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Utilization Pattern, Demand and Supply of Pearl Millet Grain and Fodder in Western India

A Amarender Reddy, OP Yadav, Dharm Pal Malik, IP Singh, NJ Ardeshna, KK Kundu, SK Gupta, Rajan Sharma, G Sawargaonkar, D Moses Shyam and K Sammi Reddy

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International Crops Research Institute for the Semi-Arid Tropics

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Abstract

This paper gives an estimate of the demand and supply of pearl millet grain and fodder for the year 2011 and 2020 in western India comprising (Rajasthan, Gujarat and Haryana). The projected pearl millet grain and stover production for 2020 was based on historical growth rates in production from 1996-2009. On the demand side, food demand was projected based on population projections for 2020 by maintaining 2004/05 per capita consumption based on NSSO 61st round. The demand for alternative uses of grain (alcohol industry) was projected based on a field survey conducted during 2011. The demand for feed and stover was based on the livestock census 2007 and feed ration from Dikshit and Birthal (2010) and projected growth rates of livestock population. Overall in 2011, in western India 46% of production of pearl millet grain goes for food use, 37.5% for cattle feed, 7.7% for poultry feed, 8.8% for alcohol industry production and only a small fraction, 0.4%, is used for seed purpose. The relative share of different uses of grain by 2020 indicated that the share of cattle feed will increase to 38.6%, share of poultry feed will increase to 9.4%, alcohol industry and other non-food uses will be increased to 11.7%, while food uses will decrease to 40%. Even though currently there is shortage of pearl millet grain production in western India, which is indicated by higher prices, by 2020 the region will become surplus to the extent of 5% if it maintains the production growth trend of the recent past, which is very high (4.22% per annum). However, Gujarat state will continue to be deficient in grain even by 2020. Dry fodder will, however, continue to be in short supply and the paper projects a deficit of 10% by 2020.

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Patancheru 502 324, Andhra Pradesh, India

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About the Authors

A Amarender Reddy	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India
OP Yadav	All India Coordinated Pearl Millet Improvement Project (AICPMIP), Jodhpur, Rajasthan
Dharm Pal Malik	Ministry of Agriculture, Krishi Bhawan, New Delhi
IP Singh	Rajasthan Agricultural University, Bikaner, Rajasthan
NJ Ardeshna	Junagad Agricultural University, Gujarat
KK Kundu	CCS Agricultural University, Haryana, India
SK Gupta	ICRISAT, Patancheru 502 324, Andhra Pradesh, India
Rajan Sharma	ICRISAT, Patancheru 502 324, Andhra Pradesh, India
G Sawargaonkar	ICRISAT, Patancheru 502 324, Andhra Pradesh, India
D Moses Shyam	ICRISAT, Patancheru 502 324, Andhra Pradesh, India
K Sammi Reddy	Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad 500 059, Andhra Pradesh, India

Contents

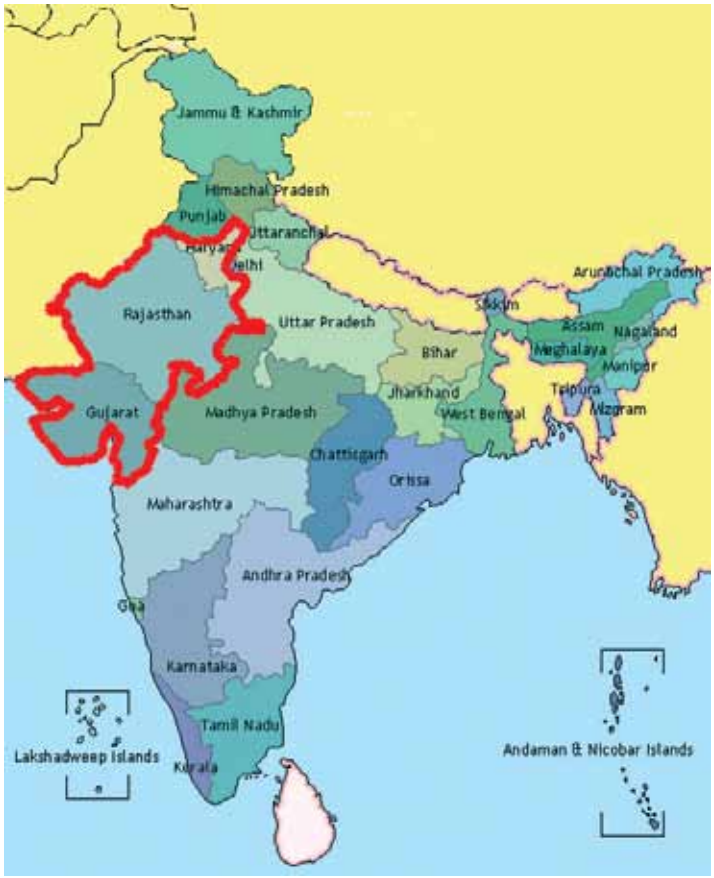
Acronyms

ACGR	Annual Compound Growth Rate
AICPMIP	All India Coordinated Pearl Millet Improvement Project
BPL	Below Poverty Line
CRIDA	Central Research Institute for Dryland Agriculture
DES	Directorate of Economics and Statistics
FGD	Focus Group Discussion
FSB	Food Security Bill
GCA	Gross Cropped Area
GOI	Government of India
Ha	Hectares
HOPE	Harnessing Opportunities for Productivity Enhancement of Sorghum and Millets in Sub-Saharan Africa and South Asia
IMOD	Inclusive Market Oriented Development
INSIMP	Intensive Millets Promotion
ME	Metabolizable Energy
MPCE	Monthly Per Capita Expenditure
MSP	Minimum Support Price
MT	Million Ton
NCP	National Commission on Population
NSSO	National Sample Survey Organisation
PDS	Public Distribution System
RKVY	Rashtriya Krishi Vikas Yojana
SA	South Asia
SSA	Sub-Saharan Africa
T	Ton
TE	Triennium Ending

Introduction

Coarse cereals, namely sorghum, pearl millet and finger millet assume significance in the cropping pattern of dryland regions as they require little inputs and are more drought resistant compared to other competing crops (Breese et al. 2002). Coarse cereals are mostly grown as dual purpose crops to meet both food, feed and fodder requirements. However, the last few decades saw these crops lose area on account of declining demand due to change in food habits that resulted in drop in real prices *vis-a vis* other competing crops leading to erosion in relative profitability of these crops. However, the lower prices of coarse cereal grains compared to other cereal crops increased their demand in alternative uses like feed from the livestock sector and more recently as poultry feed. A significant share of coarse cereal grain is also used for various industrial uses (eg, as starch in the alcohol industry). Further, the nutritional value of these crops offers much scope for development of value added products in new health conscious consumer segments (Yadav et al. 2011). The fodder from coarse cereals particularly sorghum and pearl millet are preferred as livestock feed due to their superior quality.

Pearl millet (*Pennisetum glaucum* (L.) R.Br.) is the world's hardiest warm season coarse cereal crop. It can survive even on the poorest soils in the driest regions, on highly saline soils and in the hottest climates. India is the largest single producer of pearl millet, both in terms of area (9.3 million hectares) and production (8.3 million tons). Pearl millet is an important coarse cereal crop in western India, and occupies about 38% of the total cereal cropped area in the region. About 6.5 million ha of cropped area is under pearl millet in western India with 5.5 million tons production



Map 1. Map of India showing study area.

with an average yield of 852 kg/ha of grain and 2.5 t/ha of stover yield in Triennium Ending (TE) 2008. Given substantial economic importance of pearl millet as a mainstay for small and marginal farmers in this region, the paper tries to examine demand and supply balance of pearl millet grain and fodder by 2020 in western India comprising Rajasthan, Gujarat and Haryana as shown in the map. The information on different uses of pearl millet grain and on demand and supply balance of grain and fodder would be useful to crop scientists to target their research effort for the region.

Changing pattern of food consumption

The decline in consumption of coarse cereals is due to changing food habits, more time required to process the pearl millet to prepare food, keeping the quality of flour, changing tastes and preference for finer grains as income increases, and increased availability of rice and wheat at cheaper prices due to technological advances and also policy push through the Public Distribution System (PDS). The PDS is an integral part of India's food safety net system, and handles about 40% of the total quantities of rice and wheat transacted on the market. On the other hand, coarse cereals comprising sorghum, pearl millet and maize are known to receive higher shares in the household budgets of the poor especially in the dry regions. The PDS in India is based on the wheat and rice model, which is less relevant in states like Gujarat, where pearl millet is traditionally the staple grains for household consumption (Dayakar Rao, Reddy and Seetharama 2007). In spite of the distribution of rice and wheat through PDS to households falling below the poverty line (BPL) in many states, particularly in western India (especially Gujarat and Rajasthan), consumption of coarse cereals is still important for low income households compared to higher income households both in rural and urban areas (Figure 1).

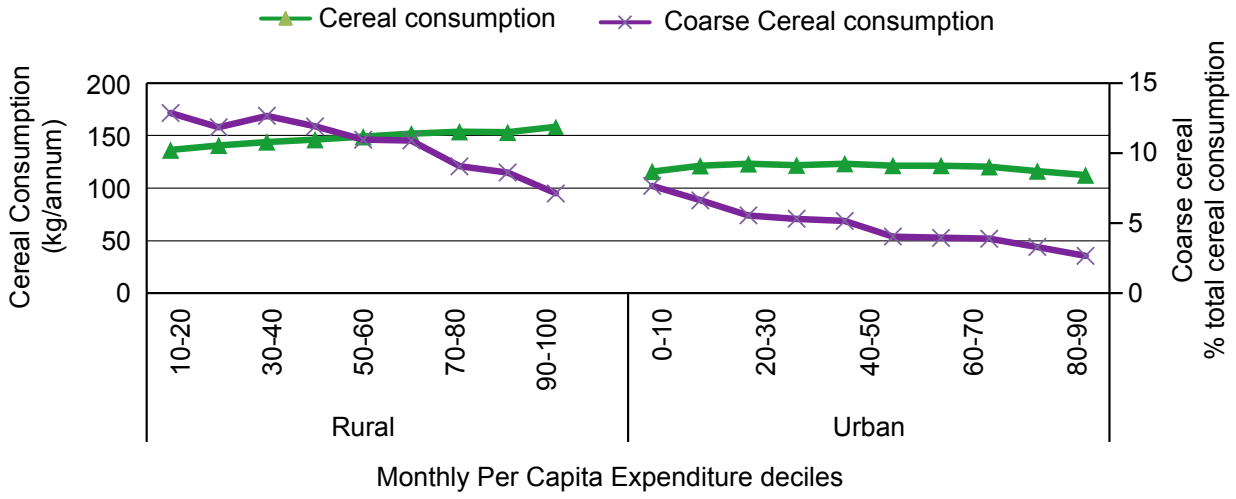


Figure 1. Coarse cereal consumption as % of total cereal consumption (2004/05).

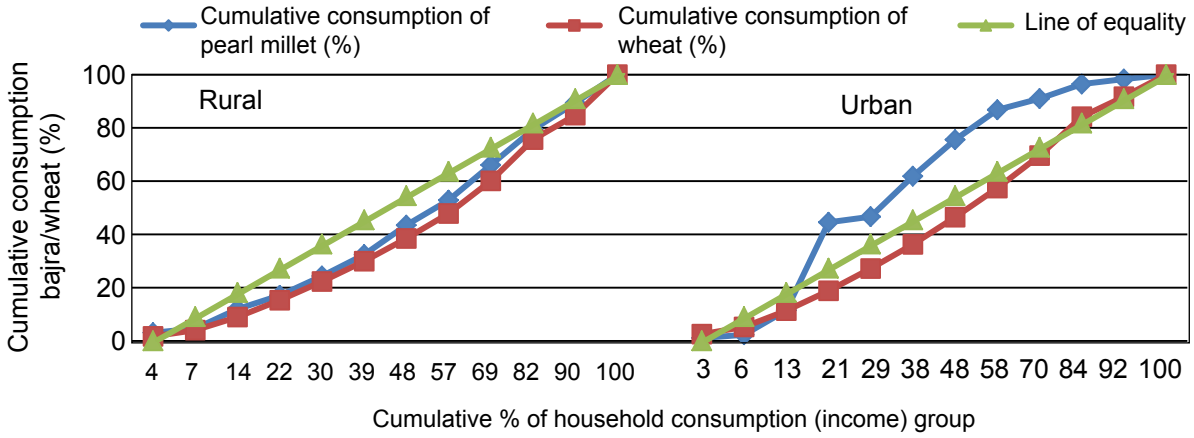


Figure 2. Pearl millet and wheat consumption concentration curve in 2004-05.

Figure 2 presents consumption concentration curves for pearl millet and wheat for rural and urban areas in western India for the year 2004-05 of 61st round of NSSO, showing the cumulative % of pearl millet and wheat consumption against the cumulative % of number of households, ranked by monthly per capita expenditure class (MPCE) beginning with the poorest households. If the curve coincides with the diagonal, all households, irrespective of their economic status, enjoy the same consumption. If the curve lies below the diagonal, inequalities in consumption favor the better-off households; we shall call such inequalities pro-rich (as in case of wheat in urban areas, wheat and pearl millet in rural areas). If the curve lies above the diagonal, we have pro-poor inequalities (as in case of pearl millet in urban areas). The consumption concentration curve for pearl millet is above the diagonal in urban areas, which indicates pearl millet consumption is higher among urban poor compared to the rich. Hence, urban poor will benefit more from increased supply of pearl millet in urban markets either through the free market or the PDS.

Figure 3 depicts the changes in pearl millet and total cereal consumption between 1973 and 2004-05 in the three states of Gujarat, Haryana and Rajasthan in western India from the NSSO consumption survey rounds. The figure shows the replacement of pearl millet with other cereals

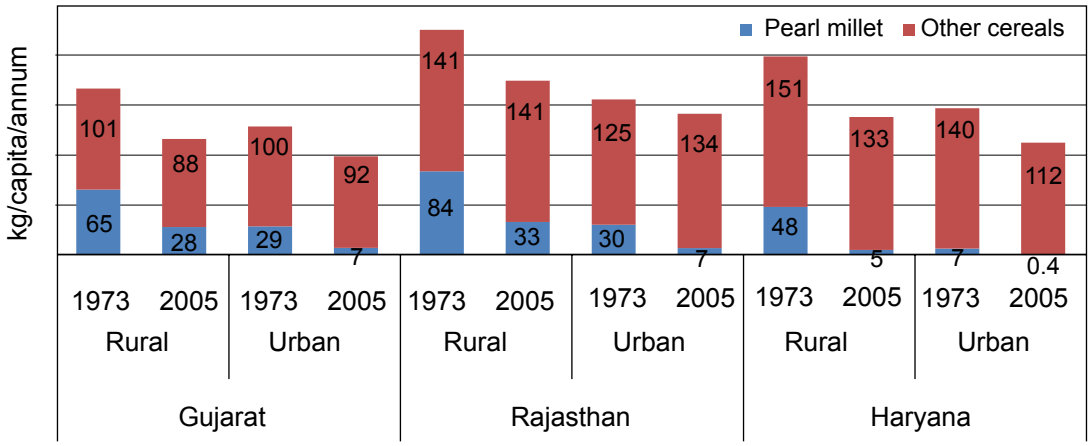


Figure 3. Consumption of pearl millet and other cereals.

(mainly wheat) in Haryana as households became richer due to green revolution leading to higher production and consumption of wheat. The figure also shows significant differences in consumption among states and within state between rural and urban areas. In 2004/05 per capita consumption in rural Gujarat (28 kg/annum) and rural Rajasthan (33 kg) is much higher than per capita consumption in rural Haryana (5 kg), urban Gujarat (7 kg) and urban Rajasthan (7 kg) compared to just 0.4 kg/annum/capita consumption in urban Haryana. One of the reasons for the decrease in relative consumption of pearl millet is decrease in prices of wheat and paddy, which makes them more affordable to a large population. The government's subsidy scheme for wheat and paddy is another reason for the decrease in pearl millet consumption.

Table 1 depicts the changes in real prices and production for pearl millet and its competing crops between TE 1969 and TE 2009. The price trends show that pearl millet prices are moving in line with maize, sorghum and wheat, but its prices are lower than all the competing crops. Real prices of pearl millet in TE 2009 are lower compared to maize and wheat due to decline in demand for food consumption since 1970s. Due to the lower prices of pearl millet compared to competing grains like broken rice, maize and sorghum, there is a possibility of increasing demand for pearl millet grain for non-food uses (like feed, alcohol industry) in future as revealed by brewery industry representatives in Haryana. However, since 2001, the prices of pearl millet are moving up steeply along with other food grains due to the general rise in price trend of food grains and the expansion of demand from the poultry and cattle feed industries and also the alcohol/starch industry (Ronald Trostle 2008).

Table 1. Trends in real prices (Rs/quintal).

Crop	% change in price between 1969-2009 (in 1986-87 constant prices)	% change in production between 1969 and 2009	Yield TE 2009 (kg/ha)	MSP (Rs/q) in 2011	Wholesale price in 2011 (Rs/q)
Maize	-18.9	214	2251	980	1100
Pearl millet	-17.4	29	957	980	871
Sorghum	-6.3	91	981	980	1225
Wheat	-10.2	405	2806	1285	1450
Pigeonpea	42.0	63	715	3200	2200

Source: Authors calculations from Directorate of Economics and Statistics 2011.

Overall, in western India, about 38% of the total cereal area is under pearl millet in TE 2009, which is equivalent to 16% of Gross Cropped Area (GCA). Area under pearl millet is about 7.3% of GCA (25% of total cereal area) in Gujarat, 9.6% of GCA (14% of cereal area) in Haryana and 22.9% of GCA (53% of cereal) in Rajasthan. There are very few studies that have examined supply and demand conditions of minor crops in general (Reddy 2011, Reddy and Reddy 2010, Reddy 2009) and coarse cereals in particular. Keeping the importance of pearl millet in total cereal area and GCA and its importance as dual purpose crop to meet the food, feed and fodder demand in western India, this paper tries to examine (i) changing pattern of pearl millet demand in western India (ii) what are the past trends in supply of pearl millet grain and fodder and projected supply to 2020. (iii) What is the expected demand for the year 2020 and (iv) estimate demand and supply gap by 2020 for grain and fodder.

Methodology for estimating demand and supply

Pearl millet grain and stover production were projected based on historical growth rates of production from 1997 and 2009 and the same extended until 2020, while food demand was projected based on population projections for 2020 by maintaining 2004-05 per capita consumption. The demand for alternative uses was estimated based on growth in poultry and alcohol sectors and competitiveness of pearl millet with alternative grains. The demand for dry fodder is based on the livestock census 2007 and feed ration based on Dikshit and Birthal (2010) supplemented by field survey data under the *Harnessing Opportunities for Productivity Enhancement of Sorghum and Millets in Sub-Saharan Africa and South Asia* (HOPE) project in western India and historical growth rates of livestock population. The demand for food is taken from the historical growth rates of per capita consumption in three states for rural and urban separately. The historical population growth rates for each state were also considered while calculating the growth in food demand. For cattle feed, poultry feed, alcohol and starch industry, and seed requirement, the primary survey collected under the HOPE project are used. As part of the HOPE project, field surveys were conducted in sub-Saharan Africa (SSA) and South Asia (SA). Under this project, market surveys have been conducted from farmers, processors, input and output dealers in three western Indian states, namely Gujarat, Haryana and Rajasthan. Markets were selected from the districts where the project has its pilot sites. These include Patan and Banaskantha in Gujarat, Jodhpur and Naguar in Rajasthan and Mahendergarh and Bhiwani in Haryana. The sampling framework is given in Figure 4. Based on the survey, the total demand for cattle feed (including all sources like paddy and wheat straw, maize and pearl millet stover) and poultry feed were estimated. Following this, the contribution of pearl millet in total demand was calculated based on field surveys. The demand for cattle feed (about 20% of total concentrate in Gujarat, 20% in Haryana, and 30% in Rajasthan) and poultry feed (about 60% of total concentrate in Gujarat, 70% in Haryana, and 70% in Rajasthan) were met by pearl millet. The alcohol and starch industry demand for pearl millet was estimated based on historical average growth rates, which was found to be at 6% per annum (with base year pearl millet grain utilization in industry as 5%, 12% and 10% of grain production in Gujarat, Haryana and Rajasthan). The demand for seed requirement was based on existing seed rate of 4 kg/ha, the same is projected taking the projected area under pearl millet in 2020. Total grain demand (food, feed, alcohol, seed purposes) and dry fodder demand (based on the field survey, about 10% of total feed requirements are met by pearl millet in Gujarat, 25% in Haryana, and 30% in Rajasthan) was projected for the year 2020.

Supply

On the assumption of business as usual (forecasting supply of pearl millet grain and stover based on historical growth rates from 1997-2009), the annual compound growth rates of production of kharif (-0.61%) and summer pearl millet (-0.34%) in Gujarat were used for forecasting production for 2011 and 2020 with TE 2009 as base year. In the case of Haryana (3.23%) and Rajasthan (5.29%), only yield growth rate was considered to forecast production (Table 2) as it was assumed that the area contribution to production growth would be negligible (assumed zero) in future. This was done since the focus group discussions had revealed that the sustained growth in area under pearl millet is difficult to achieve. The stover production was forecasted based on expected growth rates in production of grain. It was assumed that the stover productivity was at 2.5 times that of grain yield, and it was the same across all states and seasons, which was the average of the previous five years' stover to grain yield ratio calculated from cost of cultivation data for all three states (Directorate of Economics and Statistics 2011).

Table 2. Growth rates of pearl millet area, production and yield (1997-2009).

	Gujarat (*kharif*)	Gujarat (summer)	Gujarat (total)	Haryana	Rajasthan	Western India
TE 2008 (mean)						
Area (1000 ha)	762.00	163.00	925.00	614.00	4973.00	6512.00
Production (1000 t)	790.00	343.00	1133.00	955.00	3468.00	5555.00
Yield (kg/ha)	1040.00	2073.00	1225.00	1546.00	696.00	852.00
ACGR 1995-2009						
Area (%)	-1.52	-0.21	-1.30	0.45	1.16	0.71
Production (%)	-0.61	-0.34	-0.64	3.67	6.45	4.22
Yield (%)	0.92	-0.12	0.66	3.23	5.29	3.51

Source: Directorate of Economics and Statistics 2011.

Food demand

Food demand estimates for the year 2011 and 2020 were projected based on the per capita consumption in the year 2004/05 based on NSSO 61st round and the census population for the year 2011 and projected population for the year 2020 (National Commission on Population, 2006). It was assumed that the per capita consumption of 2004/05 levels would be maintained by both urban and rural populations in 2011 and 2020. This assumption was based on the recent policy development that the introduction of pearl millet in the PDS through the Food Security Bill (2011) arrests the decline in the per capita consumption over the period. The projected population and per capita consumption in each state is given in Table 3.

Table 3. Population projections and per capita consumption of pearl millet.

State	Urban/Rural	Population (million) 2011	Population (million) 2020	Consumption in TE 2004/05 (kg/capita/annum)
Gujarat	Urban	25.7	28.2	7.3
	Rural	34.7	37.3	28.1
	Total	60.4	65.5	19.2
Haryana	Urban	8.8	11.1	0.4
	Rural	16.5	17.9	5.0
	Total	25.4	29.0	3.4
Rajasthan	Urban	17.1	18.7	6.9
	Rural	51.5	58.0	33.0
	Total	68.6	76.8	26.5
Western India	Urban	51.6	58.0	6.0
	Rural	102.7	113.3	26.8
	Total	154.4	171.3	19.9

Source: GOI 2011, population projections are based on report of the technical group on population projections.

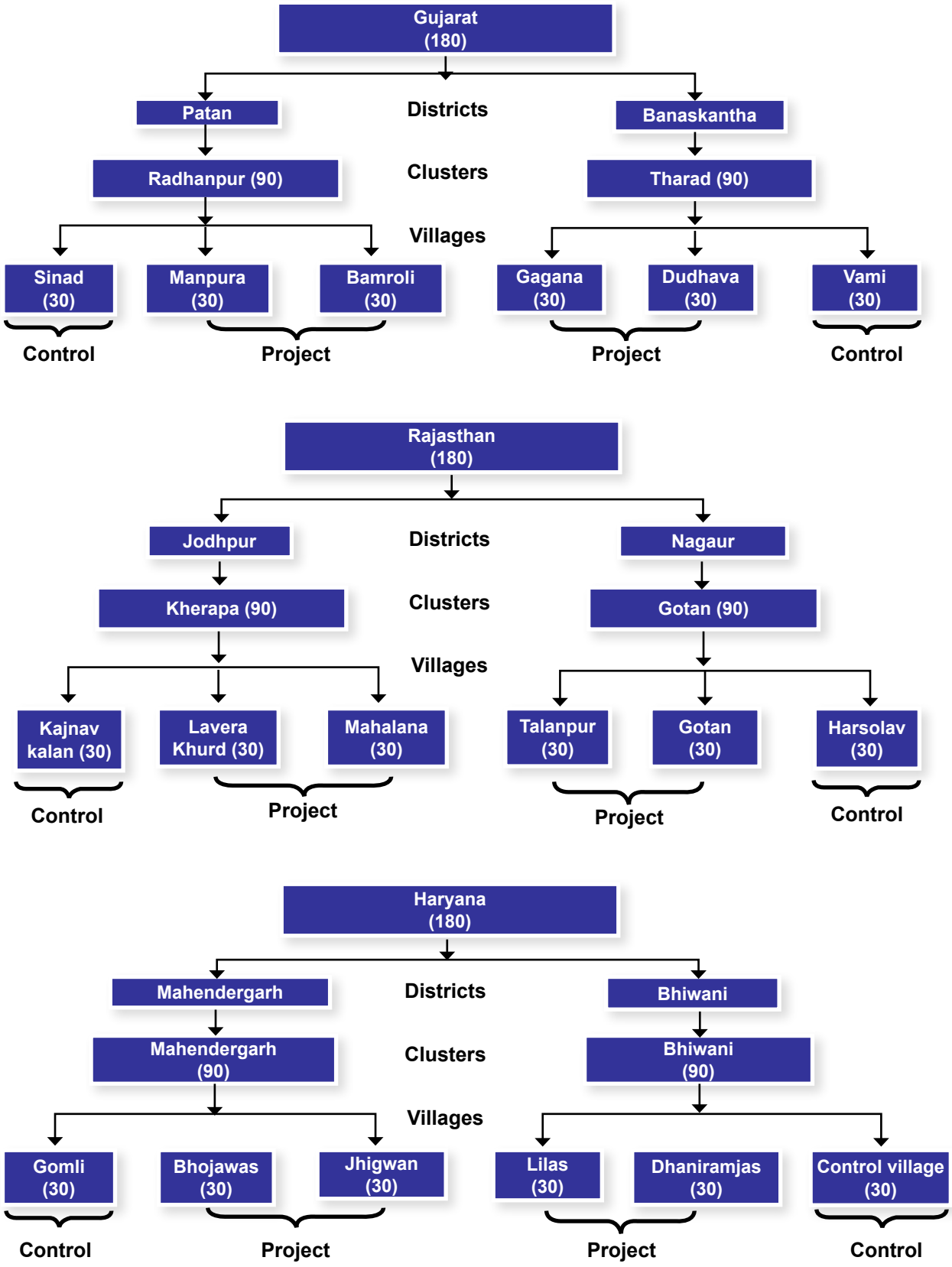


Figure 4. Sampling framework and number of farmers from which data has been collected.

Demand for feed (cattle and poultry) and dry fodder (stover)

Potential demand for feed and fodder uses of pearl millet (Gujarat, Haryana and Rajasthan) was estimated based on consumption requirements of livestock population in the year 2007 and projected for 2011 and 2020. It was assumed that the consumption per animal would be same for all the years. Conventionally, livestock feed is classified into roughages (green and dry fodders) and concentrates. We have estimated only demand for dry fodder and concentrates as data on area and production of green fodder from pearl millet are not available. Dry fodder includes crop residues, most of which are cereal straws, pulses and other legume crops like groundnut that contribute to dry fodder. Sources of dry fodder may include (i) cultivated dual purpose crop residues, and (ii) roughages gathered from different sources. Concentrate feed includes (i) food grains and their preparations, such as flour; and byproducts of milling and household processing, like husk, bran, *khuddi/chunni* (minutiae of broken grains not fit for human consumption), (ii) oilseeds, oil cakes and meals, and (iii) manufactured feeds. Table 4 presents all-India feed consumption rates of different types of feed fed to different categories of livestock at the household premises. The per day mean consumption of green fodder was 5.96 kg for a buffalo in-milk, 5.44 kg for a dry buffalo, 4.06 kg for an adult male buffalo and 2.29 kg for a young one (average for heifers and calves). The corresponding consumption rate of dry fodder was 6.34 kg for a buffalo in-milk, 4.95 kg for a dry buffalo, 7.47 kg for an adult male buffalo and 2.22 kg for young stock. The consumption rate of concentrate feed, which is essential for the animal's growth and production, was estimated as 1.05 kg for a buffalo in-milk, 0.52 kg for a dry buffalo, 0.36 kg for an adult male buffalo and 0.19 kg for a young one. These consumption rates, for any kind of feed, were lower for their counterparts of different categories of cattle, and the difference is larger in the case of in-milk and dry animals, especially for concentrate feed. There was hardly any difference in the feeding rates of young stock of buffalo and cattle. Feed consumption rates of different feeds were slightly higher for goats than for sheep (for details, Dikshit and Birthal 2010).

The state wise and animal category wise consumption demand based on the above statistics for western India is also given in Table 4. The demand for feed and stover is estimated based on consumption estimates of animals taking 2007 as base year (livestock census, 2007) and projected to increase by 3% per annum. Feed demand from the poultry industry is estimated by assuming 5% annual compound growth rate with base year 2007. After getting the overall demand for feed concentrate from all sources, the demand for pearl millet cattle feed is estimated by assuming that pearl millet constitutes 20% of concentrate in Gujarat and Haryana and 30% in Rajasthan. While estimating the pearl millet demand for poultry feed, we assume that 60% of total poultry concentrate in Gujarat (grain component), and 70% in Haryana and Rajasthan is contributed by pearl millet grain. While estimating demand for dry fodder of pearl millet, we assume that 10% of total dry fodder demand will be met by pearl millet in Gujarat, 25% in Haryana and 30% in Rajasthan. The above share is estimated based on field survey conducted in three states under the HOPE project.

Demand from breweries industry and non-food industry

Among alternative uses (besides food and feed), pearl millet grain is mostly used in the breweries industry as a source of starch. Demand from the breweries industry is assumed to grow by 6% per annum, with base year consumption as 5% of production in Gujarat, 12% of production in Haryana and 10% of production in Rajasthan based on the focus group discussions with industry

Table 4. Feed demand estimates of feed, green fodder and stover in western India in 2007.

	Cattle				Buffalo							
	In-milk	Dry	Adult male	Young	In-milk	Dry	Adult male	Young	Goats	Sheep	Others	Poultry
Livestock Population (million)												
Gujarat	1.73	1.09	2.62	2.53	3.04	1.79	0.17	3.77	4.64	2	0.1	13.4
Haryana	0.42	0.24	0.31	0.58	1.99	0.91	0.14	2.91	0.54	0.6	0.08	28.8
Rajasthan	3.22	2.3	2.08	4.53	3.93	1.89	0.1	5.17	21.5	11.19	0.55	14.4
Western India	5.37	3.63	5	7.64	8.96	4.6	0.4	11.86	26.68	13.79	0.73	56.5
Feed consumption rates including intake through grazing (kg/animal/day)												
Green fodder	5.9	4.7	7.1	4	8.9	9.7	7.1	6.1	1.5	1.7	1.5	
Dry fodder	5.5	4	6	2.1	6.3	5	7.5	2.2	0.2	0.2	0.2	
Concentrates	0.6	0.4	0.3	0.2	1.1	0.5	0.4	0.2	0.1	0	0.1	
Total consumption of green fodder (in 1000 t/annum)												
Gujarat	3742	1861	6817	3643	9877	6347	439	8405	2540	1205	56	
Haryana	914	407	795	842	6456	3244	361	6484	295	362	41	
Rajasthan	6954	3904	5394	6532	12764	6722	250	11515	11773	6739	301	
Western India	11610	6172	13006	11017	29097	16313	1051	26404	14608	8307	398	
Total consumption of stover (in 1000 t/annum)												
Gujarat	3476	1605	5773	1965	7036	3232	462	3059	339	139	7	
Haryana	850	351	673	454	4599	1652	380	2360	39	42	5	
Rajasthan	6460	3368	4569	3522	9093	3423	263	4191	1570	776	40	
Western India	10786	5324	11015	5941	20727	8307	1104	9609	1948	957	53	
Total consumption of concentrates (in 1000 t/annum)												
Gujarat	404	160	316	166	1165	340	22	262	102	29	2	148
Haryana	99	35	37	38	762	174	18	202	12	9	2	319
Rajasthan	752	335	250	298	1506	360	13	359	471	163	12	159
Western India	1255	530	603	502	3433	873	53	822	584	201	16	626

users, traders and farmers through participatory rural appraisal under the HOPE project. These figures are marginally above the figures provided by the FAOSTAT statistics, which indicates that the other uses (all non-food uses) for pearl millet are around 8-10% of total production and it is constant over the period. The increased demand for pearl millet grain for alternative uses (for example, as ingredient in preparation of beer in breweries industry, use as ingredient in poultry and cattle feed industry) since the last decade needs to be effectively met through increased supply of grain at competitive prices through innovative value chain models that link farmer with industry.

Demand for seed

Seed demand was estimated by multiplying the current seed rate of 4kg/ha with the projected area under pearl millet for all the years.

Results

Supply projections of grain and stover

Area under pearl millet increased in Rajasthan (1.16% per annum) and Haryana (0.45%), while it decreased in Gujarat (-1.3%) (Table 2). Growth in yields are also quite high (5.29%) in Rajasthan, even though yield levels are quite low (only 696 kg/ha). Even though yield is much higher for summer pearl millet in Gujarat (2073 kg/ha) compared to kharif (1040 kg/ha), expansion of area is not catching up due to competition from other irrigated crops. It is important to increase production where yields are higher and cost of production is lower to position pearl millet with other competing cereal crops like maize and even broken rice to compete as raw material for the alcohol industry. In view of the less scope for expansion of pearl millet area, most of the future production growth should come from yield increase, especially from Rajasthan.

The projected supply for the year 2011 and 2020 for grain and stover is presented in Table 5. The base year (TE 2008) production of pearl millet grain is 1,101 thousand tons in Gujarat, 970 thousand tons in Haryana and 3,823 thousand tons in Rajasthan. The projected production of grains is 8,896 thousand tons, which is an increase of 43% by 2020 in western India. The projected supply of pearl millet stover is 15.53 million ton (mt) in 2011 and it will be increased to 22.24 million ton by 2020.

Table 5. Supply projections of pearl millet grain and dry fodder.

Year	Gujarat (Kharif)	Gujarat (Summer)	Gujarat (Total)	Haryana	Rajasthan	Western India
Grain supply (1000 t)						
2011	776.00	339.00	1115.00	1050.00	4047.00	6212.00
2020	734.00	329.00	1063.00	1398.00	6435.00	8896.00
Dry fodder supply (mt)						
2011	1.94	0.85	2.79	2.63	10.12	15.53
2020	1.84	0.82	2.66	3.49	16.09	22.24

Demand Projections

Food demand

Food demand was estimated to be stagnant at 3,393 thousand tons (compared to 3,067 thousand in 2011) even by 2020, of which 60.3% would be from Rajasthan, followed by 37% in Gujarat and only 2.8% from Haryana. 90% of the food use will be contributed by rural areas and only 10% will be contributed by urban areas in western India (Table 6).

Table 6. Food demand projections.

State/area	Consumption (1000 t) 2011	Consumption (1000 t) 2020	% share in total demand
Gujarat			
Urban	187.7	206.0	6.1
Rural	974.2	1048.3	30.9
Total	1162.0	1254.4	37.0
Haryana			
Urban	3.5	4.4	0.1
Rural	82.7	89.7	2.6
Total	86.2	94.1	2.8
Rajasthan			
Urban	117.9	129.1	3.8
Rural	1700.8	1915.5	56.5
Total	1818.7	2044.6	60.3
Western India			
Urban	309.1	339.6	10.0
Rural	2757.7	3053.5	90.0
Total	3066.8	3393.1	100.0

Demand for cattle and poultry feed and dry fodder from all sources

Table 7 depicts state-wise aggregate feed and dry fodder demand. Demand for pearl millet grain for cattle feed was found to be increasing and high in Rajasthan (6,634 thousand t), followed by Gujarat (4,358 thousand t) and Haryana (2,036 thousand t) by 2020, while demand from poultry

Table 7. Demand projections for feed and fodder from all sources

Source	Year	Gujarat	Haryana	Rajasthan	Western India
Demand for grain from cattle feed concentrate (1000 tons)	2011	3341	1561	5085	9987
	2020	4359	2036	6634	13029
Demand for concentrate from poultry industry (1000 tons)	2011	180	388	194	762
	2020	279	601	301	1181
Demand for dry fodder (million tons)	2011	30	13	42	85
	2020	40	17	55	112

Note: Demand for grain from cattle feed concentrate (based on 3% ACGR of cattle population), demand for concentrate from poultry industry (based on 5% ACGR of poultry population), demand for dry fodder (based on 3% ACGR of cattle population)

feed industry was found to be small, with higher share in Haryana (601 thousand t), followed by Rajasthan (301 thousand t) and Gujarat (279 thousand t).

The demand for dry fodder from all sources was 55 mt in Rajasthan, followed by Gujarat (40 mt) and Haryana (17 mt). As the demand for cattle feed is met by different sources (sorghum, maize, wheat and rice bran), it was assumed that the pearl millet share was 20% in both Gujarat and Haryana and 30% in Rajasthan, which was derived from a survey from all stakeholders. While major sources of ingredients of poultry feed are sorghum, pearl millet, maize, and soybean, after discussions with poultry farmers it was found that pearl millet constitutes 60% of poultry concentrate in Gujarat, 70% both in Haryana and Rajasthan, while major sources of dry-fodder are wheat and paddy straw in addition to pearl millet stover. After consulting with local farmers, it was assumed that 10% dry fodder demand will be met by pearl millet in Gujarat, 25% in Haryana and 30% in Rajasthan.

Demand for pearl millet grain and fodder

After taking into account the other sources of supply of feed (sorghum, maize, rice bran, etc) and fodder (paddy and wheat straw, which are locally produced), demand estimates of pearl millet grain and fodder from feed (cattle and poultry feed), alcohol industry and seed purpose is given in Table 8. In western India, in 2011, food needs are a major source of demand for pearl millet grain followed by cattle feed, alcohol industry, poultry industry and lastly the seed requirements. However, by 2020, the cattle feed industry will be the major user of the grain followed by food uses, the alcohol industry and the poultry industry. The total grain demand increased from 1,997

Table 8. Demand for pearl millet grain and dry fodder.

Grain/fodder	Year	Gujarat	Haryana	Rajasthan	Western India
Cattle feed (1000 t)	2011	668.00	312.00	1525.00	2505.00
	2020	872.00	407.00	1990.00	3269.00
Poultry feed (1000 t)	2011	108.00	271.00	136.00	515.00
	2020	168.00	421.00	211.00	800.00
Alcohol and starch industry (1000 t)	2011	56.00	126.00	405.00	587.00
	2020	94.00	213.00	684.00	991.00
Demand for seed requirement (1000 t)	2011	3.60	2.50	19.90	25.90
	2020	3.20	2.50	19.90	25.50
Total grain demand (food, feed, alcohol, seed purposes) (1000 t)	2011	1997.00	798.00	3904.00	6699.00
	2020	2391.00	1138.00	4949.00	8478.00
Dry fodder demand (million tons)	2011	3.05	3.21	12.59	18.84
	2020	3.98	4.19	16.42	24.59

Note:
1. Demand for cattle feed (assuming 20% of concentrate in Gujarat, 20% in Haryana, 30% in Rajasthan is pearl millet),
2. Demand for poultry feed (assuming 60% of concentrate in Gujarat, 70% in Haryana, 70% in Rajasthan is pearl millet),
3. Demand for alcohol and starch industry (alcohol industry demand growth @ 6% per annum (started from 5%, 12% and 10% of production in Gujarat, Haryana and Rajasthan, respectively),
4. Demand for seed requirement (assuming 4kg/ha seed rate),
5. Total grain demand including food, feed, alcohol, seed purposes;
6. Demand for dry fodder (assuming 10% in Gujarat, 25% in Haryana, 30% in Rajasthan is pearl millet).

thousand ton to 2,391 thousand ton in Gujarat, from 798 thousand ton to 1138 thousand t in Haryana and 3,904 thousand ton to 4,949 thousand ton in Rajasthan from 2011 to 2020. Taken together, in western India grain demand is projected to increase from 6,700 thousand ton in 2011 to 8,478 thousand ton by 2020. The demand for pearl millet dry fodder is higher in Rajasthan (12.59 mt) followed by Gujarat (3.05 mt) and Haryana (3.21 mt) in 2011. Overall, in western India the demand for pearl millet dry fodder is projected to increase from 18.84 mt in 2011 to 24.59 mt in 2020. Further, decline in area under permanent pastures and grazing land, and stagnation in area under cereals, which are major sources of fodder, will contribute to the growing demand for pearl millet fodder in the future.

Supply and demand gap

Demand and supply projections showed that there was a deficit of about 7% in pearl millet grain production in western India to maintain the 2004/05 levels in food consumption and to meet the growing livestock feed demand. However, by 2020 it was projected that there would be surplus grain production to the extent of 5% of the demand due to productivity increase. Most of the grain deficit would be in Gujarat state. For dry fodder the deficit was found higher at 18% in 2011, but would be reduced to 10% by 2020. In 2011, there was about 20% deficit of dry fodder in Rajasthan, 18% deficit in Haryana and 9% deficit in Gujarat (Table 9). Given the growing demand for livestock products (milk, meat and their products), the demand for fodder will increase exponentially in the region. Fodder availability in Gujarat and Rajasthan is 32 kg/animal/day and 26 kg/animal/day, respectively, compared to the all-India average of 44 kg/animal/day. There would be a huge gap between supply and demand (shortage) for fodder in these three states in western India by 2020. Local prices of dry fodder vary between Rs 200 and 500 per quintal based on source, season and variety. Wheat straw generally fetches higher prices than pearl millet stover. Local informal commission agents facilitate fodder trading with 0.5 to 1% commission on trade value of fodder. Color, size, moisture, softness, purity, cleanliness and variety are some of the parameters that are taken into account during negotiation and price determination of fodder. Fodder having uniform color, thin stalk and bright lustre is preferred. More fodder quantity with leaves, storability of fodder and palatability (quality and taste) are important factors in determining the price of fodder.

Table 9. Demand supply gap (deficit) in pearl millet grain and fodder.

	Year	Gujarat	Haryana	Rajasthan	Western India
Demand supply gap in grain (1000 ton)	2011	-882.00	252.00	143.00	-487.00
	2020	-1327.00	260.00	1486.00	419.00
Demand supply gap in dry fodder (million ton)	2011	-0.26	-0.58	-2.47	-3.31
	2020	-1.32	-0.69	-0.33	-2.35
Grain deficit as % of demand	2011	-44.00	32.00	4.00	-7.00
	2020	-56.00	23.00	30.00	5.00
Dry fodder deficit as % of demand	2011	-9.00	-18.00	-20.00	-18.00
	2020	-33.00	-17.00	-2.00	-10.00

Note: Positive figures indicate surplus, negative figures indicate deficit.

Overall, in 2011, 45.6% of production of pearl millet grain goes for food use, 37.5% for cattle feed, 7.7% as poultry feed, 8.8% to alcohol industry and only 0.4% for seed purpose (Table 10). The projected relative shares of different uses by 2020 shows that the share of cattle feed will be increased to 38.6%, share of poultry feed will be increased to 9.4%, share of alcohol industry and other non-food uses will be increased to 11.7%, while food uses will decrease to 40%. The food share is high in Gujarat and Rajasthan, while share of cattle feed and poultry feed is much higher in Haryana. Even though there is not much use of pearl millet grain in the alcohol industry at present, there is good potential in future, given the rising prices of alternative stalks like sugarcane (molasses), broken rice and maize. State wise demand projections show that even by 2020 in Gujarat, food and feed (cattle) are major contributors to demand. Cattle feed, poultry feed and alcohol industry are major drivers of demand growth in Haryana, while in Rajasthan cattle feed and food consumption together contribute to larger share of demand.

Table 10. Share (%) of different uses of pearl millet grain in 2011 and 2020.

Year	Utilization	Gujarat	Haryana	Rajasthan	Western India
2011	Food grain	58.1	10.6	46.3	45.6
	Cattle feed	33.5	39.2	39.3	37.5
	Poultry feed	5.4	34.1	3.5	7.7
	Brewery and other non-food uses	2.8	15.8	10.4	8.8
	Seed	0.2	0.3	0.5	0.4
	Total	100.0	100.0	100.0	100.0
2020	Food grain	52.5	8.3	41.3	40.0
	Cattle feed	36.5	35.8	40.2	38.6
	Poultry feed	7.0	37.0	4.3	9.4
	Brewery and other non-food uses	3.9	18.7	13.8	11.7
	Seed	0.1	0.2	0.4	0.3
	Total	100.0	100.0	100.0	100.0

Some micro issues

Cattle feed industry

Pearl millet is a high protein and low calorie grain compared to maize for preparation of cattle and poultry feed. Its protein has more lysine, methionine and tryptophan than other food grains. Pearl millet contains more thiamin (Vitamin B1) and iron compared to other cereals and is the cheapest source of iron and zinc (Parthasarathy Rao et al. 2006). The cattle feed industry is composed of both small and large plants, some large feed manufacturers have a capacity of 600 tons/day with an annual capacity of 120,000 t/annum; however, they mostly use maize and sorghum as feed ingredients. Because of the small size of the pearl millet grain, grinding is difficult and it adversely affects the palatability and digestibility of feed. In addition, pearl millet grain is palatable to cattle only if it is pre-boiled, which is not a general practice and not inbuilt in the feed manufacturing plants. However, the demand for feed is growing from dairy farms due to increased

demand for milk, leading to increase in milk animals. For example, Banas dairy maintained by Banaskantha district cooperative in Gujarat increased its size from 100t/day in 1980 to 600t/day in 2009. Similarly, many factories have reported an increase in the production capacity. Most of the small/medium scale plants are engaged by the Banas dairy for manufacture of feed on contract basis with specific quality parameters that specify the proportion of different ingredients. Banas dairy produces many different branded feed products with different composition of ingredients. The share of raw material (rice bran, maize, rice polish, pearl millet, etc) cost is about 90% of the production cost of feed manufacturers. The proportion of feed ingredients and substitution among them depends on their relative prices. Feed manufacturers use about 5-10% pearl millet as ingredient in feed concentrate; there is a possibility that the share of pearl millet can be increased to 15%, if prices of pearl millet are sufficiently lower than its competing grain substitutes like maize and sorghum. According to feed millers, pearl millet is included in feed rations mainly due to its low cost compared to maize and sorghum. Among many reasons, low storability and small grain size of pearl millet grain are the reasons for non-inclusion of pearl millet grain by large millers. The adjustment of machinery that suits different grain sizes will greatly improve the use of pearl millet grain as feed ingredient.

Poultry industry

There are many poultry feed manufacturers in western India especially in Haryana. There are many small scale poultry feed manufacturers with a capacity of 5 to 10 t/day. The price of maize (Rs 11/kg) is more than that of pearl millet (Rs 8/kg). The ingredients of feed concentrate for broilers contain maize (55%), soya (25%), pearl millet (10%) and rice bran (10%), while ingredients of feed concentrate for layers includes pearl millet (30%), maize (30%), soya (25%) and rice bran (15%). The sale price of feed concentrate is Rs 16 to 17/kg. At poultry farms, farmers mix pearl millet with feed concentrate in a 2:1 ratio for preparation of feed ration just before feeding.

Breweries / Distilleries

A significant portion of pearl millet, especially lower quality, and blackened grain (including severely blackened) is used in Haryana and Rajasthan for manufacture of alcohol. The distilleries prefer varieties with higher starch and less protein content. Distilleries purchase kharif season pearl millet from traders and brokers in the main producing centers and also from the secondary market, as the prices are low. In Haryana, there are 8 distilleries, which were mostly commissioned in early 1990s. Out of 8 distilleries, 6 are using broken rice or pearl millet. From each distillery, 48,000 t/annum demand exists for grain. Currently, mostly barley and potato are used in alcohol making. Some prefer broken rice over pearl millet as the former contains more starch (66-70%) than the latter (55-60%). However, whenever the prices are lower for pearl millet, ie, below Rs 8000/t compared to Rs 10,000/t for broken rice, they used pearl millet (Table 11). Sorghum, barley and potato are used in beer making, while pearl millet and broken rice are used in whisky preparation. Distilleries prefer any material that contains high starch for making alcohol. Now increasingly, many distilleries are shifting from sugarcane molasses to pearl millet as ingredient. Distilleries are willing to pay a premium (or willing to undertake contract farming with farmers) for varieties with high starch (>65%) content. Keeping the demand, summer pearl millet is more suitable for contract farming, since with assured irrigation there would be less supply uncertainty for both farmers and distilleries. Distilleries buy through brokers after examining the quality for starch content and moisture content (12% for pearl millet, <10% for rice).

Table 11. Cost-benefit analysis of alcohol production with pearl millet.

Item	Pearl millet	Broken rice
Price (Rs/t)	8000	10000
Rs/kg starch	13.7	14.7
Concentrate (96% alcohol) (l/t)	380	433
Concentrate production value (@32/l) price varies between Rs 30-Rs 35/l	12160	13856
Profit (Rs/t)	4160	3856
Solid content (used as cattle feed)	Rs 1.5/kg	Rs 2/kg
Processing cost (Rs/l)	5	5

Starch Industries

Some starch manufacturers have used pearl millet whenever there is a shortage of maize and sorghum in the markets. Mostly, starch manufacturers are not in favor of pearl millet as raw material, as starch content is low and crude protein content is high. The pearl millet grain contains 11.5% crude protein and 2900 kcal metabolizable energy (ME) as against 9% crude protein and 3330 kcal ME in maize (Prasad and Panwar 1997). Hence, the quality of the end product will be affected. Mostly, the surplus summer pearl millet production in Gujarat will move to Rajasthan although in small quantities, while the kharif harvest will move from Rajasthan to Gujarat for cattle feed. If prices of sorghum and maize go substantially above pearl millet, most of the pearl millet market arrivals will be purchased by feed manufacturers or large dairy farm holders.

Policy options and limitations

To meet the growing demand for pearl millet grain and fodder the current high yield levels need to be maintained and sustained since increase in production through area expansion is limited. To sustain the high yields and in view of the declining food use of pearl millet grain, the Government has announced an allocation of Rs 300 crores under Rashtriya Krishi Vikas Yojana for promotion of millets as Nutri-cereals. Scheme on Initiative for Nutrition Security through Intensive Millets Promotion (INSIMP) has been formulated since 2011 (AICPMIP 2011). The scheme aims to demonstrate the improved production and post-harvest technologies in an integrated manner with visible impact to catalyze increased production of millets in the country. Besides increasing production of millets, the Scheme through processing and value addition techniques is expected to generate consumer demand for millet based food products.

The shortage of dry and green fodder requirements could be met by cultivating pure fodder pearl millet crop. Pearl millet sole crop grown for grain on average yields 25 t/ha green fodder (which is equivalent to 2.5 to 3 t dry fodder), 2-2.5 t/ha grain, while, the crop grown purely for fodder yields about 40 t/ha of green fodder (equivalent to 4 t of dry fodder). However, pure fodder purpose crop is not common in western India particularly under rainfed conditions. Some efforts need to be made to promote pearl millet fodder crop with limited irrigation.

Both grain and stover of pearl millet have a better mineral profile than many other cereals. However, the bioavailability of these minerals is low because of the presence of some inherent anti-nutritional factors, for example, phytate, and polyphenols in grain; and oxalic acid in fodder and forage. Its flour acquires a rancid odour within a few days of milling because of high concentration of lipids that contribute to the development of fat acidity, lipolytic activity and accumulation of peroxides of lipids in the meal during storage (AICPMIP 2011). The typical grey color of pearl millet grain and its products due to polyphenolic pigments present in the peripheral area of the endosperm further restricts efficient utilization of pearl millet. However, several processing techniques have been developed to enhance food value and shelf-life of pearl millet products and to improve the availability of starch, protein and minerals.

Malting reduces anti-nutritional factors and imparts desirable flavor and taste. The shelf life of pearl millet flour is also increased by malting as this lowers the levels of lipids that are responsible for off-flavors. Blanching and heat treatment improve the storability and stability of flour. Acid treatment of grain may bleach grey color, remove anti-nutritional factors and improve digestibility and shelf life of pearl millet flour. A wide range of value-added products may be prepared from pearl millet processed flour.

Formulation of poultry feed using pearl millet may help to reduce costs. Pearl millet-supplemented poultry feeds are generally superior to sorghum and equivalent to maize in broiler diets. In general, pearl millet is at least equivalent to maize and often superior to sorghum in cattle, pig and sheep rations because of its high energy and grain protein levels. Similarly, its grain, as a high-energy alternative source of inexpensive feed, could be exploited and utilized in aquaculture production also.

To address the bulk grain demand from breweries industries, there is a need for development and up scaling of low cost innovative value chains to link widely dispersed farmers with the brewing industry. To meet the brewing industry demand it is also important to expand the cultivation of pearl millet in summer season, wherever feasible as the productivity of summer crop is about three to four times higher than the *kharif* crop. There is more scope for contract farming in the case of summer pearl millet, in view of its high-input and high-output production system, which provides favorable conditions for contract between farmers and industry.

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www.icrisat.org

Contact Information

ICRISAT-Patancheru (Headquarters)
Patancheru 502 324
Andhra Pradesh, India
Tel +91 40 30713071
Fax +91 40 30713074
icrisat@cgiar.org

ICRISAT-Liaison Office
CG Centers Block
NASC Complex
Dev Prakash Shastri Marg
New Delhi 110 012, India
Tel +91 11 32472306 to 08
Fax +91 11 25841294

ICRISAT- Kano
PMB 3491
Sabo Bakin Zuwo Road,
Tarauni, Kano, Nigeria
Tel: +234 7034889836;
+234 8054320384
+234 8033556795
icrisat-kano@cgiar.org

ICRISAT-Bamako (Regional hub WCA)
BP 320
Bamako, Mali
Tel +223 20 223375
Fax +223 20 228683
icrisat-w-mali@cgiar.org

ICRISAT-Bulawayo
Matopos Research Station
PO Box 776
Bulawayo, Zimbabwe
Tel +263 383 311 to 15
Fax +263 383 307
icrisatzw@cgiar.org

ICRISAT-Niamey
BP 12404, Niamey
Niger (Via Paris)
Tel +227 20722529,
20722725
Fax +227 20734329
icrisatsc@cgiar.org

ICRISAT-Nairobi (Regional hub ESA)
PO Box 39063, Nairobi,
Kenya
Tel +254 20 7224550
Fax +254 20 7224001
icrisat-nairobi@cgiar.org

ICRISAT-Maputo
c/o IIAM, Av. das FPLM No 2698
Caixa Postal 1906
Maputo, Mozambique
Tel +258 21 461657
Fax +258 21 461581
icrisatmoz@panintra.com

ICRISAT-Lilongwe
Chitedze Agricultural Research Station
PO Box 1096
Lilongwe, Malawi
Tel +265 1 707297, 071, 067, 057
Fax +265 1 707298
icrisat-malawi@cgiar.org

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