



# Baseline Scenario of **Rainy Season** **Pearl Millet Economy in Gujarat**

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and MG Chandrakanth



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## Abstract

Gujarat state is one of the most important pearl millet producing states where it is consumed as staple food supporting poor smallholders and livestock in the harsh agro-climatic region. Currently, the productivity levels are relatively low due to limited adoption of dryland technologies by the poor. The Harnessing Opportunities for Productivity Enhancement (HOPE) project aimed at increasing the productivity of pearl millet by 35-40% over the base level. In this regard, the baseline survey was carried out 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 the non-intervention area (non-HOPE), where improved technologies have not been used. The objective of the baseline survey was to appraise the existing situation of the targeted clusters Radhanpur and Tharad with respect to adoption of technologies, productivity, income, yield gaps and other socioeconomic issues.

Integrated farming system of pearl millet with livestock (buffaloes) is predominant in Gujarat. Pearl millet is the major crop in the rainy season followed by mustard and cumin in the rabi season. The average productivity of pearl millet ranges from 0.95-1.15 tons/ha as against the potential yield of 2.4 tons/ha leaving a yield gap of 130-150% showing further scope for improvement in the productivity level. The adoption rate of hybrids is quite impressive, especially the proprietary hybrids in all the clusters surveyed. However, the public hybrids adoption rate is modest, covering 15% of *kharif* (rainy season) pearl millet area. In non-HOPE areas, the adoption of public hybrids is only 7%. The most popular hybrids of pearl millet being cultivated include GHB 558 and GHB 719. On an average, the farmers' net benefit was of Rs 4168 per ha in HOPE areas and Rs 5578 per ha in non-HOPE areas, after accounting for the paid out costs. Farmers' most preferred traits in public hybrids of pearl millet *inter alia* include more palatable grain and fodder quality and disease-pest-moisture stress. Key critical constraints expressed by the farmers are shortage of labor, especially during harvesting, high wage rate, moisture stress and lack of appropriate machineries. Targeting on the key recommended technologies and management practices is vital as there is a significant yield gap between the baseline yield and the potential yield from the improved cultivars.

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## Summary

The overall objective of the Harnessing Opportunity for Productivity Enhancement of Sorghum and Millets in Sub-Saharan Africa and South Asia (HOPE) project is to enhance the productivity of *rabi* sorghum and pearl millet by 35-40% over the base level over a 4-year period in rainfed drylands of South Asia, and to improve household food security and incomes in the region. In this regard, the project has been implemented in three states of western parts of India, Gujarat, Rajasthan and Haryana, by introducing latest technologies and management practices in the targeted clusters. 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 the non-intervention area (non-HOPE), where improved technologies have not been used. This enables in collecting baseline data from participating and non-participating farmers, which helps to identify comparable counterfactual in impact evaluation.

The baseline survey was conducted with an objective of appraising 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, labor participation and earnings, marketing channels and costs and gender participation. Sampling technique is used to conduct the baseline survey in Radhanpur and Tharad clusters. The key findings of the survey are given below:

### **Marginal and smallholdings with poor literacy**

The HOPE and non-HOPE areas have predominantly marginal and smallholder farmers (with 1.2–1.3 ha area) with modest irrigation (on 23–38% of cultivated land), constituting 80% of the total sample size. Their literacy level is low with 2-3 years of schooling, with agriculture as primary occupation (98%) of sample farmers, falling in the middle age group (of 35–55 years). In HOPE (83%) and non-HOPE (60%) areas the other castes are in appreciable proportion.

### **Pearl millet-buffalo combination (*Bajra*-buffalo combination)**

A majority of the sample farmers (> 85%) have 2 she-buffaloes, and a few of them (5-10%) have draft animals. Thus, integrated farming system involving a combination of *bajra* and buffalo even on small and marginal farm holdings under the harshest climatic conditions is evident. However, their incomes are not remunerative and far from satisfactory. Crops contribute 50% and dairy 25% of their total farm income, enabling farmers to realize around ₹ 19,750 of the per capita income from all sources in HOPE and ₹ 15,960 of the income per capita from all sources in non-HOPE area. This shows that the HOPE area is almost similar to the non-HOPE area with regard to per capita income, when considering the baseline survey data.

The *Bajra*-Buffalo Combination (BBC) not only provides employment and income to the farmer, but also offers nutrition in the form of milk to the farm, which is employing and empowering farm women with regular income from dairy, in addition to providing organic manure for crops. Due to the lack of draft power and economic scarcity of labor, farmers are using mechanized

power. Most farmers have good communication infrastructure (mobile, TV) and more than half of them commute on two-wheelers. Even with access to irrigation, economic status has not substantially improved, due to lack of technology transfer, awareness and extension efforts.

Pearl millet is the major crop in the rainy season followed by mustard and cumin in the *rabi* season. The per capita consumption of food grains is 365 grams per day, which is much below that of an average Indian (487 grams per day). Farmers' have little exposure and trust in markets, as they retain more than 60% of the food and feed for their domestic use. Though a majority of the farmers preferred to sell in the regulated market, their realized prices were not different from what they got by selling in village markets.

### **Labor – Major item of cost of production**

In the study sites, pearl millet was cultivated on 50% of gross cropped area with a modest return to cost ratio of 1.3 to 1.4, where it is a sustaining staple crop, due to the arid climate and integrated farming system and also supports milch buffaloes. Mustard and cumin support farmers in providing cash income in *rabi*. Proprietary varieties rule in pearl millet, which are still unable to excel under rainfall duress as the productivity is 0.71-0.73 tons per ha in normal rainfall conditions, 1.05-1.1 tons in above normal rainfall conditions and 0.3 tons in below normal rainfall conditions, while its potential yield is around 2.4 tons per ha. In the cultivation of pearl millet, labor accounts for about 70% of variable cost. According to sample farmers, in the proprietary varieties of pearl millet, what needs to be improved are the duration, keeping quality, palatability and shelling. Yield level of pearl millet under high and medium management practices don't vary substantially. The HOPE farmers in the high management group (HMG) realized grain yield of 1.05 tons/ha where the same is 1.0 ton/ha for the low management group (LMG) farms. HMG farms in non-HOPE area realized 0.96 tons/ha of grain yield as against 0.92 tons/ha in LMG. Thus, it implies that farmers invariably apply fertilizers in amounts more or less equal to what is recommended.

The adoption rate of hybrids was quite impressive especially the proprietary hybrids in all clusters. However, the adoption rate of public hybrids is modest, covering 15% of *kharif* (rainy season) pearl millet area. In non-HOPE, the adoption of public hybrids is only 7%. The most popular hybrids of pearl millet being cultivated include GHB 558 and GHB 719. The yield gap of improved hybrids of pearl millet was estimated as 130%, as compared to the potential yield, which shows further scope for improvement in productivity level by the introduction of recommended package of practices along with improved varieties.

### **Relative profitability, consumption and marketing, and preferred traits**

In both HOPE and non-HOPE areas, castor is the crucial competing commercial crop, which fetches around three times higher return (BCR 2.74 and 2.78, respectively) as compared with pearl millet. However, castor needs irrigation, a limiting factor for its expansion.

About 33% of the HOPE farmers consumed 100% of their pearl millet production of 910 kg per farm, while 57% of the farmers who produced 1590 kg per farm sold 610 kg in the regulated market. From among the preferred traits of crop varieties, opined by the farmers, 98% preferred



high productivity, 50% desired that the variety should fit into the cropping system, 36% of the farmers indicated that the variety should be of short duration with regard to consumption characteristics; the most important quality parameter was 'keeping quality' as opined by more than 60% of the sample farmers.

### **Gender Involvement**

In pearl millet cultivation, there was gender involvement in all activities except that of plant protection and irrigation. Their involvement includes activities where drudgery is involved such as land preparation. Involvement of women varied from 38% in land preparation to 48% in marketing activity in both bran and brain works. Thus, pearl millet in Gujarat is a model for the country reflecting Integrated farming systems leading to nutrition security on the farm, employing and empowering female labor, and contributing to synergies in farm operations enriching organic manure.

### **Critical constraints**

Some of the key critical constraints expressed by the farmers are shortage of labor, especially during harvesting. High wage rate, moisture stress and lack of appropriate machineries are the other constraints.



## I. Significance of the study

The majority of the rural poor are smallholder and marginal farmers owning less than 2 hectares and they live in dryland areas and are food insecure. To cope with the harsh agro-climatic conditions, they tend to grow dryland cereals such as sorghum and millet, which are the hardest crops and less risky. Because of its tolerance to difficult growing conditions such as drought, low soil fertility and high temperature, Pearl millet can be grown in areas where other cereal crops, such as maize or wheat, would not survive. Pearl millet production is concentrated in the developing countries (Asia, Africa), which account for over 95% of the production and acreage where annual production exceeds 10 million tons, of which India contributes about 50%.

Most of the smallholder and marginal farmers deter from investing in improved technologies due to risk and uncertainty associated with biotic and abiotic stress. Hence, in order to increase the productivity of dryland sorghum and increase household incomes and food security, the HOPE project has been implemented in South Asia (SA). To achieve this vision, six specific objectives were chosen that attend to market chain and delivery constraints/opportunities, and to the genetic and production systems specific to these crops and better targeting. One of the objectives of the HOPE project is better targeting. In this endeavor, a baseline study was undertaken in the predominantly pearl millet growing state of Gujarat. 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.

## II. Importance of pearl millet in India

Pearl millet grain is the staple diet for the poor and its fodder is a valuable livestock feed in SAT areas. In the recent years, pearl millet production is gradually getting influenced by market forces due to alternative uses such as feed, alcohol, processed food. In India, pearl millet is cultivated in about 9.4 million ha producing 10.1 million tons with a productivity of 1070 kg ha<sup>-1</sup> (2011-12). In terms of area, Rajasthan, Uttar Pradesh, Haryana and Gujarat are the major pearl millet producing states with respective shares of 59, 9, 7 and 8% (2008-09). In pearl millet production, shares of Rajasthan, Uttar Pradesh, Haryana and Gujarat are 48, 15, 12 and 11%, respectively. The area has been declining in the traditional growing states of Gujarat, Rajasthan and Haryana due to focus of green revolution on high yielding and high input utilization crops such as wheat and rice to meet the demands of food security, which has resulted in policies favoring their cultivation. Further, these crops received research, extension and market support. Thus, on the supply side, there was a shift in area under cultivation from coarse cereals to rice and wheat even in rainfed areas. On the demand side, distribution of rice and wheat through the public distribution system (PDS) at subsidized prices contributed to the decline in consumption of sorghum and millets.

On the consumption side in urban areas, increase in incomes, urbanization, change in consumer taste and preferences, engagement of both husband and wife in jobs, advent of fast-food chains and ready-to-eat food products, penetration of diversified value added products of rice and wheat, ease of preparation and lesser cooking time for rice and wheat-based products resulted in their increased consumption. Contrastingly, longer cooking time, difficulty in preparation, and lack of value addition and value added products contributed to decline in consumption of sorghum and millets.

### III. Pearl millet in Gujarat

Gujarat ranks third in pearl millet area in India. Realizing this importance, the pearl millet research station was established at Jamnagar and the research efforts have impacted on increasing the productivity from 310 kg ha<sup>-1</sup> (1961) to 1231 kg ha<sup>-1</sup> (2009-10) due to the development of improved cultivars and crop production technology.

The average area, production and yield of *kharif* pearl millet in Gujarat state since 2004-05 to 2009-10 was 585,200 ha, 606,400 tons and 1036 kg ha<sup>-1</sup>, respectively. In Gujarat, Banaskantha and Patan are the important districts occupying a major share of pearl millet acreage in the most harsh and vulnerable climatic conditions. Banaskantha district has a 143,900 ha area with 78,100 tons production and 543 kg ha<sup>-1</sup> yield and Patan district has a 70,000 ha area with 38,400 tons production and 550 kg ha<sup>-1</sup> yield. Among all the districts of Gujarat, Banaskantha and Patan had more growing area under *kharif* pearl millet.

### IV. Methodology

The baseline survey depicts the ‘what it is’ situation, enabling decision makers to obtain information about resource and infrastructure endowments. This facilitates appraising the existing situation of the project area, which is crucial before the commencement of the action research HOPE project. The main objective of conducting baseline surveys in targeted locations and establishing benchmark sites with proper counterfactuals is to monitor adoption and impact pathways. Specifically, baseline surveys enable to capture the status of resource endowments, cropping patterns, input-output levels and the profitability of crop production, technology and trait preferences of farmers, income and consumption levels, labor participation, cost of production and marketing channels.

#### IV.1. Sampling

In Gujarat, two districts Patan and Banaskantha were chosen for the baseline survey, where project interventions are being implemented. In Banaskantha district in the northwestern side, at 24°23'33"N 71°37'29"E coordinates, Tharad cluster, with six villages (Jandi, Ghesada, Karanpura, Kothi, Gagana, Mungrol, Dudhava and Lodhnor) and in Patan district, Radhanpur cluster with ten villages (Delanu, Sukarpura, Satuna, Motipinoli, Manpura, Sadpura, Kolivada, Bandharoli, Lakhapura and Huminpura) were selected for the HOPE project.

The baseline survey was conducted in Banaskantha and Patan districts with the total sample size of 180 farmers. From each district, three villages, of which two belong to HOPE project area and the third represents the non-project area, are sampled using probability proportional to farm size (PPS) method. In each village, 30 farmers were chosen, which leads to a total of 90 sample farmers in each cluster. The sampling frame (Figure 1, Figure 2) provides the village-wise number of farmers. In all, 120 farmers are sampled from HOPE area and 60 farmers from non-project area (as control).

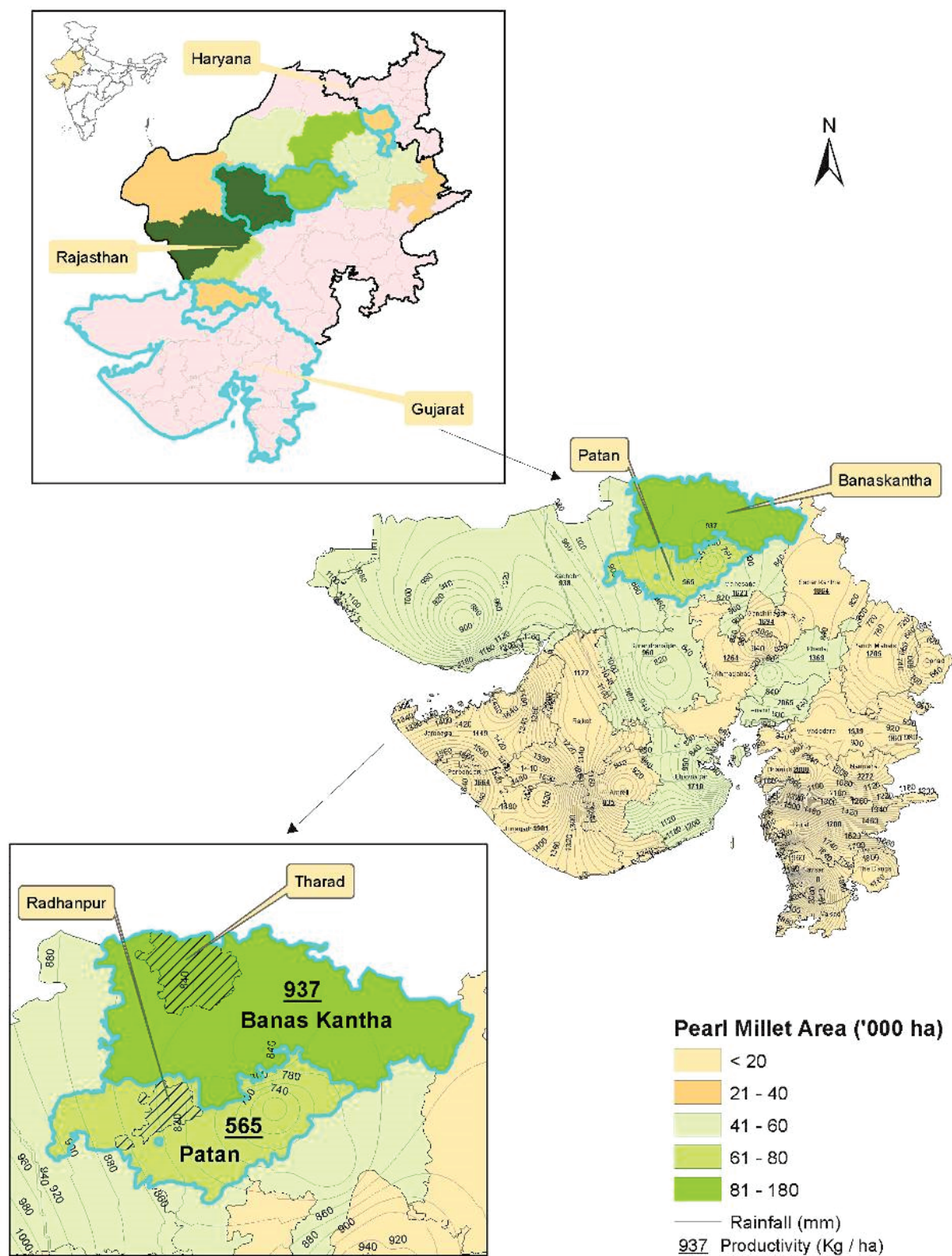


Figure 1. Map of the study area.

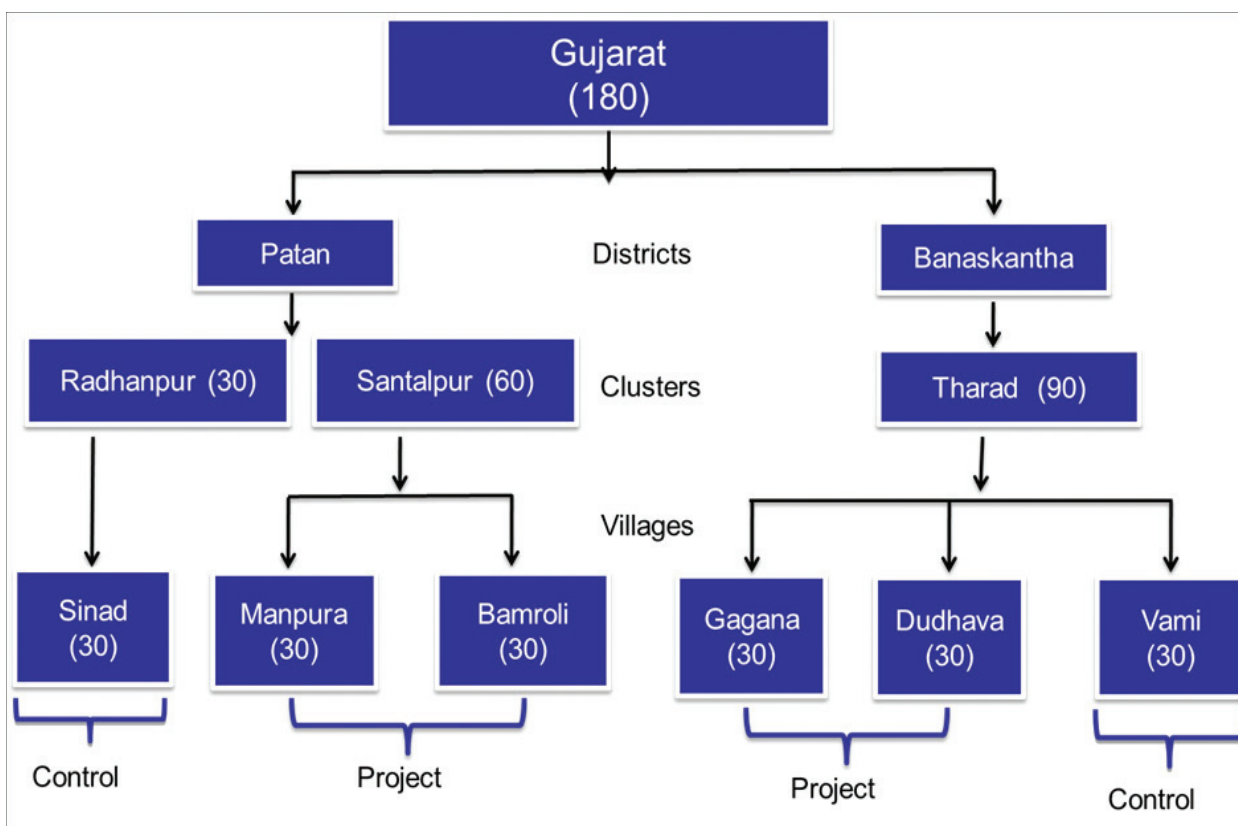


Figure 2. Sampling framework.

## V. Results and discussion

### V.1. General characteristics of sample farmers

The family size of sample farmers was around six members in both HOPE and non-project areas, but with poor literacy, as the number of years of schooling is a modest 1 to 2 years. In both HOPE and non-HOPE areas, other communities (largely OBCs) dominate, while STs form an appreciable proportion of the population in non-HOPE areas. Marginal and smallholder farmers constitute more than 80% of the holdings with their size of the holding of 1 to 1.3 ha with agriculture being the primary source of occupation of more than 98% of the farmers in both HOPE and non-HOPE areas. More than 65% of the farmers belong to the middle-aged group of 35 to 55 years, a facilitative human capital for diffusion and adoption of farm innovations. The medium and large holdings have the holding size of around 3 to 4 ha per family (Table 1).

**Table 1. Characteristics of sample households in Gujarat state in 2010.**

Characteristics	HOPE project area	non-HOPE project area
Mean family size	6	6
Mean literacy (years of schooling)	2.7	1.6
Social classification (% of farmers)		
1. SCs + STs	4.17	35.00
2. Backward classes	12.50	5.00
3. Other castes	83.33	60.00
Size class of holdings		
Small and marginal : <2 ha (%)	85.8	80
Average size (ha)	1.3	1
Medium & large: >2.01 ha (%)	14.2	20
Average size (ha)	3.1	3
Agriculture as primary occupation (% of holdings)	98.33	100.00
Age cohort of farmers		
1. Youth (< 35 years) %	13	18
Average age in years	27.5	29.09
2. Middle-aged (35-55 years) %	72	65
Average age in years	42.83	45.97
3. Aged farmers (> 55 years) %	15	17
Average age in years	63.89	61.7

## V.2. Land holding pattern

The average size of the holding ranges from 1.4 to 1.6 ha in both HOPE and non-HOPE areas. In HOPE area, around 23% of the land of the sample farmers is irrigated, while in non-HOPE area, 38% of the land of the sample farmers is irrigated. Compared to other predominant farming regions of India, the leasing in and out of land is also modest as is the market value of land (Table 2).

**Table 2. Pattern of land holding among sample farmers in Gujarat State.**

Land pattern	HOPE project area		non-HOPE project area	
	Area (ha)	Proportionate to total operating land	Area (ha)	Proportionate to total operating land
Own land				
Dry	1.20	77	0.87	61
Irrigated	0.36	23	0.54	38
Leased out land			0.01	1
Operating land				
Dry	2.97	77	0.87	62
Irrigated	0.88	23	0.54	38
Total	1.56	100	1.41	100



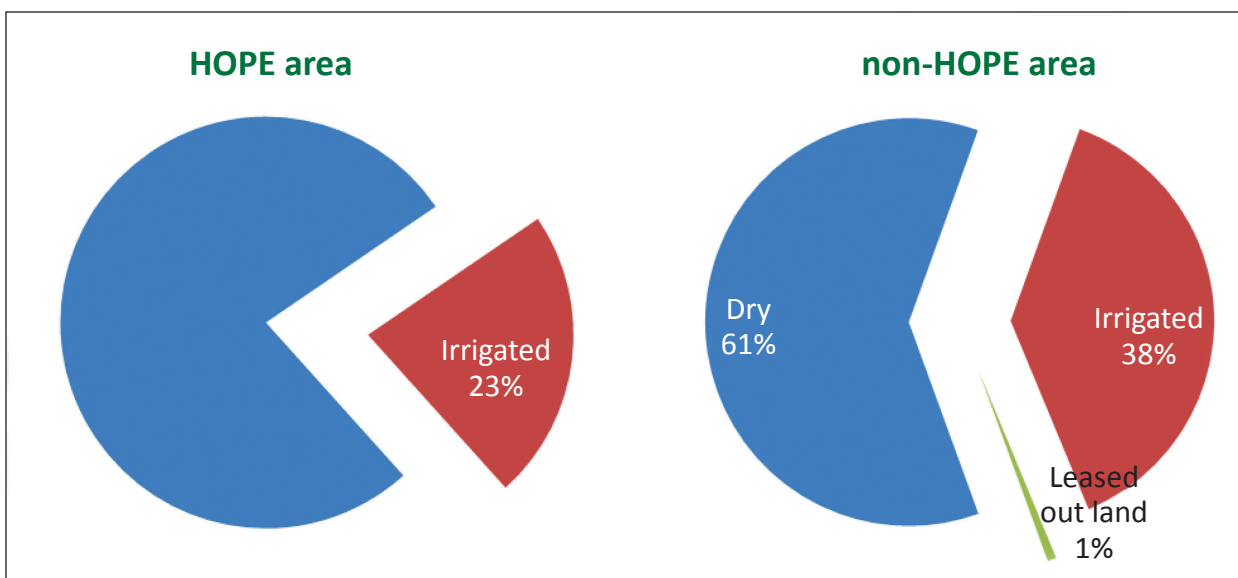


Figure 3. Land holding pattern among sample farmers in Gujarat.

### V.3. Pattern of livestock holding

The striking feature of farm endowment is that more than 80 percent of the farmers kept two she-buffaloes in both HOPE and non-HOPE areas. The value of she-buffaloes per family is around ₹ 84,000 in HOPE and ₹ 56,000 in non-HOPE areas. This reflects the complementary enterprise relationship with the crops grown on the farm in rainfed areas. Thus, a majority of the farmers cultivate pearl millet for both grain and fodder (Table 3).

On the flip side, only 10 percent of the farmers in HOPE area and only 5 percent of the farmers in non-HOPE area possessed draft animals for agricultural operations, showing gradual reduction in the use of draft animals for farm operations even in areas dominated by millets and low market value grains. The local cows are popular among 25 percent of the farmers.

**Table 3. Pattern of livestock holding among sample farmers in Gujarat state.**

Particulars	HOPE project area (N=120)			non-HOPE project area (N=90)		
	No. per family	% of farmers owning	Value of the livestock (₹)	No. per family	% of farmers owning	Value of the livestock (₹)
Draft animals	1.9	10.0	29500	2	5.0	26667
Local cows	1.5	24.2	12259	1	33.3	7550
Crossbred cows	1.3	5.8	21286	2	13.3	20375
She-buffaloes	2.5	82.5	84343	1.7	81.7	56184
Sheep and goats	12.7	7.5	46167	-	-	-
Others (poultry birds, young stock, etc)	1.4	53.3	14625	1.1	43.3	12038



#### V.4. Pattern of farm machinery and household items

In both non-HOPE and HOPE areas, farmers possessed residential house worth around ₹ 70,000 to ₹ 96,000. Almost all the farmers possessed mobile phones. In both the areas, more than 50 percent of the farmers have TVs and two-wheelers. More than 30 percent of the farmers in both the areas have radios. More than 40 percent of the farmers in both the areas have a separate farmhouse and milling equipment. The milling equipment is especially for pearl millet, which, due to impressive fat content, becomes rancid if the flour is stored for a long time. The value of assets with HOPE farmers is more than that of non-HOPE farmers. Around 30 percent of the farmers in HOPE area possess tractors, while only 8 percent of the farmers in non-HOPE area possess tractors. Around 43 percent of the HOPE sample farmers have irrigation pump sets, which are enabling them to earn around ₹ 15,000 per year from the water market for irrigation (Table 4). Overall, the targeted areas are relatively less developed compared to the non-HOPE areas and thus there is scope for productivity and profitability enhancement.

**Table 4. Pattern of farm machinery and equipment holding among sample farmers in Gujarat state.**

Particulars	HOPE project area (N=120)			non-HOPE project area (N=90)		
	Average	Current value (₹)	% of farmers owning	Average	Current value (₹)	% of farmers owning
Agro processing equipment	1	1930	44	1	1019	45
Farmhouse	1	23119	56	1	11146	40
Harvester/thresher	1	41250	8	1	10000	2
Irrigation pump set (electrical and diesel pump sets)	1	138431	43	1	37485	55
Power tiller	1	10000	3	-	-	-
Radio/tape recorder	1	732	31	1	817	45
TV	1	6500	53	1	6938	53
Residential house	1	96328	99	1	73883	100
Tractor	1	228571	29	1	410000	8
Two-wheeler	1	25324	59	1	28032	63
Mobile phone	1.1	2239	91	1.1	2434	98
Total	11.1	574424	516	10.1	581754	509

#### V.5. Assessment of various sources of income

In the HOPE area, average holding size is around 1.6 ha per farm. A majority of the farmers realized a gross income of around ₹ 53,000 per farm forming around 50% of the total income (from pearl millet–cumin–mustard), followed by dairy income of around ₹ 38,000 per farm from 2 Murrah buffaloes forming around 25% of the total income, supported by the fodder from pearl millet. Around 17% of the farmers with irrigation facility were found to sell water in the water market, realizing around ₹ 16,400 per year (Table 5).

In the non-HOPE area, the farmers under rainfed and irrigated endowments formed 50 percent each with an average holding size of 1.4 ha, respectively. The rainfed farmers received annual income of around ₹ 46,000 per farm from crops, and about ₹ 25,000 from dairy income from 2 buffaloes. Their wage and non-farm income was around ₹ 16,500 per annum (realized by around 40 percent of the farmers). Around 37 percent of the farmers received wage and non-farm income of ₹ 16,500.

Considering the livestock enterprise combination, in both HOPE and non-HOPE areas, it is the *Bajra*-Buffalo Combination (BBC) that is ruling, since more than 75 percent of the farmers cultivate *bajra* (pearl millet) and rear she-buffaloes. This can also be categorized as Millet Milk Combination (MMC), which is sustaining farmers in such harsh hot weather conditions with extremities of drought. What is crucial to note is the impressive feed conversion ratio of buffaloes consuming pearl millet fodder. If a buffalo produces around 7 liters of milk per day valued at ₹ 140, and feeds on ₹ 40 worth of fodder and concentrates, the feed conversion to milk is around 1:3.5. Thus, the choice of HOPE area is in order since (1) more than 75% of the (sample) farmers are rainfed and (2) there are no substantial differences between rainfed and irrigated areas with regard to socioeconomic status of farmers.

**Table 5. Sources of income for sample farmers in Gujarat state.**

Sources of income	HOPE project area		non-HOPE project area	
	Value	% of farmers receiving income	Value	% of farmers receiving income
Size of holding (ha)	1.6		1.4	
Family size	6		6	
Income from crops	53675	100.0	46233	100.0
Wage income and non-farm income	25714	23.3	16591	36.7
Income from dairy	37752	90.8	25365	86.7
Wage income from hiring bullock labor	8167	5.0	5000	1.7
Income from livestock	50000	0.8	-	0.0
Income from water market for irrigation	16400	16.7	11500	3.3
Income from custom hiring	17259	22.5	18000	8.3
Rent from land, building and machinery	-	0.0	17500	3.3
Caste occupations	12000	0.8	13333	5.0
Business	51167	5.0	51417	20.0
Regular salaried jobs (Govt.)	84667	2.5	-	0.0
Regular salaried jobs (Private)	66875	13.3	47556	15.0
Income from all sources	115850	100.0	94933	100.0
All income per capita	19747		15955	
Crop income per ha	33547		33024	

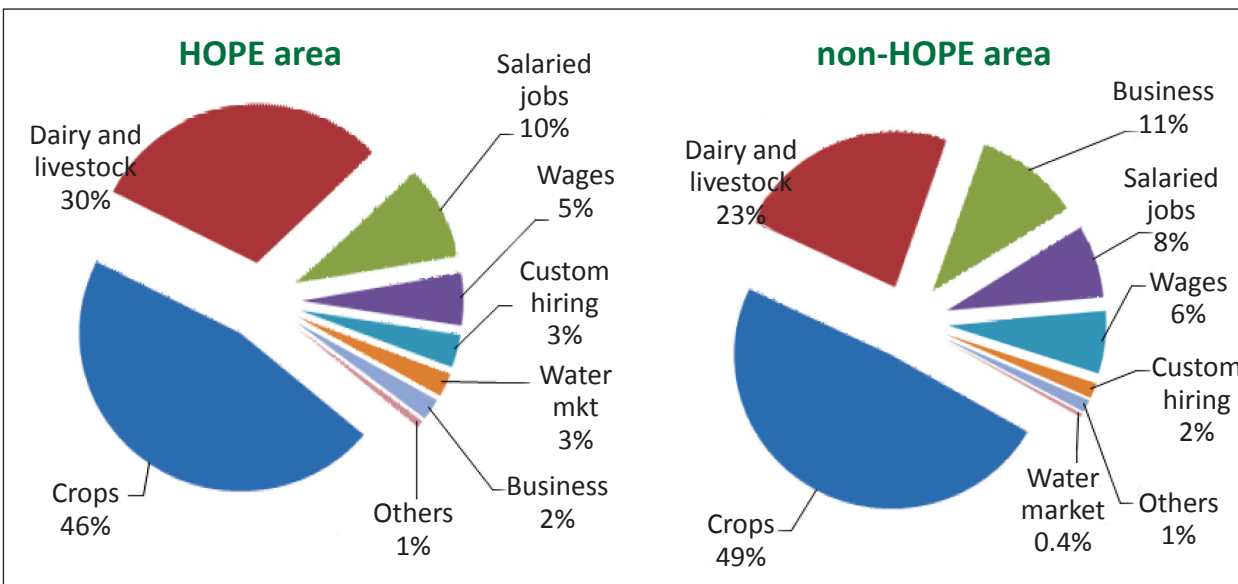


Figure 4. Different sources of income among sample farmers in Gujarat.

The per capita income from all sources for HOPE farmers is ₹ 19,750 and for non-HOPE farmers, it is ₹ 15,950. Considering income from all sources, the HOPE farmers have received ₹ 1.1 lakhs, while those of non-HOPE area have received an income of ₹ 95,000 irrespective of being rainfed or irrigated.

## V.6. Crop production, cropping pattern and yields

In the HOPE area, the cropping pattern is clearly dominated by pearl millet, since 80% of the *kharif* (rainy season) area and about 50% of the Gross Cropped Area (GCA) is occupied by pearl millet. In the *rabi* (postrainy) season, mustard occupies around 50% of the *rabi* area, followed by cumin (39%) and wheat (13%). Mustard forms around 20% of the gross cropped area, ranking

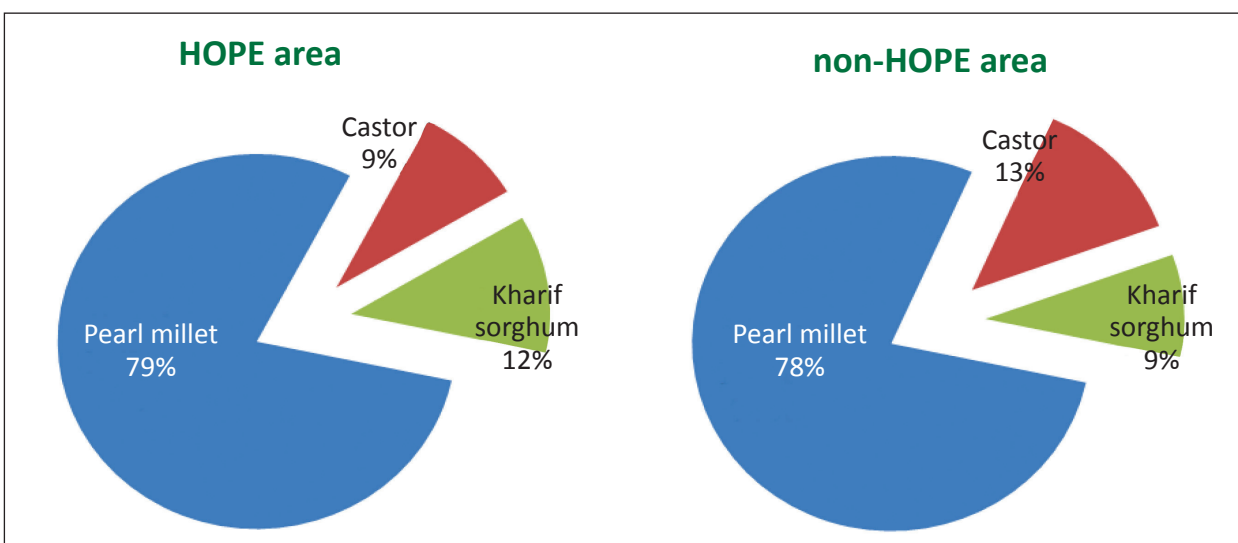
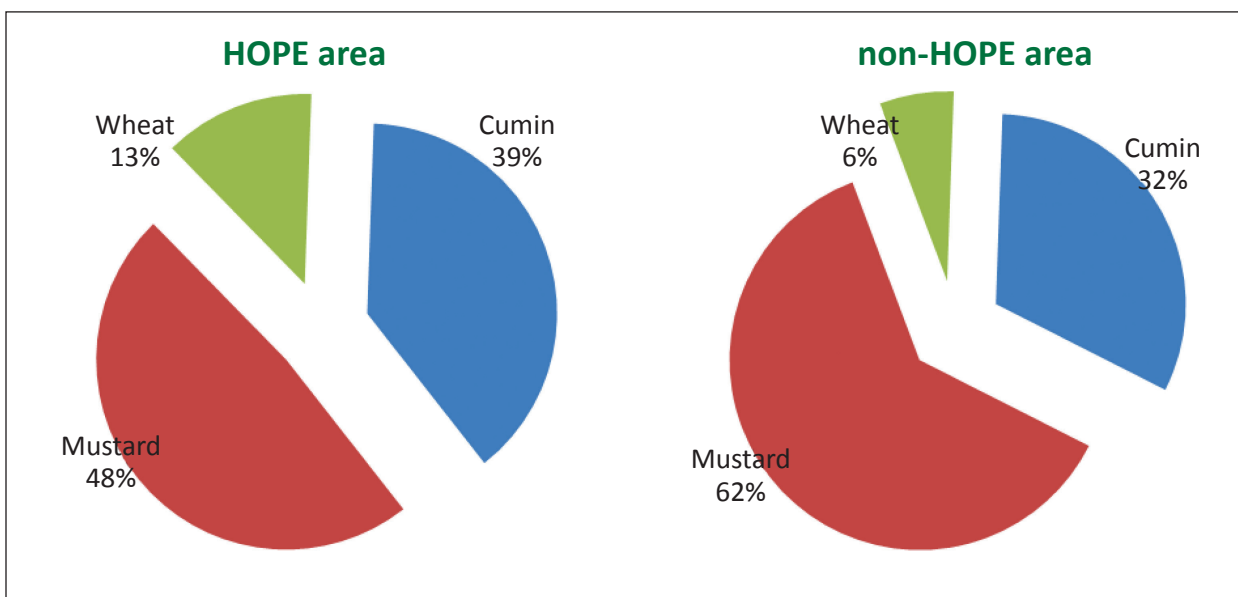


Figure 5. Choice of crops during kharif season in Gujarat.

next to pearl millet. In the non-HOPE area, the cropping pattern is similarly dominated by pearl millet, as around 80% of the *kharif* area, which forms about 46% of the GCA is covered by pearl millet. In the *rabi* season, mustard occupies 62% of the *rabi* area, followed by cumin, 32%. Considering GCA, mustard occupies 26% and cumin 13% (Table 6).

**Table 6. Choice of crops among sample farmers in Gujarat state.**

Crops	HOPE project area				non- HOPE project area			
	Area covered (ha)	% of GCA	% of season area	Yield (t/ha)	Area covered (ha)	% of GCA	% of season area	Yield (t/ha)
<b><i>Kharif</i> (rainy season)</b>								
Pearl millet	149.9	47.2	79.4	1.0	64.3	45.8	78.3	1.0
Castor	16.4	5.2	8.7	1.9	10.5	7.5	12.8	2.4
Sorghum	22.5	7.1	11.9	0.3	7.3	5.2	8.9	0.4
<b>Total <i>kharif</i> area</b>	<b>188.7</b>	<b>59.4</b>	<b>100</b>		<b>82.1</b>	<b>58.5</b>	<b>100</b>	
<b><i>Rabi</i> (postrainy season)</b>								
Cumin	50.2	15.8	38.9	1.1	18.6	13.3	31.9	1.1
Mustard	62.3	19.6	48.3	1.8	36	25.7	61.8	1.8
Wheat	16.6	5.2	12.9	2.1	3.6	2.6	6.3	2.1
<b>Total <i>rabi</i> area</b>	<b>129</b>	<b>40.6</b>	<b>100</b>		<b>58.3</b>	<b>41.5</b>	<b>100</b>	
<b>Gross Cropped Area (ha)</b>	<b>317.8</b>	<b>100</b>			<b>140.3</b>	<b>100</b>		



*Figure 6. Choice of crops during rabi (postrainy season) season in Gujarat.*

During a normal year, there is a rainfall of around 650 to 750 mm. Pearl millet is largely a rainfed crop, except for a few pockets in which the crop is irrigated during summer. According to the opinion survey, with normal rainfall, there is no substantial difference in the productivity of pearl millet ranging from 0.6 to 0.7 tons per ha irrespective of whether the variety is from public or proprietary source. Similarly, with above normal rainfall conditions, pearl millet responds greatly irrespective of the varietal source yielding around 1.0 to 1.1 tons per ha. In a situation of below normal rainfall, none of the varieties performed well; all varieties yielded around 0.2 tons per ha (Table 7).

**Table 7. Crop productivity in pearl millet among sample farmers in Gujarat State in *kharif* season: Opinion survey of farmers (tons/ha).**

HOPE project area		non-HOPE project area	
Public variety	Proprietary variety	Public variety	Proprietary variety
Normal year (650 mm to 750 mm)			
0.72	0.71	0.57	0.69
Above normal (> 750 mm)			
1.05	1.11	1.02	1.09
Below normal (< 650 mm)			
0.21	0.23	0.21	0.24

The adoption rate of hybrids is quite impressive in studied areas, especially the proprietary hybrids in all major farming clusters. However, the public hybrids adoption rate is modest, covering 15% of *kharif* pearl millet area (out of 150 ha). In the non-HOPE area, the adoption of public hybrids is only 7% (out of 64 ha). The most popular hybrids of pearl millet being cultivated include GHB 558 and GHB 719 (Table 8).

**Table 8. Area of adoption (in ha) of public and private bred pearl millet hybrids in Gujarat.**

Particulars	HOPE project area	non-HOPE project area
Public hybrids	22 (15%)	4 (7%)
Proprietary hybrids	128 (85%)	60 (93%)

Note: figure in parentheses are percentages to total.

The yield gap between actual and potential indicates how much extra yield could be generated from the existing level under good management, given the yield gap constraints are alleviated. The yield gap of improved varieties of pearl millet with farmers' practice was estimated at 130% as compared to the potential yield (2.4 tons/ha) (potential yields are recorded experimental yield of improved cultivars at farm level), which shows further scope for improvement in productivity level by farmers' adoption of recommended package of practices along with improved varieties.

## V.7. Economics of pearl millet according to input use and relative profitability

Considering the cost of cultivation of pearl millet on per ha basis, total cost of cultivation was around ₹ 11,732 and ₹ 11,024 in HOPE and non-HOPE areas, respectively. Land preparation forms the single largest component of the cost of cultivation (23% of total variable costs), followed by input costs.

On an average, the grain productivity of pearl millet was 1.06 tons per ha and 0.97 ton per ha with 3.54 tons per ha and 3.41 tons per ha of fodder in HOPE and non-HOPE areas, respectively (Table 9). The income received through fodder is almost equal to that from grain. This shows the importance attached to the fodder of pearl millet since she-buffaloes prefer pearl millet fodder as feed as it is converted to milk, which is a great boon for farmers even in such harsh climate areas, where temperatures surpass 45 degrees Celsius in the *kharif*.

Considering the total variable costs, farmers are realizing a net return of ₹ 4213 per ha in HOPE area and ₹ 3815 per ha in non-HOPE area. While considering the paid out costs, net return per ha accrued by the farmers in HOPE area was ₹ 4877 and in non-HOPE ₹ 4439 (Table 11). Since a majority of the farmers (90 percent in HOPE area and 86 percent in non-HOPE area), possess dairy buffaloes, pearl millet is a crucial crop in this integrated farming system, which on a sustainable basis serves as the linkage with milch animals and vice versa.

**Table 9. Economics of pearl millet in the *kharif* for the cropped area in Gujarat State (per ha).**

Particulars	HOPE project area		non-HOPE project area	
	Value in ₹	Proportion to TC (%)	Value in ₹	Proportion to TC (%)
Land preparation	2710	23	2504	23
FYM application	647	6	465	4
Sowing	926	8	953	9
Input cost	2501	21	2566	23
Weeding	929	8	1012	9
Plant protection	400	3		0
Watching	431	4	293	3
Harvesting	425	4	437	4
Threshing	1450	12	1545	14
Marketing	649	6	625	6
<b>Variable Cost</b>	<b>11068</b>	94	<b>10400</b>	94
Interest on variable cost @ 6 % per annum	664	6	624	6
<b>Total Cost</b>	<b>11732</b>	100	<b>11024</b>	100
Main product yield (t)	1.06		0.97	
Value of main product (₹ per t)	7275		7163	
By-product yield (t)	3.54		3.41	
Value of by-product (₹ per t)	2326		2314	
<b>Total return</b>	<b>15946</b>		<b>14839</b>	
Net return over total cost	4213		3815	
<b>Return to cost ratio</b>	<b>1.36</b>		<b>1.35</b>	

The disaggregation of farms according to input usage shows that only 15-19% farmers are operating below the recommended dosage of fertilizers. But it should be noted that the low management group farms are operating marginally below the recommended level of fertilizers. Therefore, there was no considerable difference between yield level achieved by high management group (HMG) and low management groups (LMG) in both HOPE and non-HOPE areas (Table 10).

**Table 10. Economics of pearl millet according to input use pattern (low input management and high input management) in Gujarat.**

Particulars	HOPE project area		non-HOPE project area	
	HMG (81 %)	LMG (19 %)	HMG (85%)	LMG (15%)
Grain yield (tons/ha)	1.05	1	0.96	0.92
Grain price received	7250	7370	7220	6830
Fodder yield	3	3.56	3.36	3.14
Fodder price received	2330	2320	2310	2310
Total cost	11586	11098	10678	10017
Total returns	15471	15652	14707	13565
Net returns	3885	4554	4029	3548
Return to Cost ratio	1.34	1.41	1.38	1.35

Note: Figures in parentheses are percentage of farmers to total.

In HOPE and non-HOPE areas, the main competing crops are castor cultivated under assured irrigation and *khariif* sorghum (fodder sorghum). In both the areas, castor is the crucial competing commercial crop, which fetches around three times higher return (BCR 2.74 and 2.78 in HOPE and non-HOPE areas, respectively) when compared with pearl millet. It must be noted that pearl millet is widely cultivated under rainfed conditions only. Also, the market price of pearl millet grain is comparatively lower than minimum support price (MSP), which fetches relatively low net returns (Table 11).

**Table 11. Relative profitability of crops in Gujarat.**

Particulars	HOPE project area			non-HOPE project area		
	Pearl millet	Castor	<i>Khariif</i> sorghum	Pearl millet	Castor	<i>Khariif</i> sorghum
Total cost (₹)	11732	27628	11161	11024	28709	12905
Total paid out cost	11068	11790	8118	10400	12046	10036
Main product yield (t)	1.06	2.57	0	0.97	2.67	0
Value of main product (₹/ t)	7275	29430	0	7163	29640	0
By-product yield (t)	3.54	0	4.43	3.41	0.26	4.12
Value of by-product (₹/t)	2326	0	3300	2314	2700	3300
Total return (₹)	15946	75635	14619	14839	79841	13596
Net return over total cost (₹)	4213	48007	3458	3815	51132	691
Net return over total paid out cost (₹)	4877	63845	6501	4439	67795	3560
Return to cost ratio	1.36	2.74	1.31	1.35	2.78	1.05

## V.8. Utilization of output (grain and fodder)

About 33 percent of the HOPE farmers consumed 100% of their pearl millet production of 910 kg per farm, while 57 percent of the farmers who produced 1590 kg per farm sold 612 kg in the regulated market and 10 percent of the farmers who produced 1096 kg per farm sold 208 kg in the village market. This reflects a positive relationship between crop productivity and scale of production.

In the non-HOPE area, 55 percent of the farmers who produced around 798 kg per farm of pearl millet retained 100% of their produce for home consumption, 32 percent of the farmers who produced 1558 kg per farm, sold 495 kg per farm in regulated market and 13 percent of the farmers who produced on an average 1116 kg per farm sold 148 kg in the village market. The grain price received ranged from ₹ 7 to 8 per kg. Thus selling at the regulated market did not bring any great benefit for the pearl millet farmers since there is limited difference (₹ 1/kg) between prices in the regulated and village markets (Table 12).

**Table 12. Utilization and marketing of grain in Gujarat.**

Particulars	HOPE project area			non-HOPE project area		
	No sale (33%)	Regulated market (57%)	Village market (10%)	No sale (55%)	Regulated market (32%)	Village market (13%)
Grain produced (kg/farm)	910	1590	1096	798	1558	1116
Grain consumed (kg)	744	724	746	660	826	712
Grain retained for other uses (kg)	163	223	142	123	189	256
Grain kept for future use (kg)	4	31		15	48	
Marketable surplus (kg)		612	208		495	148
Marketed surplus (kg)		612	208		495	148
Total marketing cost (₹/kg)		63	16		19	16
Price received (₹/kg)		8	7		7	8

Note: Figures in parentheses are percentage of farmers involved.

Around 70 percent of the project farmers who had an average pearl millet area of 1.17 ha (0.93 ha in non-HOPE area) produced 3.8 t/ha (2.9 t/ha) of fodder and consumed 3.4 t (2.7 t) of it due to strong on-farm demand of fodder in HOPE (non-HOPE) area. In HOPE area, 10% farmers who produced 3.1 t/ha marketed 2.1 t for ₹ 2530 in the formal market and the rest of the farmers produced 6.3 t/ha and sold 3 t in the village market for ₹ 2560. In non-HOPE area 15 percent of the farmers produced 4 t/ha and marketed 2.7 t in the formal market for ₹ 2380 and the rest of the farmers produced 4.6 t/ha and sold 1.8 t for ₹ 2310 (Table 13).



**Table 13. Fodder production and utilization by sample farmers in Gujarat.**

Particulars	HOPE project area			non-HOPE project area		
	No sale (72%)	Formal market (10%)	Village market (18%)	No sale (70%)	Formal market (15%)	Village market (15%)
Average crop area (ha)	1.17	0.91	1.95	0.93	1.33	1.46
Fodder production (tons)	3.8	3.1	6.3	2.9	4	4.6
Fodder retained for own use (tons)	3.4	1	3.4	2.7	1.4	2.8
Marketable surplus (tons)	0.4	2.1	3.0	0.2	2.7	1.8
Marketed surplus (tons)		2.1	3.0		2.7	1.8
Price received (₹/tons)		2530	2560		2380	2310
Marketing cost (₹)		16	1		8	0

Note: Figures in parentheses are percentage of farmers involved.

## V.9. Production characteristics of technologies and trait preferences of farmers

Considering the constraints expressed by farmers regarding the attributes of pearl millet hybrids, public hybrids in pearl millet are not popular among the majority of the surveyed farmers, as 95 percent of the surveyed farmers in both HOPE and non-HOPE areas are using proprietary hybrids. Among the responses received, about 47 percent indicated that the hybrids are of long duration, 42 percent farmers indicated poor taste, 31 percent indicated that the grains are of small size, 24 percent indicated that grains are of poor color, 20 percent indicated that the grains have low recovery due to poor shelling percentage, and 20 percent indicated that hybrids are susceptible to storage pests. In non-HOPE areas, 43 percent of the farmers indicated small grain size, 42 percent indicated long duration, 33 percent indicated poor color and 28 percent farmers indicated low recovery/ shelling percentage (Table 14).

**Table 14. Constraints for pearl millet cultivation in Gujarat (in %).**

Characteristics	HOPE project area	non-HOPE project area
Low yield	5.0	1.7
High pest incidence	0.8	-
High disease incidence	4.2	6.7
Long duration	46.7	41.7
Small grain size	30.8	43.3
Poor color	24.2	33.3
Low recovery/shelling %	20.0	28.3
Low market price	10.8	11.7
Doesn't fit into cropping system	3.3	3.3
Susceptible to storage pest	19.2	13.3
Poor fodder quality	10.0	5.0

### V.9.1 Production

Among the preferred traits (proprietary hybrids/ varieties) opined by the farmers, 98 percent preferred high productivity, 50 percent desired that the variety should fit into the cropping system, 36 percent of the farmers indicated that the variety should be of short duration, 34 percent indicated that it should improve soil fertility. Similar trends were observable in non-HOPE area also.

**Table 15. Production traits of pearl millet in Gujarat (in %).**

Characteristics	HOPE project area	non-HOPE project area
High yield	98.3	98.3
Short duration	35.8	38.3
Drought resistance	1.7	-
Pest resistance	6.7	1.7
Disease resistance	41.7	51.7
Fits into cropping system	50.0	45.0
Improves soil fertility	34.2	30.0

### V.9.2 Consumption

With regard to consumption characteristics, the most important quality parameter was ‘keeping quality’ as more than 60 percent of the sample farmers preferred this attribute, followed by cooking time and better tastes. The private hybrids in pearl millet need to concentrate on improving the above consumption characteristics in order to be economically viable and popular in the field.

**Table 16. Consumption traits of pearl millet in Gujarat (in %).**

Characteristics	HOPE project area	non-HOPE project area
Better taste	38.3	35.0
Less cooking time	50.8	50.0
High keeping quality	61.7	70.0

### V.9.3 Fodder

93 percent of the sample farmers opined that fodder quantity is a crucial parameter for their selection of varietal types since pearl millet fodder is a preferred feed of she-buffaloes. This is followed by storability of the fodder and free from pests and diseases. The fodder quality as indicated by palatability–quality and taste is the third ranking variable.

**Table 17. Fodder traits of pearl millet in Gujarat (in %).**

Characteristics	HOPE project area	non-HOPE project area
More fodder quantity with leaves	93.3	88.3
Palatability (quality/taste)	20.8	18.3
Storability of fodder (free from pests and diseases)	43.3	45.0

### V.9.4 Marketing

About 68 percent of the farmers opined high-demand as the most important trait of proprietary hybrid, followed by bigger grain size and low price fluctuations as the important marketing traits. Similar opinions are expressed by farmers in the non-HOPE area, except that, these farmers ranked low price fluctuations to be their second key characteristic, ranking bigger grain size the third.

**Table 18. Marketing traits of pearl millet in Gujarat (in %).**

Characteristics	HOPE project area	non-HOPE project area
High demand	67.5	51.7
Fetches higher price	20.8	18.3
Low price fluctuations	30.0	41.7
Bigger grain size	30.8	30.0

### V.10. Consumption level

Pearl millet is the dominant food grain consumed by both HOPE and non-HOPE farmers. In the HOPE area, the quantity of pearl millet consumed (802 kg per annum) formed 78% of the total food grains consumed by the farm family. The farm family retained 61% of the pearl millet produced for home consumption including feed and fodder (Table 19). In the non-HOPE project area, the farm family consumed 793 kg per year, which formed 80% of the total food grain consumed. The farm family consumed 73% of the pearl millet produced on the farm for feed and fodder.

**Table 19. Per capita cereal consumption per annum in Gujarat.**

Cereal/Millet	HOPE project area			non-HOPE project area		
	Avg. quantity consumed as food and feed (kg)	Total grain produced	% consumed	Avg. quantity consumed as food and feed (kg)	Total grain produced	% consumed
Rice	8			6		
Wheat	31			27		
Pearl millet	134	219	61%	132	180	73%
<b>Overall</b>	<b>172</b>			<b>165</b>		

Around 56 percent of HOPE farmers and 62 percent of non-HOPE farmers indicated that in perspective, there would be increase in the consumption of pearl millet due to an increase in the family size and an increase in longevity of family members. However, a very small proportion of farmers in HOPE and non-HOPE areas indicated that pearl millet consumption would decrease because it is replaced by other food grains such as wheat. Most farmers in HOPE and non-HOPE areas indicated that pearl millet is not being replaced by any other crop and is being sustained. Correspondingly, a modest proportion of farmers (5 to 8 percent) indicated that pearl millet consumption is decreasing due to preference for wheat (by children) and due to increase in standard of living (by 1 percent) of the farmers.

**Table 20. Opinion survey regarding consumption of pearl millet in retrospect and prospect in Gujarat.**

Particulars	HOPE project area		non-HOPE project area	
	Number of farmers	% of farmers	Number of farmers	% of farmers
% of farmers reporting an increase in consumption	67	55.83	37	61.67
Due to family size increase	29	21.67	17	28.33
Due to longevity of family	26	22.5	14	23.33
Due to pearl millet being more palatable than wheat	1	0.83	1	1.67
Due to it being conventional food	11	9.17	5	8.33
Which crop is pearl millet replacing?		P millet is sustaining	P millet is sustaining	
% of farmers reporting decrease in consumption	10	8.33	3	5
Children preferred wheat to pearl millet	9	7.5	3	5
As standard of living increased	1	0.83		
Which crop is replacing pearl millet?		Wheat		Wheat

### V.11. Participation of labor force in cultivation process according to gender

The involvement of gender in pearl millet cultivation is seen in all cultural activities excepting plant protection and irrigation in both HOPE and non-HOPE areas (Table 21). The activities in which labor participation of men are predominant in the cultivation of millet are land preparation, threshing and marketing, while participation of women is discernible in activities such as sowing, fertilizer application, weeding, harvesting and threshing. However, female labor participation in the cultivation of pearl millet is reasonable and modest, whereas male laborers are prominently involved. Hence, involvement of women is substantial in all activities of cultivation of pearl millet including watch and ward and marketing, though the proportion of farmers using men and women labor varies depending on the cultural operations.

Thus, on an average there is around 40% involvement of women laborers and 60% men laborers in most operations in both HOPE and non-HOPE areas of millet cultivation. This is a pointer towards the active involvement of women in both labor activities as well as decision making activities such as sowing and marketing. In addition, this reflects the substantial contribution of women in rainfed agriculture dominated by millets. In addition, as more than 85 percent of the farmers possess milch animals (she-buffaloes), the involvement of women is substantial in the BBC (*Bajra*-buffalo combination) or MMC (millet-milk combination) in Gujarat.

**Table 21. Gender involvement in pearl millet cultivation in Gujarat State.**

	HOPE project area			non-HOPE project area		
	Man days	Woman days	% involvement of men, women	Man days	Woman days	% involvement of men, women
Land preparation	3.8	2.3	100, 38	3.5	3.1	100, 27
Transport & application of FYM	4.4	3.3	99, 59	4.4	3.2	100, 72
Sowing	3.6	2.2	100, 68	3.4	2.3	100, 70
Application of fertilizers	3.5	2.4	97, 61	3	2.1	100, 67
Hand weeding	4.7	3.4	98, 68	4	3.2	97, 88
Intercultural/mechanical weeding	6.7	5.1	72, 29	7.1	5.6	77, 33
Plant protection measures	3.7	-	9, 0	3	-	2, 0
Irrigation	1.7	-	8, 0	1.2	-	15, 0
Watch and ward	3.2	1.1	98, 14	3.1	2.3	92, 10
Harvesting ear heads & fodder stock	5.4	3.5	100, 82	4.5	3	100, 93
Threshing	5	3.2	98, 86	4.5	3	100, 95
Marketing	3.1	2.9	83, 41	2.6	2.4	98, 50

## VI. Conclusion and policy implications

Gujarat has been one of the important pearl millet producing states where it is consumed as staple food and fodder, supporting poor smallholders and livestock in the harsh agro-climatic region. The baseline survey results reveal that out of the total cropped area, pearl millet occupied more than 70% of the cultivable area. The average productivity of pearl millet ranges from 0.95-1.15 tons/ha as against the potential yield of 2.4 tons/ha leaving a yield gap of 130-150%. There was no considerable difference between yield level achieved by high management group (HMG) and low management group (LMG) in both HOPE and non-HOPE areas. The most popular improved cultivar of pearl millet being cultivated includes GHB 558 and GHB 719, occupying an area of 15%. The main competing crops for pearl millet were castor and the *kharif* sorghum (for fodder purpose only). There is a strong evidence of replacement of pearl millet by wheat, even though 75% of pearl millet produced is home-consumed. Around 55% of the farmers indicated that pearl millet consumption is increasing as pearl millet is a staple food having more palatability than wheat. The marketed surplus of grain and fodder was to the tune of 40% and 30-40%. Farmers' most preferred traits in hybrids of pearl millet inter alia include more palatable grain and fodder quality and disease-pest-resistant. Key critical constraints expressed by the farmers are shortage of labor, especially during harvesting, high wage rate, moisture stress and lack of appropriate machineries. Targeting the key recommended

technologies and management practices is vital as there is a significant yield gap between the base line and the potential from the improved cultivars. While minimum support price (MSP) was announced for dryland cereals, none of them including pearl millet grains are procured. Hence, MSP should be followed by procurement to provide market support to farmers. Farmers preferred varieties/hybrids responding to low input usage, short duration with good quality of grain and fodder, drought and downy mildew tolerant attributes. Hence, these value added attributes need to be incorporated into the breeding program of pearl millet.

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