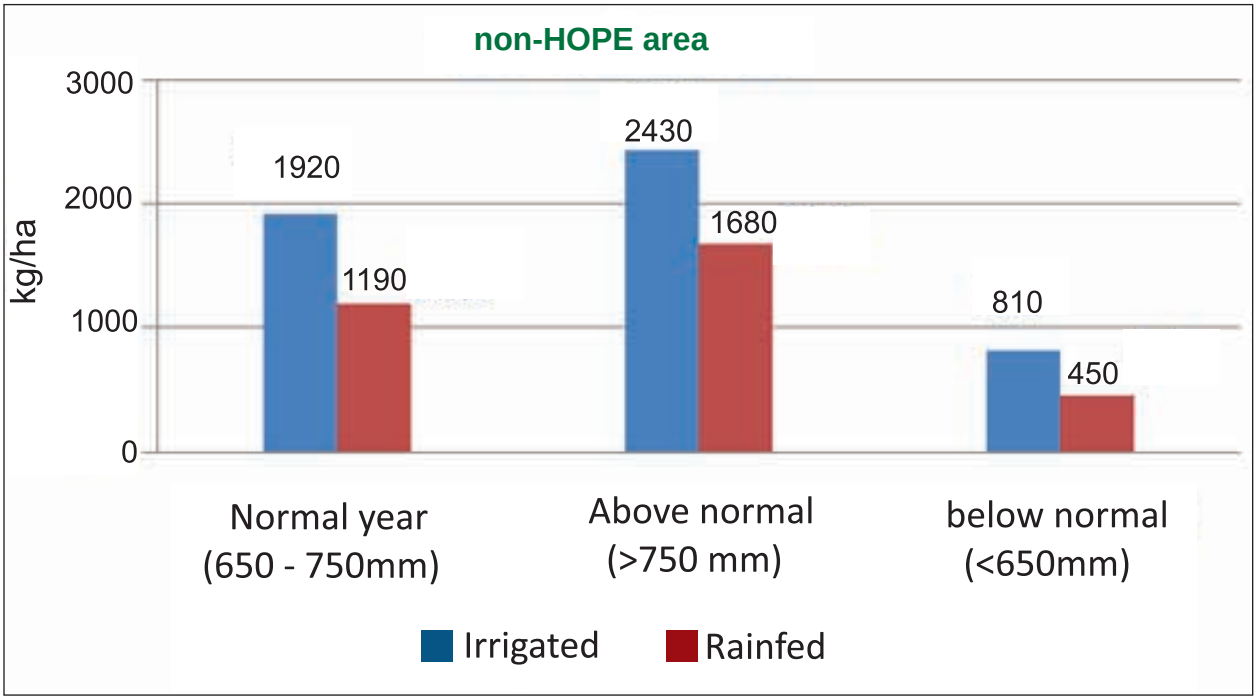


Figure 6. Crop productivity in Rabi Sorghum among sample farmers in Western Maharashtra.

Table 8. Crop productivity in *Rabi* Sorghum among sample farmers in Western Maharashtra (kg per ha).

	HOPE project area		non-HOPE project area	
Particulars	Irrigated	Rainfed	Irrigated	Rainfed
Normal Year (650 mm to 750 mm)	1750	1210	1920	1190
Above normal (> 750 mm)	2410	1720	2430	1680
Below normal (< 650 mm)	850	480	810	450

Economics of *rabi* (postrainy season) according to input use and relative profitability

Considering total cost of production, HOPE farmers spent ₹ 13,735/ha, which is considerably more than non-HOPE farmers (₹ 11,511/ha), and this is because of high input use with protective irrigation (Table 10). Considering the paid out cost of ₹ 12,959 per ha in HOPE areas and ₹ 10,835 in non-HOPE areas, land preparation (30% in HOPE and 39% in non-HOPE) dominates followed by harvesting (19% in HOPE and 16% in non-HOPE), input costs (16% in HOPE and 15% in non-Hope) and weeding (6% and 5% in HOPE and non-HOPE).

The productivity of sorghum and fodder in HOPE and non-HOPE areas is comparable (Table 10). On an average, the grain yield of *rabi* sorghum per ha was 1.06 t/ha and fodder yield of 2.28 t/ha in HOPE areas, whereas in non-HOPE areas, the grain yield was 1.05 t/ha and fodder yield was 2.52 t/ha.

The price realized in both areas is uniform. Gross returns are ₹ 17,723 per ha in the HOPE areas and ₹ 16,669 per ha in the non-HOPE areas. After deducting the paid out cost, on an average in HOPE and non-HOPE areas, farmers earn a net return of ₹ 3988 and ₹ 5158 per ha with a return to cost ratio of 1.29 and 1.45 respectively.

Table 9. Economics of *rabi* sorghum in Western Maharashtra (per ha).

	HOPE project area		non-Hope project area	
Particulars	Values in ₹	Proportion to TC (%)	Values in ₹	Proportion to TC (%)
Land preparation	4081	29.7	4471	38.8
FYM application	500	3.6	450	3.9
Seed treatment	39	0.3	57	0.5
Sowing	1032	7.5	812	7.1
Input cost	2123	15.5	1638	14.2
Weeding	907	6.6	609	5.3
Plant protection	13	0.1	57	0.5
Supplemental Irrigation	338	2.5	138	1.2
Watching	93	0.7	118	1.0
Harvesting	2670	19.4	1832	15.9
Threshing	880	6.4	488	4.2
Marketing	283	2.1	165	1.4
Variable Cost	12959	94.4	10835	94.1
Interest on variable cost @ 6% per annum	776	5.6	676	5.9
Total cost	13735	100	11511	100
Main product yield (t)	1.06		1.05	
Value of main product (₹/t)	10880		11000	
By-Product yield (t)	2.28		2.52	
Value of by product (₹/t)	2710		2010	
Total return	17723		16669	
Net return over total cost	3988		5158	
Return to cost ratio	1.29		1.45	

Relative profitability of crops in Western Maharashtra

The relative profitability of different crops in HOPE and non-HOPE areas indicates that in HOPE areas, the profitability of onion is higher by ₹ 43,000 over non-HOPE areas, as the productivity of onion is higher in the HOPE area due to use of improved seeds. The total returns from onion in the HOPE area are 83% higher than in the non-HOPE area, because the productivity of onion in the HOPE area is higher by 88% over the non-HOPE area. In the case of gram and wheat, productivity in the non-HOPE area is higher by 24% and 11% respectively. The productivity of sorghum between HOPE and non-HOPE areas is comparable (Table 10).

Table 10. Relative profitability of crops in Western Maharashtra. (Values in ₹ per ha)

	HOPE project area				non-HOPE project area			
Particulars	*Rabi* Sorghum	Onion	Gram	Wheat	*Rabi* Sorghum	Onion	Gram	Wheat
Total cost (₹)	13735	55126	16430	24483	11511	42592	18611	24027
Total Paid out cost (₹)	12959	30870	10674	17028	10835	27815	12979	16412
Main product yield (q)	10.6	195.8	9.6	20	10.6	104.4	11.9	22.5
Value of main product (₹/q)	1088	633	2033	1433	1100	650	1933	1367
By-Product yield (q)	22.8	0	5.1	9.4	25.2	0	3.2	8.2
Value of by product (₹/q)	271	0	60	38	201	0	80	25
Total return (₹)	17712	123941	19823	29017	16615	67860	23259	30963
Net return over total cost (₹)	3977	68835	3312	4537	5104	25248	4590	6935
Net return over paid out cost (₹)	4753	93090	9068	11992	5780	40026	10222	14551
Return to cost ratio	1.29	2.25	1.2	1.19	1.44	1.59	1.25	1.29

Utilization of output (Grain and Fodder)

In both HOPE and non-HOPE areas, the farmers prefer to sell in regulated markets over village and weekly markets. The majority of the farmers in HOPE and non-HOPE areas preferred to sell sorghum in a regulated market with a marketable grain surplus of 67% in HOPE and 73% in the non-HOPE area, where the distance to market was around 20 km (Table 11).

Table 11. Utilization and marketing of grain by sample farmers in Western Maharashtra.

	HOPE project area			non-HOPE project area		
Name of market	No sale (13%)	Regulated market (71%)	Village & weekly market (16%)	No sale (7%)	Regulated market (60%)	Village & weekly market (33%)
Grain produced (kg/Farm)	451	1411	979	417	1967	1172
Grain consumed (kg)	349	298	302	377	295	353
Grain retained for future use (kg)	20	14	22	3	23	28
Grain retained for other use (kg)	76	54	79	33	54	60
Marketable surplus	6	1045	576	3	1595	731
Grain sold (kg) calculated	0	945	597	0	1559	947
Price received (grain) (₹/kg)	0	11	11	0	10	11
Distance to market (km)		20	20		17	4
Marketing cost of grain (₹)		199	61		190	106

(Note: % refers to the proportion of farmers in each activity)

More than 60% of the fodder produced on farm is retained for livestock on the farm. Thus sorghum fodder offers excellent feed security for livestock on the farm supporting both draft animals and milk production (Table 12).

Table 12. Fodder production and utilization by sample farmers in Western Maharashtra.

	HOPE project area (N=180)			non-HOPE project area (N=90)		
Particulars	No sale (64%)	Village Market (28%)	Regulated Market (8%)	No sale (58%)	Village Market (30%)	Regulated Market (12%)
Average cropped area (ha)	1.02	1.02	1.34	1.39	1.39	3.07
Fodder produced (kg)	1980	2610	2600	2680	3680	14190
Fodder retained (kg)	1900	830	580	2710	1830	6140
Marketable surplus (kg)	80	1780	2020	-40	1850	8050
Marketed surplus (kg)	0.0	1750	1920	0.0	1850	8050
Marketing cost (₹/kg)	-	2600	6600	-	1600	1800
Price received (₹/kg)	0.0	29000	5000	0.0	29000	26000

Production characteristics of technologies and trait preferences of farmers

The opinions of farmers regarding the traits of varieties reflect the reasons for the farmers being influenced to adopt a variety or not. With regard to the *rabi* (Maldandi) sorghum, farmers in both HOPE and non-HOPE areas have indicated low productivity, pest and disease incidence, long duration as the major constraints in adoption. With regard to improved varieties, pest and disease incidence and long duration are the constraints opined in common by both HOPE and non-HOPE area farmers (Table 13).

Table 13. Technology and trait preferences of public and private HYVs/hybrids among sample farmers in Western region of Maharashtra state. (% farmers' response)

	HOPE project area		non-HOPE project area	
Characteristics	Local and M-35-1	Improved (Swati, P Vasudha)	Local and M-35-1	Improved (P Mauli & P Vasudha)
Low yield	94	56	92	25
High pest incidence	75	62	62	75
High disease incidence	71	77	67	75
Long duration	75	74	81	58
Small grain size	36	67	70	17
Poor colour	16	44	20	33
Poor taste	29	51	28	58
Low recovery/shelling %	28	28	37	33
Low market price	25	38	36	83
Doesn't fit into cropping system	23	95	19	17
Susceptible to storage pest	27	23	38	67
Poor fodder quality	35	74	24	100

Preferred Traits: Production: Farmers in HOPE area prefer high productivity, short duration, drought resistance, pest and disease resistance in the Maldandi sorghum, while in the non-HOPE area, farmers prefer the same traits except for high productivity. With regard to improved varieties, farmers in the HOPE and non-HOPE areas prefer almost the same traits as in HOPE area for the local variety (Table 14.1).

Preferred traits: Tables 14.1 to 14.4

Table 14.1. Preferred traits: Production

	HOPE project area		non-HOPE project area	
Characteristics	Local and M-35-1	Improved (Swati, P Vasudha)	Local and M-35-1	P Mauli and P Vasudha
High yield	100	23	43	100
Short duration	82	95	76	83
Drought resistance	96	74	87	92
Pest resistance	82	79	74	58
Disease resistance	79	77	83	58
Fits into cropping system	78	74	62	67
Improves soil fertility	9	44	43	67
Others (Good fodder quality)	0	41	93	0

Consumption: In both HOPE and non-HOPE areas, farmers as consumers prefer to have tasty sorghum with high keeping quality and less cooking time in both local and improved varieties (Table 14.2).

Table 14.2. Preferred traits: Consumption

	HOPE project area		non-HOPE project area	
Characteristics	Local and M-35-1	Improved (Swati, P Vasudha)	Local and M-35-1	P mauli and P Vasudha
Better taste	100	95	93	83
Less cooking time	64	54	62	67
High keeping quality	97	85	94	92
Others	0	0	5	8

Fodder: In both HOPE and non-HOPE areas, the preference for fodder is for higher productivity, storability and palatability of fodder for livestock. The response indicates that farmers who prefer Maldandi and the local variety of sorghum do so due to better palatability, higher quantity of leaves and fodder storability (Table 14.3).

Table 14.3. Preferred traits: Fodder

Characteristics	HOPE project area		non-HOPE project area	
	Local and M-35-1	Improved (Swati, P Vasudha)	Local and M-35-1	P mauli and P Vasudha
More fodder quantity with leaves	100	72	97	67
Palatability (quality/taste)	92	54	91	67
Storability of fodder (free from pest and diseases)	92	85	92	83

Marketing: With regard to grain for marketing, in both HOPE and non-HOPE areas, the economic factors, namely, demand, higher price and price stability are the traits preferred by farmers in addition to the bigger size of grain. However, farmers who prefer Maldandi and the local variety of sorghum are sure of the established demand, higher price and price stability in relation to improved variety, as reflected in the wide market. In the case of fodder, farmers in the HOPE and non-HOPE areas list the same qualities as they listed for grain. Thus, grain and fodder quality are better in Maldandi and local sorghum compared to the improved variety. If improved varieties are to be more acceptable, then they need to be bred for the grain and fodder qualities similar to Maldandi and the local sorghum varieties (Table 14.4).

Table 14.4. Marketing: (Grain & fodder)

Characteristics	HOPE project area		non-HOPE project area	
	Local and M-35-1	Improved (Swati, P Vasudha)	Local and M-35-1	P Mauli and P Vasudha
Grain				
High demand	98	67	92	75
Fetches higher price	87	74	83	67
Low price fluctuations	84	38	92	92
Bigger grain size	51	77	73	83
Fodder				
High demand	100	67	93	75
Fetches higher price	85	69	88	83
Low price fluctuations	84	51	86	92
Low thickness of stem	58	28	79	67

Consumption level

In the HOPE and non-HOPE areas, the consumption of sorghum is 40% while that of rice and wheat is around 47% (Table 15). However, the direct consumption of millets forms 60% of the production, while the remaining 40% of the grains is for milch animals. Thus, while considering demand forecast in sorghum and other millets, it is crucial to consider the feed demands from the livestock sector, which is sustainable as proved by the wide market for livestock feed. It is also important to note that while food demand may fluctuate, the fodder demand will have relatively lesser fluctuation since there are no alternatives to fodder in the semi-arid tropics and in the drought years.

Table 15. Per capita cereal consumption per annum in Western Maharashtra.

	HOPE project area Family size : 6.6			non-HOPE project area Family size: 7.3		
Cereal/ Millet	Avg Quantity consumed as food and feed (kg)	Market price (₹/kg)	% consumed	Avg Quantity consumed as food and feed (kgs)	Market price (₹/kg)	% consumed
Rice	14	28	10	8.7	27	7
Wheat	50.1	13	37	51	14	43
Pearl millet	16.23	12	12	14.32	12	12
Sorghum	54.11	11	40	44.18	12	37
Others (pigeonpea, green gram)	0.71	60	1	0.6	56	1
Total	135.15		100	118.8		100

It is agreed by 86 percent of the farmers in the HOPE area that *rabi* sorghum is preferred to wheat. These farmers have either sustained the consumption of sorghum, or increased the proportion of sorghum in their diet. This factor will increase the demand for *rabi* sorghum. However among the factors that decrease consumption of millets, the consumption of wheat, is listed as a major factor as it is preferred by children. Farmers in non-HOPE areas have no definite indication regarding the perspective of consumption of *rabi* sorghum. The replacement of sorghum by wheat is recognized by 60 percent of the farmers in the HOPE area and by 45 percent of the farmers in non-HOPE areas. Even though sorghum is a climate change ready crop, the crop will have to struggle to retain its position as food and feed, due to policies in greater support of wheat and rice, and the markets favouring superior cereals at the cost of inferior cereals (Table 16). Though sorghum provides better fodder compared with wheat, as food and fodder are joint products, the reduced demand for sorghum as food, will automatically reduce its supply of fodder.

Table 16. Opinion survey regarding consumption of r*abi* sorghum in retrospect and prospect in Western Maharashtra (%).

Particulars	HOPE project area	non-HOPE project area
Percentage increase in consumption	32	21
No other choice	-	5
Cheap as compared to other cereals	15	11
Health consciousness	3	26
Percentage of aged persons who prefer sorghum	28	53
Suitable for the region	-	26
Due to more palatable than wheat	86	32
Due to easy availability on farm	29	-
Due to family size increase	5	-
***Crop replaced by rabi* sorghum**		
Wheat	25	30
Pearl millet	15	25
Percentage decrease in consumption	42	50
Due to poor grain quality	7	11
Due to disease and pest incidence	-	2
Due to canal irrigation area under sorghum declining	-	7
Sorghum is not profitable due to high wage rate, low productivity and climate change	5	9
Less palatable than wheat	3	16
Not preferred	3	2
Pearl millet more preferred than sorghum	28	20
Wheat available at low price through PDS	20	24
Wheat preferred more by children and adults	75	58
Sorghum preferred more only in summer months	5	-
Crop by which sorghum is replaced		
Wheat	60	45
Pearl millet	20	15
Sorghum is sustained	26	29

Participation of labor force in cultivation process according to gender

Sample farmers in the HOPE and non-HOPE areas indicated that women participate in agriculture in different farm operations. Women's participation is recognized in land preparation, seed bed preparation, application of FYM, sowing, fertilizer application, irrigation, harvesting, threshing and marketing. Thus, with the exception of a few operations such as application of PPCs, women's presence and involvement is apparent in all other operations. About 95 percent of the farmers reiterated women's role in harvesting and 75 percent of the farmers emphasized their role in weeding. Thus women farmers dominated in those activities that involved considerable bending (Table 17).

Table 17. Gender involvement in *rabi* sorghum cultivation in Western Maharashtra (Per farm).

	HOPE project area			non-HOPE project area		
	Man days	Women Days	% involvement of men, women	Man days	Women Days	% involvement of men, women
Land preparation	3	5.7	79, 32	3.4	4.1	74, 40
Seedbed preparation	3	4.7	76, 34	2.4	2.8	74, 29
Application of FYM	3.9	3.9	44, 44	2.9	2.4	67, 64
Sowing	2.3	1.9	64, 18	2.2	1.7	77, 39
Seed treatment	0.5	0.4	30, 16	0.7	0.6	50, 4
Fertilizer application	1.1	0.9	63, 32	1.4	1.9	72, 23
Thinning	1.1	2	4, 3	1.5	1.5	2, 4
Intercultural operation	3.1	2.5	37, 7	3.7	3.2	50, 13
Weeding	5.1	14	24, 74	3	14.1	19, 72
PPC application	1.4	-	4, 0	1	1	4, 2
Irrigation	4.1	3.6	52, 21	4.5	4	28, 3
Watch and ward	2	2.1	26, 17	4.3	7.6	26, 11
Harvesting	10.8	12.3	99, 96	13.5	13.5	100, 94
Threshing	1.9	2.8	94, 84	1.8	2	90, 70
Marketing	1.4	1.7	64, 26	1.4	1.2	61, 28

Conclusions and Policy Implications

In Western Maharashtra, *rabi* sorghum is cultivated as a dual purpose crop for food and fodder supporting poor smallholders and livestock in the region. *Rabi* sorghum fodder is valued more than the grain by majority of the farmers, reflecting the relative importance of fodder over grain. A majority of the rainfed farmers are practicing integrated farming systems, integrating crops with livestock. Most of the fodder produced is retained for consumption by livestock. In the *rabi* season, the largest proportion of area is under sorghum (25%) followed by bengal gram (9%) and wheat (8%). On an average, the productivity of improved varieties is 45% higher compared with the local cultivars. The proportion of area under improved varieties of sorghum is around 29% in the HOPE area and and 13% in the non-HOPE areas. The 51% estimated yield gap for improved *rabi* sorghum varieties shows further immense scope for improvement in the productivity level by introduction of a recommended package of practices along with improved varieties. The relative profitability of different enterprises indicates that sorghum is less profitable compared to other competing crops like onion and wheat. This clearly shows that in spite of the rich nutritional value of grain and fodder, it fetches a low return, implying lack of economic incentives to grow on a large scale. Thus, policy support to stimulate demand for *rabi* sorghum is crucial.

The baseline results indicated that the bulk of the *rabi* sorghum area is occupied by local cultivars and M-35-1. Further, biotic and abiotic factors constrained yield improvement in *rabi* sorghum. Thus, the research priority in sorghum is to address the enhancement of grain and fodder productivity by addressing the key constraints. Any significant yield improvement requires the use of improved varieties, better/best management practices and market support for economic incentive and value addition.

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