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Sorghum Utilization and the Livelihoods of the Poor in India

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**Sorghum Utilisation and the Livelihoods
of the Poor in India: Summary Proceedings
of a Workshop**

4-5 Feb 1999, ICRISAT, Patancheru, India

Edited by

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Section 1

Background

This publication presents the key findings of a major food policy project 'Sorghum utilisation in India' The Project was funded by the Department for International Development (DFID) UK Crop Post-Harvest Programme, it operated from Jan 1997 to Dec 1998.

The Project's purpose was to develop a research strategy for future sorghum postharvest or utilisation research in India. The importance of this task was reflected by the collaboration of six key stakeholders in the sorghum research and development sector in its implementation. These stakeholders included Natural Resources Institute (NRI) UK, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), National Research Centre for Sorghum (NRCS) India, National Centre for Agricultural Economics and Policy Research (NCAP) India, Intermediate Technology Development Group (ITDG) UK, and Indian Grain Storage Management Research Institute (IGSMRI). The Project was managed by A.J. Hall, a science policy specialist from NRI, based at ICRISAT, Patancheru, India. The geographical scope of the Project was Andhra Pradesh (AP), Maharashtra (MA), and Karnataka (KA).

The Project undertook a comprehensive study of sorghum postharvest systems and the factors that condition them. The trends and causal factors in sorghum utilisation were examined. Key constraints were identified. The insight that this gave was used to determine if the resolution of these constraints would ultimately benefit the poor.

This publication presents in Section 2 a review of Project findings and recommendations, and summaries of key components of the research, based on papers presented at a workshop held in Feb 1999 in Section 3. Section 4 lists workshop participants, and Section 5 details the Projects' published and unpublished reports and databases and explains where copies of these can be obtained.

Section 2

Sorghum Utilisation and the Indian Poor : a Review of Findings and Recommendations

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Introduction

Sorghum in India is widely perceived as a crop produced and consumed mainly by the poor. In the past it was assumed that scientific research on the crop would ultimately benefit the poor through improved food security. Research programs at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and national programs in India, have made significant advances in yield improvement and stabilisation through varietal enhancement.

As the agenda of poverty alleviation moves on from achieving food security to encompass the wider livelihood security issues of accessing both food and non-food items, the scientific agenda also needs to be re-examined. Options for alternative utilisation and value-added processing — both potentially beneficial to rural livelihoods — have previously been technically explored. However, sporadic adoption patterns of these types of technology suggests they fit poorly into the needs and agendas of the poor. Generally, stagnant or declining levels of sorghum production and consumption in India suggest that more pervasive economic and social factors are affecting the prospects of improved utilisation. Such factors may even be affecting the overall relevance of the crop to the livelihoods of the poor. Furthermore, this may undermine the assumption that improved markets for the commodity will stimulate the adoption of new production technology, and in this way provide a way to bring about increases in rural productivity.

This suggests that re-examination of the research agenda needs to go beyond revisiting scientific research strategies and priorities. A more fundamental questioning of the underlying assumption that supporting sorghum is analogous to supporting the livelihoods of the poor is required. Only by using this livelihoods framework can potential opportunities be identified and prioritised in the context of options, strategies, and agendas pursued by the poor themselves.

This review presents an overview of a study that attempted to answer these questions by looking at both the technical and non-technical factors affecting improved utilisation. To achieve its goal the study was designed around 5 research components under the following 3 broad themes :

Rural production and consumption

- A participatory rural appraisal (PRA) undertaken to establish the relative importance of sorghum to the livelihoods of the poor and to gain a historical perspective on changes in livelihoods, and the relative importance of sorghum over time.
- A questionnaire survey providing data for farm budget analysis, the quantification of production and consumption patterns over time, and the key factors responsible for change.
- A farm survey of grain quality and postharvest losses to determine their relative importance as factors affecting improved utilisation.

Urban consumption

- A study of factors affecting sorghum consumption in urban areas.
- An analysis of district-level data from the Indian National Sample Survey for patterns of urban and rural consumption over time.

Industrial utilisation

- A study of the potential for industrial utilisation of sorghum, that examines current patterns of utilisation, constraints, and future prospects.

Each of these components represents a major piece of research in its own right and each is reported separately in depth (see Section 5 for full list). The purpose of this review is to present a concise summary of the unfolding sorghum utilisation story in India.

Overview of findings and recommendations for the direction of future research

The findings of this study reveal a pattern of sorghum production and traditional utilisation (food and fodder) that has clearly undergone changes in the past 30 years, particularly during the period up to the early 1990s. Areas of production and human consumption, particularly in urban areas, have declined. However, utilisation by the agro-industrial sector has strengthened and there is indication that demand is likely to grow.

The nature of rural livelihoods

The point of departure was to revisit the underlying assumption of the relative importance of sorghum to the livelihoods of the poor. The study by Hall et al. (2000) began by examining whether the crop only remained important in instances where subsistence production of food and or livestock (with its associated demand for fodder) were the most important livelihood strategy. Alternatively, had the move to cash-based livelihoods reduced the relevance of the sorghum to current livelihood strategies? As might be expected, when the nature of livelihood strategies was examined, it was found, that households followed more mixed strategies than anticipated. Given sufficient resources, household agendas appear to achieve a balance of these strategies. A key finding was that differences in the strategies adopted tended to arise as a result of the resources available to particular households as much as a result of opportunities and constraints arising in specific locations or agro-ecological zones.

For example : it was found that the ability of households to produce enough food for their family needs for the whole year, and the availability of land were primary wealth criteria consistently described in villages. Access to large amounts of better-quality land allowed the rich to produce all their own food for the whole year. In contrast, those households classified as poor could not produce all their own food due to lack of, or poor quality of land. So in actual fact, it was the rich households who were found to be 'subsistence' — in the sense that they produced all the food that they consumed — rather than the poor as had been assumed. The poor, with limited opportunities to produce food, relied to the greatest extent on the market for food and were highly dependant on accessing food via both agricultural and non-agricultural labour. It was also observed that despite limited resources, the poor may eschew food production and engage in cash cropping, as a more efficient way of accessing food via cash.

Ownership of livestock was not restricted to the rich. Although poor households owned less livestock, the relative importance of this livelihood strategy was probably greater for the poor due the use of livestock as a coping strategy in times of distress.

Who are the poor?

Hall et al. (2000) reported that the picture that emerged was one in which the rich — by the villagers' own definition — had the resources to follow a diverse set of livelihood options. In contrast the poor with extremely limited resources still had the overriding concern of accessing sufficient food, by whatever means. What proportion of the rural population do the poor represent? According to landholding size, more than 60% of rural populations are made up of medium – and small-scale farmers, who cultivate less than 40% of land resources. Half of the rural households are small-scale and marginal farmers or landless. Wealth ranking

suggested that the poor by their own definition, i.e., limited access to food and resources — represented 40–50% of households with the medium-wealth groups representing another 30% of rural households.

The poor are clearly the numerically dominant social group in rural society. At the risk of overstating the point, **the rural poor are, at best, marginal farmers, and at worst, landless.** Although those with land do produce some of their own food, agricultural labouring represents a crucial mechanism for achieving a secure livelihood. They are net purchasers of food. They rely on the sustainability of farming systems and the employment they derive from them as much as on any agricultural technology that benefits them directly. It is important to bear this in mind when considering future intervention mediated through a commodity such as sorghum.

Sorghum as food for the rural poor

The relative importance of sorghum as food to rich and poor households also reveals patterns of consumption that demonstrate the divergent strategies adopted by different households. Hall et al. (2000) found that when both rich and poor households are examined together, over half of the total cereal consumption is sorghum. It therefore probably represents half of the cereal consumption of 60 million people in the target states of the study¹. With the exception of rich households in a number of districts that produce hybrid rainy-season sorghum, the crop remain the most preferred food. In the postrainy-season producing areas although both the rich and the poor preferred sorghum, it represented a greater proportion of the diets of the rich than the poor. This reflects the inability of the poor to produce enough of their own food. Food is

1. 15% of gross cropped area was used as a value to represent areas where sorghum was important. These areas were the focus of the conducted field studies. Findings are therefore representative of areas where 15% of the gross cropped area is sorghum.

accessed by these households through the market via cash from on-farm and off-employment, and through the sale of cash crops. The relatively higher price of postrainy-season sorghum results in the poor purchasing alternative cheaper sources of food, particularly pearl millet.

The converse of this situation is observed in rainy-season producing districts. Even though the rainy-season varieties, produce higher yields than those grown in the postrainy season, the poor struggle to produce sufficient food for home consumption. Food is bought for cash as discussed above. However the lower price of rainy-season sorghum results in it playing a greater role in the diets of the poor. In contrast, the rich in these areas consume proportionately more rice and wheat.

These broad patterns of food preference and consumption were conditioned to some extent by access to alternative food crop options. In districts where rice and wheat production was significant — usually as a result of the introduction of irrigation — these cereals were more important in the diet. This is particular so for rich households, but to some extent also true for the poor.

Sorghum as fodder

In the areas studied Hall et al. (2000) found that sorghum stover is the main fodder crop for cattle (dairy and draught animals used for traction) and buffaloes. Estimates of its proportion in total fodder varied, but consistently emerged as at least 50% of livestock diets. Although rice, wheat, and millet straws were proportionately important where available, sorghum stover was constantly indicated to be the most preferred source of fodder.

A comparison of the importance of sorghum stover between the rich and poor relates to the absolute and relative importance of livestock in these two wealth groups. While it is difficult to be categorical about this issue, a number of clear lessons emerge :

- If the poor own cattle, sorghum will be valued as a source of fodder and will play an important role in animal diets
- The poor will use their own fodder if they produce sorghum and they consistently indicate the fodder value of sorghum in their discussions of crop decision-making. If they are non-sorghum producers, but livestock owners, the poor will buy sorghum stover
- If poor households are sorghum producers and they own no cattle their sorghum stover can be sold. There is a strong market for stover, usually in the village, but certainly within neighboring villages and towns. Alternatively stover will be used to pay for animal hire.

The livestock-feeding strategies of farmers, characterised by supplementing sorghum stover with green grass and other crop residues at different times of the year, reflect a broad scenario of dry fodder shortages. These shortages are one of the main reasons for the reduction in livestock numbers in the past.

Sorghum as source of cash

Sorghum is not an important cash crop for either the rich or the poor — although the poor in postrainy-season areas may market sorghum strategically to gain access to low-price foods. Broadly, less than 30% of households (mainly rich) sell grain, and this constitutes less than 40% of the total sorghum production. Very few households sell stover, those that do are generally poor households without livestock who do not need the stover their crops produce. This pattern reflects the limited sorghum production, particularly by poor households with limited production resources. It also reflects the crop's low profitability that is linked to low productivity (Hall et al., 2000).

Sorghum as source of employment for the poor

In areas where few alternative crops are grown, particularly in postrainy-season areas, sorghum is still an important source of employment,

harvesting and threshing being the main activities. Employment at harvest time is important as wages are often paid in kind, giving the poor direct access to food, although this practice is declining in importance. Sorghum tends to be more important as a source of employment for women than men, particularly where employment on cash crops is available. Despite this, the poor very clearly articulated the fact that other crops were a much better source of employment. For example, rice, that requires many more labour inputs throughout the season for transplanting, weeding, spraying etc. operations not performed during sorghum production (Hall et al., 2000).

Sorghum in years of poor rainfall

Farmers' year-to-year cropping strategies exhibited a great deal of variation. This was predominately related to the quantity and distribution of rainfall during any specific year. Production in the rainy season also determined decisions on crop production in the postrainy season. For example, if food production in the rainy season was low, the postrainy season had a stronger emphasis on food production. However if the converse was true, more emphasis would be given in the postrainy season to cash crop production. This had an implication for the importance of sorghum. In poor rainfall years farmers would devote proportionately more of their land to sorghum, partly because a farmer's primary objective is to produce sufficient food and fodder for home consumption. Although this option was not necessarily open to the poor, due to both land quantity and quality constraints, the second element of this strategy was related to the fact that in years of very low rainfall sorghum may be the only crop that can be considered. In this sense the crop underpins livelihoods in the worst years. In these years, those with land can at least produce some grain and fodder, and to the landless sorghum may represent one of the only sources of on-farm employment (Hall et al., 2000).

Sorghum as an input into farming systems

The results of this study have established that sorghum stover makes up around 50% of animal diets. While the significance of this has been discussed in relation to other crop residues, and the role of livestock in livelihoods has also been discussed, this to some degree underplays the importance of the combination of these factors in farming systems. The earlier discussion of the joint importance of food, cash, and livestock in livelihoods, rather than the dominance of an individual strategy, underlines the fact that these are mixed farming systems. In other words, farming systems in which there is strong integration and interdependence of crop and livestock components. In the villages visited, almost without exception, all land was prepared by traction animals. Farmers frequently discussed the importance of livestock in terms of traction, manure production, and sales of animals and animal products. Animal provision of traction and manure make crop production possible. Even though chemical fertilisers are widely used, farmers value manure as a source of soil fertility. In more than one instance farmers described the downward spiral of falling fodder yields causing reduction in livestock numbers, in turn leading to reduced availability of manure, followed by further reduction in fodder yields. This again emphasises the systemic nature and integration of the crop and livestock components in the agricultural production practices (Hall et al., 2000).

Although it was difficult for farmers to discuss this issue in relative terms, they nevertheless articulate the fact that sorghum fodder is a key input into farming systems — this is evidenced most strongly by farmers' clear preference for dual-purpose sorghum varieties. In this sense, sorghum as an input significantly underpins the mixed farming systems. This suggests that its relative importance goes beyond that evidenced by its relative importance in the desegregated roles discussed above.

Sorghum postharvest losses and the poor

The inferior characteristics of rainy-season sorghum and particularly hybrids grown in that season are well established. Has this resulted in households, including the poor, moving away from sorghum production and consumption in favour of more easily stored food crops? Field studies by Hodges et al. (1998; 2000) indicated that after on-farm storage for one year, levels of insect infestation in sorghum increased significantly. Infestation was more pronounced in rainy-season than in postrainy-season varieties. The type of storage structure was not related to levels of infestation. However, a key finding was that while extended storage of rainy-season sorghum does represent a constraint, in the case of poor households this problem is irrelevant. It was found that the poor, with their limited resources for grain production, routinely store sorghum for 5 months less. In other words, they do not have enough grain to store long enough for postharvest losses to cause a significant loss of food. However another finding was that rainy-season sorghum blackening, caused by in-field fungal infection following untimely rains, is a significant problem. Although this is not a postharvest problem per se — it relates to plant maturity, morphology, and structural aspects of starch in the grain — it has postharvest consequences in terms of quality deterioration. The poor, with few options for accessing food, are often faced with the dilemma of consuming this grain as there is no alternative. In years of particularly heavy fungal infection the grain is sold in the market at the lowest price for poultry feed and grain alcohol production.

While postharvest losses are not impacting on the poor at farm-level storage, the implications of poor storage characteristics are not known in bulk and long-term storage situations. These scenarios may emerge in the context of wider industrial utilisation, and the technical aspects — as a constraint to the market demand for sorghum — need to be explored (Hodges et al., 1998; 2000).

The changing relevance of sorghum to rural livelihoods

Evidence suggests that overall sorghum does play a key role in rural livelihoods, including those of the poor, either directly in specific roles, or through its systemic importance in underpinning farming systems. It is this systemic importance that is most relevant to the poor. However, patterns of production and consumption over the last 30 years indicate a changes in importance have taken place. What are the factors causing these changes? Will they continue? How will the future scenario influence the relative importance of sorghum to poor?

The relative importance of sorghum in both diets and cropping patterns has changed over the last 30 years (Dayakar Rao, 1999; Dayakar Rao et al., 1999; Hall et al., 2000). It is also apparent that consumption patterns are strongly linked to cropping patterns. Dayakar Rao et al. (1999) provide evidence that the decline in production area has been more in rainy-season producing areas (58%) than in postrainy-season areas (38%). This change has not been consistent across all locations and households, with only about 50% of households registering a decline, and sorghum areas having remained more stable in poor households. Rural studies suggest that consumption of sorghum declined by 16% in postrainy-season areas, the decline taking place predominately amongst poor households, although this finding is rather distorted by the unexpectedly high decline found in one district (Pune). In the rainy-season areas, although considerable variation existed, consumption actually increased by 4%. This reflects the resource endowments of the poor to whom the relatively high price of postrainy-season sorghum makes it less accessible. The converse is true for the poor in rainy-season areas where sorghum represents one of the cheapest sources of food in the market (Dayakar Rao et al., 1999).

Dayakar Rao's 1999 examination of National Sample Survey data for the major rainy-season sorghum producing districts in the target states

for the period 1987/8 to 1993/4 reveals a pattern of consumption trends that exhibits a much greater degree of stability than previous studies indicated. Consumption remained stable in 13 out of 24 districts, with major declines (greater than 20 %) only taking place in districts where the introduction of irrigation had caused major changes in cropping patterns. The trends also reveal a broad picture of rainy-season sorghum being more important for the poor than the rich, and the reverse for postrainy-season sorghum.

Changes in production patterns occurred in a response to both the increasing household needs for cash and the increasing options that occurred for cash-cropping strategies, i.e., new crops and better access to markets. Access to irrigation was often a pivotal factor (Hall et al., 2000). To reiterate this point, it was not only that farmers started to move from a subsistence to a cash-based livelihood that brought about these changes in cropping strategies, but rather that the opportunities presented by new technology and markets allowed farmers to follow strategies they had been unable to follow in the past. In terms of the livelihood opportunities this offered to farmers, sorghum became less attractive because of its lower profitability – due to a combination of low prices and low productivity. For example, the introduction of high-yielding rainy-season varieties allowed a reduction in sorghum area that freed land for more profitable crops. Conversely, the introduction of irrigation in some areas allowed farmers to produce rice, a much more profitable crop. The introduction of hybrid cotton and the price support for oilseeds in the late 1980s made these crops much more competitive in traditional rainfed sorghum production environments. These factors appear to have had their effect on cropping pattern changes by the early 1990s².

2. The implication of this statement, based mainly on the finding of PRA studies, is circumscribed by the fact that the study sites were chosen to reflect areas where sorghum remained important (i.e., it held 15% of gross cropped area).

Production changes in turn had impact on consumption patterns. This was particularly so if cereals other than sorghum were grown for the first time, particularly rice and wheat. Also, the adoption of hybrids in the rainy season resulted in production of grain with inferior taste, that encouraged a shift in consumption towards rice and wheat. This was mainly true for the rich, because they could afford to change, but the poor started to eat more inferior grains because they cost less (Hall et al., 2000).

The Public Distribution System (PDS) was indicated to be a factor influencing the decline in sorghum consumption. However, this simplistic analysis should not be overlaid. It appears that the presence of the PDS helped to facilitate changes in preference and diet that were already taking place due to changes in cropping patterns and the broader influence of urban food habits reaching rural communities. Quantities supplied through the PDS do not account for the extent of the changes that took place, with the possible exception of Andhra Pradesh, due to the high level of household allocations in that State (Hall et al., 2000).

Future sorghum consumption in rural areas will probably follow broadly similar trends those of recent years. Rice and wheat will continue to increasingly feature in rural diets, more so for the rich in rainy-season producing areas, and in areas where rice and wheat production has assumed significance. The poor in postrainy-season areas will increasingly find sorghum beyond their means, unless they can access it by new cash-generating strategies, or in the unlikely event of a major production breakthrough for postrainy-season sorghum. Postrainy-season sorghum will continue to be the main and preferred staple in areas where it is produced, and for the non-poor households who can either produce it in sufficient quantities or afford to purchase it. The poor in rainy-season areas will increasingly depend on sorghum as the cheapest source of

food. Hybrid sorghum in rainy-season areas will truly become the food crop of the poorest, even if through force of circumstances rather than choice.

Another key element in sorghum consumption is the stover consumed by livestock. As already described, currently sorghum is the most important single source of fodder, even though shortages are apparent. Have livestock numbers been reduced to cope with the reduction in the quantity of sorghum fodder available? Hall et al. (2000) indicate that numbers have indeed decreased, and the main reason has been shortages of fodder. However this is also related to climate and the variety grown as much as to reduced area of production. Distress sales of animals have also been a major reason, particularly for poor households. Despite the changes that have taken place, it is apparent that household requirements for fodder are a key determinate of the area of sorghum production. The dual importance of grain and fodder is very clearly articulated by farmers. In the case of richer households in hybrid rainy-season producing areas, the need for fodder is the key area determinate, with grain almost being viewed as a by-product. With the importance of fodder for traction animals, it seems unlikely that demand will fall without major changes in the farming system — for instance rapid tractorisation. The growing market for milk and other animal products seems likely to ensure that livestock, and the sorghum stover on which they depend, will remain a persistent feature of Indian farming systems in the semi-arid tropics and of the livelihoods that depend on them. For poor livestock-owning households, access to sufficient quantities and qualities of fodder will continue to be critical. This will be particularly so if livestock become an enterprise in which landless households can engage.

The changes that have taken place in sorghum production have occurred partially as a result crop substitution. This substitution has been to some extent induced by irrigation, by strong markets for other

commodities, and even by productivity gains in sorghum itself. While it seems likely that these changes have been played out — in the absence of new opportunities arising. Dayakar Rao et al. (1999) analysed income: cost ratios (ICRs) and revealed an interesting pattern. In many instances particularly in the postrainy-season areas, sorghum is considerably less competitive in these terms. Nevertheless it covers over 50% of the gross cropped area, and has even increased in some districts. It appears that with current levels of household demand for food and fodder the opportunity cost of meeting these demands equals or exceeds the value of producing more profitable crops. This is also true, but to a slightly lesser extent for rainy-season sorghum for which the gap between the ICR of sorghum and competing crops narrows. So while sorghum cannot compete on a profitability basis with cash crops, the strategies of households are such that cash crops cannot compete for land with a crop that is so central to household food and fodder needs (Dayakar Rao et al., 1999).

A related element is that production environments are such that the viable production of alternative crops is simply not possible or extremely risky, particular in the postrainy-season areas. The pattern of production that presently exists therefore probably reflects a combination of the current level of household demand, and the fact that sorghum is grown in marginal areas where more remunerative cash crops cannot be grown. In the case of postrainy-season sorghum, prices are already strong enough to exclude the poor — suggesting that productivity increases remain the key route to using sorghum to leverage impacts on the poor in these areas. This is a significant challenge.

Hybrid rainy-season production displays a slightly different pattern, with ICRs approaching (and even exceeding) those of competing crops: cotton, castor, pluses, groundnut, and wheat. It was in these areas that the sorghum area was seen to increase, when years of poor rainfall

favoured the production of sorghum over other crops. This strongly suggests that sorghum has — or is approaching — a comparative advantage in these areas. If this is indeed the case, it suggests that both production and market support (development of demand) in rainy-season areas would be supporting a crop that farmers, including the poor, have a comparative advantage in producing. If this support were to result in even lower prices (through incentives to adopt more efficient practices and technology), it would benefit both households that were purchasing from the markets and those consuming their own production. If the poor are to benefit from this scenario, productivity gains must be achieved to fulfil new demand, but not at the expense of cheap food. While cost-reducing technology would help improve the competitiveness of sorghum, as a crop with relatively low production costs, these competitiveness gains must come from higher yields. The predicted future levels of market demand and the associated levels of productivity gains to meet this demand are discussed in the context of industrial utilisation (Dayakar Rao et al., 1999).

Agricultural policy, sorghum, and the poor

The scenarios described above are to some extent conditioned by the future shape of Indian agricultural and trade policy, and particularly by the response to the World Trade Organization (WTO). Day's 1997 analysis of the policy environment suggests that input subsidies, including those on water and power, have clearly supported the production of rice and wheat to a greater extent than dryland crops such as sorghum that use fewer inputs. While it seems likely that subsidies on these inputs will eventually be removed altogether, this will not necessarily allow sorghum to compete with rice and wheat. The marginal profitability of alternatives is so great, particularly for rice, chillies, and other horticultural crops, that even with full-priced inputs they will remain more profitable than

sorghum. However the process of subsidy withdrawal could mean that the government-supported expansion of irrigation will slow. This suggests a stabilisation of sorghum area in regions where irrigated rice emerges as the main competitor, for example, in Andhra Pradesh. But, it must be accepted that if access to irrigation water is available, sorghum is never going to be the best option for farmers, including the poor — even for food and fodder (Day, 1997).

In the past, trade restrictions have penalised the production of all food grains, by restricting access to (higher) world market prices. Effectively agriculture has been taxed (despite the apparent levels of subsidies, because of the low prices farmers receive. As Indian trade policy has relaxed since liberalisation in 1991, fine grains, particularly rice have achieved greater access to world markets than course grains including sorghum. Day (1997) suggested that coarse grain export quotas are so small as to be irrelevant. Imports of course grains have been very restricted, but have still favoured maize over sorghum. While this may have been an attempt to protect Indian sorghum prices, they are usually import-competitive, and therefore in most years sorghum would probably not have been imported. However, the price of sorghum does fluctuate and a result, in the non-food market there are frequent shifts between sorghum and maize depending on the price ratio of the two commodities. Access to imports would allow non-food use of sorghum to develop specialisation in certain industrial sectors because of its impact on price stabilisation. Equally, access to export markets would benefit producers in surplus years and in years when world market prices rose significantly

Price support through tariffs on the import of edible oils since the late 1980s has artificially increased the competitiveness of soybean and sunflower at the expense of sorghum, particularly in Madhya Pradesh, but also in Maharashtra. However, tariff protection has been gradually reduced, currently standing at 20%, and is likely to be removed

completely. While these oilseeds presented a significant opportunity to farmers in rainfed areas — of which they very clearly take advantage — with the removal of tariff protection, sorghum may become the next best bet in many areas.

It has already been indicated that the impact of the PDS has tended to facilitate changes that were already taking place in food habits because of wider cropping and cultural changes. But it clearly did impact on sorghum consumption to some extent. Furthermore, as sorghum was not included in PDS, and therefore not procured by the Government to supply the system, the crop never benefited from guaranteed markets in the way wheat and rice did — albeit with low prices. The restructuring of the PDS to a more decentralised mode of operation has been mooted by the Government of India, but this may prove politically very difficult, particularly so at the state level where subsidised rice schemes have been used to great political effect. However, the reality in the short-to medium-term is that, in its current form, the PDS is financially unsustainable. Decentralised operation at the village or community level, suggested as an option by the Ministry of Food (GoI, 1998)³ would mean that in areas where sorghum is the produced and preferred staple it would replace rice and wheat. Apart from any other consideration of the impact of this commodity on markets, it would mean that the poorest people — particularly in post-rainy-season areas — would have access to their preferred staple. Bulk long-term storage options would need to be explored if this were to become a reality, particularly in areas of hybrid rainy-season sorghum production. Equally important will be the need to devise institutional mechanisms to achieve this type of decentralised approach.

3. Government of India, 1998 Report of Steering Committee on the introduction of modern technology in handling storage and transportation of food grains. Krushi Bhavan, New Delhi, India; Department of Food and Consumer Affairs, Ministry of Food.

The Essential Commodities Act (ECA) of 1953, places restrictions on the level a stock trader can hold, the development of futures markets, and interstate commodity trading. Although the ECA has been relaxed in recent years for some food grains, including sorghum, it is periodically reintroduced when shortages occur in specific states. The net effect is that producers cannot benefit from price rises to the extent that they may be able to otherwise, and that consumers suffer from price fluctuations that would normally be smoothed out by a nationally integrated grain market. Even when relaxed, the fact that the ECA can be reintroduced creates a lack of confidence in those engaged in the market. Many observers have called for the abolition of the ECA.

Under the rules of the WTO, Indian agricultural trade policy is legislated to be fully liberalised in the short- to medium-term. In theory this means that current import and export quotas will be abolished and decannalised (i.e., trade will be allowed by organisations other than state bodies). Some tariffs will remain at levels agreed under WTO rules. Predictions suggest that trade liberalisation, in combination with the reduction of input subsidies and the removal of the ECA will favor the production of sorghum, i.e., it will be a more attractive option for farmers than other crops. (These predictions are based on measures of social profitability and resource-use efficiency, ICRISAT 1999)⁴ This suggests that it will benefit farmers already growing the crop, and may cause some to revert to it, although major shifts should not be expected. This will be more so in areas producing hybrid rainy-season sorghum and less so in postrainy-season sorghum areas. In other words, changes will lead to farmers being able to grow a 'best bet' crop suited to their production environments, rather than one that compared to productivity in other countries, is both marginal and risky.

4. ICRISAT, 1999. Typology construction and economic policy analysis for sustainable rainfed agriculture. A report on the sustainable rainfed agriculture research and development : Database development, typology construction, and economic policy analysis (Module I). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 142pp.

Although this paints a rather optimistic picture, the reality is that in the current political scenario, policy reform will be slower than might have been expected 2 years ago. But it is a process that once started cannot easily be reversed. Also, the expenditure elasticity of coarse grains is low, particularly for rainy-season sorghum and amongst urban consumers. This suggests that if sorghum does become more attractive to farmers in some regions, stronger domestic markets for the crop will need to develop, if they do not, any increase in crop production will result in a rapid decline in its price. Although much optimism about the export potential of the crop is often raised, at this point the reality is bleak. World markets are thin and highly competitive — although Indian sorghum is import-competitive it is not export competitive. The United States is an important player in world sorghum markets and benefits from highly efficient and subsidised production. Other players in the Asia region, e.g., Thailand, also have advantages over India. Not least of these is efficient port-handling facilities for grain export. In the case of India, poor export infrastructure may provide as effective a deterrent as any of the export quotas imposed in the past (Day, 1997).

Off-farm demand for sorghum

The discussion so far has concentrated on the findings from rural studies. In terms of sorghum consumption, the linkage has been made between the level of household consumption and the amount of sorghum produced. This in turn has led into the discussion of crop-competitiveness or profitability. In this connection it is useful to examine off-farm demand for the crop as this will relate to price, the factors affecting this demand, and its future prospects and constraints.

Sorghum consumption among the urban poor

Data from the National Sample Survey shows a very clear decline in sorghum consumption in urban areas. However this level of aggregation

tends to distort the picture of consumption patterns, particularly in districts where sorghum is still important (Dayakar Rao, 1999; Marsland, 1997). Azam Ali's 1999 examination of this phenomenon amongst the urban poor in a number of sorghum districts suggested of that:

- Sorghum continues to be important for the urban poor in areas where there is sufficient effective demand to maintain regular supplies
- As price is still the overriding concern of the poor, consumption is greatest where sorghum is the cheapest available food
- Postrainy-season sorghum exhibits greater income elasticity of demand than rainy-season sorghum

Where sorghum is culturally identified as food, and where supplies are available locally, it will continue to be of major importance. However over time the process of urbanisation will continue to erode the importance of sorghum. This is mainly as a result of the time constraints of urban women, and the social status of fine grains generally, but particularly in rainy-season areas.

Evidence of increases in sorghum consumption by the non-poor in postrainy-season areas, while interesting, should not be taken as an indication that major reversals are likely to take place in consumption patterns.

Despite the fact that urban food habits are clearly changing, it is also clear that the process of urbanisation is entering a new dynamic phase. Rural–urban migration is taking place at a pace unseen in recent years — witnessed by the new phenomenon of rural labour shortages in Peninsular India. The urban India of the next decade is likely to be characterised by an unprecedented influx of unskilled, poor, rural families from rainfed (sorghum-producing) areas where rural poverty and alternative livelihood options are most limiting. Price shocks to wheat and rice, both currently well below their true level due to input subsidies and procurement policies, could mean that cheaper sources of food,

including coarse grains, will continue to have an important welfare premium for much longer than projected human development statistics suggest. Urban poverty is likely to be more acute and more persistent than might have been expected (Azam Ali, 1999).

Industrial utilisation

The above discussion has outlined a scenario for sorghum demand as food that is at best static or stable, and at worst i.e., the urban case, likely to witness continued, if more gradual, declines in consumption. What then is the case of non-food demand for sorghum grain? Are new markets emerging in the agro-industrial sector? Will this source of demand growth feed back into the livelihoods of the poor, and will it help improve the relevance of sorghum their livelihoods?

Prior to this study there was no clear picture of the extent of sorghum industrial utilisation. The work undertaken was an attempt to make a systematic study of the various industrial uses of the crop, the current levels of utilisation, prospects for growth, and constraints faced by users.

From the findings of Kleih et al. (2000) it emerged that rainy-season rather than postrainy-season sorghum is the grain type chosen for industrial utilisation. This reflects the lower price of rainy season grain. The main industrial sectors using sorghum include:

- Animal feed (mainly poultry, but also dairy) manufacturers
- Alcohol distilleries
- Starch industries.

The potential for utilisation in the brewing, malting, and confectionery industries were also explored, but the prospects were found to be fairly limited.

Table 1 summarises the current demand for sorghum and presents projections for the year 2010. These two estimates are based on data collected from industrial users and their apex organisations. Projections

Table 1. Summary of industrial demand for sorghum in India (in '000 tonnes)

Industry	1998 ¹	2010 ²
Poultry feed		
Broilers	86 – 129	570 – 1150
Layers	312 – 468	1100 – 1830
Others	20 – 30	156 – 234
Dairy feed	160 – 240	290 – 570
Alcohol	90 – 100	200 – 500
Starch	50	30 – 80
Brewing	0	?
Food industry	0	0
Exports	0	?
Total	718 – 1017	2346 – 4364

1. These figures reflect average utilization of sorghum during the 1990s, based on past inclusion rates and current requirements on raw material, rather than or specific data for 1998 itself. The poultry and starch industries use sorghum only when maize is expensive or not readily available.

2. Projection.

Source: Kleih et al., 2000.

are based on expected levels of growth in demand for the products of these sectors at current inclusion rates. The figures suggest that in recent years industrial utilisation of sorghum has accounted for between 6.5–9.2% of total sorghum production (currently approximately 11 million tonnes per annum). However, bearing in mind that only rainy-season grain is used, this represents 10.2–14.5% of rainy-season grain production. Industrial utilisation of sorghum draws grain from a very specific sector of the market, namely low-quality, low-priced grain, often blackened or damaged in some way. With relatively stagnant levels of sorghum production predicted, the projected demand of between 2–4 million tonnes by the year 2010 suggests that industrial consumption could then

account for between 20–39% of total sorghum production. In terms of rainy-season production alone, these figures suggest that industrial utilisation could account for between 32–61% of production (Kleih et al., 2000).

Research on industrial utilisation of sorghum has highlighted a number of generic factors that need to be considered in approaches to increasing utilisation, particularly so for the animal-feed sector.⁵ Firstly, it almost goes without saying that prospects for increased utilisation are linked to the demand for the various industrial products. Secondly, sorghum is — or is perceived to be — inferior to maize, and must be able to compete in terms of price. Thirdly, perceptions of inferior quality almost certainly lead to clandestine use, making estimates of utilisation difficult. Fourthly, (low) inclusion rates of sorghum are conditioned by a number of persistent misconceptions of the crop's functional properties. This has reinforced the impression of sorghum as an inferior raw material. Although some of the utilisation constraints are technical, they are also institutional in nature. This reflects the gulf which exists between public-sector sources of knowledge and information and (potential) industrial users in the private sector.

Implications of increased industrial utilisation of sorghum

The implications of a trend of increasing agro-industrial utilisation are two-fold. Firstly it needs to be recognised that sorghum (particularly that grown in the rainy season) is making the transition from a subsistence food crop to a traded agro-industrial input (although it is already a traded food commodity and will continue to act as a subsistence food crop). Furthermore this process seems set to accelerate.

5. The grain alcohol sector is slightly different. Its main competitor is molasses. Excise rules and associated policy are only licensing new distillers to use *grain* as a raw material. Quality and perceptions of quality are of far less importance, as in fact sorghum, particularly damaged sorghum, has price advantages over most other sources of carbohydrate.

Poverty impact. Precise predictions of the impact of this process on the poor were beyond the scope of this current study. However improved markets for a crop that is well-adapted to semi-arid production environments would tend to suggest that this will have a beneficial impact on the rural economies in these regions as a whole. In the specific case of the poor, differential impacts are likely to occur, depending upon whether households are net purchasers or surplus producers. Impacts will also depend upon whether the poor can achieve the quality and quantity requirements needed to engage competitively in the market for agro-industrial raw materials. Impacts on agricultural employment opportunities, and value of in-kind payments in sorghum grain also need to be considered. Overall, with increasingly cash-based rural livelihoods, with a clearly articulated demand for improved markets for sorghum grain by farmers, and with the continued importance of sorghum fodder in the mixed farming systems of the Indian semi-arid tropics (Hall et al., 2000) the development of agro-industrial demand for sorghum should be viewed as positive. **This tends to suggest that strategic support of agro-industrial utilisation is within the domain of both international and national 'public good activities'.**

Quality characteristics. The second implication of the development of agro-industrial utilisation concerns the quality characteristics suited to the emerging agro-industrial applications. There are two elements to this. Firstly, the intrinsic quality characteristics of specific sorghum varieties. Varietal improvement activities have in the past been aimed at food use. However, even for this target, incorporating client preferences has proved difficult, particularly so for hybrids. Characteristics suitable for poultry and dairy feed will need to be given much closer consideration. This is probably not such an important issue for grain alcohol utilisation, but it may be for starch production.

The second element of quality consideration concerns deterioration

during storage. Evidence suggests that on-farm storage — particularly by the poor who have smaller quantities to store, and for shorter periods — is not a major issue (Hodges et al., 1999). Agro-industries who may want to store large quantities for up to a year could encounter problems. This was certainly indicated by the animal feed sector, and suggests that industrial users and the marketing chains that supply them may need to re-examine the storage arrangements for sorghum, overcome new constraints, and/or change practice accordingly. Further research in this area would be justified, since it is apparent that postharvest concerns need to be given much greater consideration in sorghum improvement programs and sector development.

Related to the issues of quality and quantity of grain are the linkages between agro-industries and farmers. These linkages have started to emerge with respect to maize in the starch to manufacturing sector, and are a mechanism that allows agro-industries to ensure adequate supplies of grain of the types required. This type of linkage has not yet emerged for sorghum and it would be useful to find out why not, and pursue initiatives to support it.

Sorghum competitiveness with other raw materials

The demand for sorghum in poultry feed largely depends on the price of maize, the energy source preferred by poultry producers. According to industry sources, to make sorghum competitive, its price should be 20 – 30% lower than that of maize (Kleih et al., 2000). Predictions made by Kleih et al. (2000) indicate that the growth in demand for poultry products is such that increased demand for poultry feed is expected to lead to a deficit in energy sources, particularly because of the limited supply of maize. Maize imports are being considered, but are currently too expensive due to the lack of adequate port-handling infrastructure and transport facilities. As a consequence, sorghum appears to stand a

chance as an alternative raw material in this sector, but is likely to face competition from imports in the medium- to long-term. However, the low yield of sorghum in Indian production environments needs to be satisfactorily addressed in order to ensure its continued competitiveness with imported grain.

In the starch sector, sorghum has difficulty competing with maize in terms of both price and functional properties. Sorghum produces an inferior starch and is only used at times when maize is unavailable in the market. This may be possible to address through varietal improvement, although the potential of achieving this goal was not explored by this study.

Constraints to increased industrial utilisation

The study by Kleih et al. (2000) highlighted the fact that agro-industrial users perceive a number of technical constraints that prevent increased sorghum utilisation. This is exhibited either by a reluctance to use sorghum, or to use it only at relatively low inclusion rates. Such perceptions are widespread and concern mainly the animal feed sector. They include:

Poultry and dairy sector

- Levels of tannin in Indian sorghum too high
- Levels of mycotoxins in blackened grain affect health and productivity of poultry and cattle
- Energy level of sorghum inferior to that of maize
- Difficulties in processing sorghum grain (milling technology designed for maize)
- Difficulties with long-term storage.

Poultry sector

- Sorghum lacks carotenoids for egg yolk pigmentation.

Institutional constraints

A notable feature of the study by Kleih et al. (2000) was the finding that the emergence of agro-industrial utilisation of sorghum has occurred independently of any specific intervention. Scientific research on sorghum utilisation in India has not contributed significantly to the process. At the outset of the study national and international research institutions engaged in sorghum improvement lacked a database on sorghum agro-industrial utilisation. No systematic study had been undertaken of the scope of agro-industrial applications, or of the level of utilisation. This only goes to underscore the poor linkages between scientific research institutions, and what has emerged as a major client sector.

During the course of the study it became apparent that perceptions of constraints to sorghum utilisation voiced by various agro-industries, were actually topics already well researched in Indian scientific institutions. Examples include levels of tannins, impacts of mycotoxins, energy values, and storage technology. The de-linking of private agro-industrial enterprise from these sources of scientific and technical knowledge on the potential for sorghum utilisation has been a major constraint to increased utilisation. However, it was also clear that this was not just a knowledge gap, but a gap in the process of knowledge generation, i.e., agro-industrial enterprises were not part of the problem identification and solving process. The study also noted that in the animal-feed sector, private-sector consultancy companies have emerged and have undertaken feeding trials to resolve technical constraints of agro-industrial enterprises. This suggests that arrangements for this type of activity are not functioning optimally in the public-sector research system, and that some fresh thinking will be required to resolve the problem.

It is essential that any future technical research on improving sorghum utilisation be undertaken in association with appropriate institutional

partners engaged in relevant agro-industrial sectors — particularly private enterprise.

Sorghum marketing systems

The case has been made that demand for sorghum as food is declining in urban areas, and that this is a result of changes in food preferences and life styles. Conversely the last section painted a rather optimistic picture of increases in industrial demand for sorghum. Both these types of conclusion make assumptions about the structure and efficiency of marketing systems for sorghum. In the first instance, is it only declining changing food habits that are causing declining demand, or do other features of the marketing system tend to act against sorghum compared to other crops? Is there a sufficient marketed surplus of a crop, that may be of marginal preference amongst the basket of other cereals? In the case of industrial utilisation, are marketing systems sufficiently efficient and capable of handling the higher volumes which demand projections suggest? Can increased productivity cope with the new demand for sorghum, while at the same time keeping prices relatively low and stable? The study of these issues by Marsland and Parthasarathy Rao (1999) highlighted the following:

During the 1980's, of all India's states Maharashtra accounted for by far the largest volume of sorghum arrivals at regulated markets: about 60% of recorded arrivals. It was followed by Madhya Pradesh (14%), Karnataka (8%), then Andhra Pradesh, Tamil Nadu, and Uttar Pradesh all around 5%. During the 1990s, the marketed volume of sorghum in Madhya Pradesh was roughly on a par with that of Andhra Pradesh and considerably below that of Karnataka, whilst market arrivals in Maharashtra continued to outstrip every other state's.

Table 2 presents market arrivals in the four states as a percentage of all-India production during the 1990s. This gives a rough approximation

of surplus marketed through regulated channels at the all-India level as these states account for over 90% of regulated market activity. It can be seen that market arrivals varied between 8.6 and 11.8% of production.

Table 2. Percentage of regulated market arrivals to all-India sorghum production in major states, 1990/91 to 1995/96

Year	Production (mt)	Maharashtra	Karnataka	Andhra Pradesh	Madhya Pradesh	Total
1990/91	11.68	7.20	1.27	0.59	0.41	9.47
1991/92	8.10	7.40	2.05	0.90	0.44	10.79
1992/93	12.81	9.74	1.14	0.38	0.58	11.84
1993/94	11.41	6.76	1.21	0.49	0.71	9.17
1994/95	8.97	7.24	0.74	0.41	0.16	8.55
1995/96	9.33	8.30	0.60	0.53	0.50	9.99
1996/97	11.09	–	0.42	0.47	–	–

Source: Bulletin of Food Statistics, Krushi Bhavan, New Delhi, India; Directorate of Economics and Statistics, Ministry of Agriculture (Various issues).

Marketed surplus. The farm-level sample survey undertaken by the Project found an average level of marketed surplus in excess of 30%. Given that official figures suggest that about 10% of sorghum is marketed through regulated markets, the sample survey findings raise the possibility that substantial amounts of sorghum are being marketed through unregulated channels. Before coming to any conclusions however, it should be noted that in a study of western Maharashtra, Garande et. al. (1997)⁶ also found that marketed surplus was around 30%, however, the authors estimated that two thirds of the surplus was going through regulated channels.

Market channels. The paucity of data on unregulated market transactions for sorghum suggests a clear need for further research on this issue. The

6. Garande, B.B., Gawade, B., and Deshmukh, P.D., 1997. Marketable surplus and marketing cost of important cereals in western Maharashtra. Pages 675-678. Agricultural Situation in India. New Delhi, India : GOI, Directorate of Economics and Statistics, Ministry of Agriculture.

volume of unregulated market transactions needs to be established across the major sorghum-producing states, and this be compared to regulated volumes. It may well be that unregulated market transactions are more important than previously thought. It may be the case that informal marketing channels are becoming established in association with industrial utilisation, whereas the formal channels reflect activities in the food grain market.

Market efficiency and future prospects. The high producer's share in the consumer's rupee for both postrainy – and rainy-season varieties indicates that there are no major distortions in the regulated marketing chain, such that particular players are making excessive profit to the detriment of either producer or consumer. Moreover, notwithstanding the PDS and associated subsidy schemes, the marketing system per se does not appear to put sorghum at a disadvantage in comparison with other crops as a food grain. For both these reasons it appears that the marketing system per se does not present a constraint to utilisation of the crop as a food grain.

At the same time, however, it is possible that existing marketing arrangements may not be optimal for industrial users. It may well be that industrial users will not wish to go through the regulated channels, as they may be able to obtain sorghum more efficiently through new institutional arrangements that compress the marketing chain to fewer actors, through for example, contract farming arrangements. In this sense, it is possible to envisage a two-track marketing system developing. One track will be the food grain marketing system, through which high quality postrainy-season sorghum and indifferent quality rainy-season sorghum will predominate (high-quality grain emanating from, and largely consumed in the postrainy-season 'triangle' that covers southern Maharashtra and northern Karnataka, and indifferent grain from the rainy-season crop being consumed by lower-income consumers

particularly in Maharashtra, and more generally by the poor in urban areas of all three states). The other track will be the non-food system for industrial users through which exclusively hybrid rainy-season sorghum will be traded. There are some indications that this may already be happening, but further work is necessary to investigate this (Marsland and Parthasarathy Rao, 1999).

Conclusions and recommendations for future postharvest research

Before finally drawing conclusions and recommendations for future research policy it is useful to reiterate a few points about the nature of the study and its findings.

Regional importance of sorghum to the Indian poor. Firstly the rural field work component was central in drawing conclusions on the relative importance of sorghum, both in terms of farming systems and livelihoods. This in turn was used to link the livelihoods of the poor to future prospects for sorghum. The sampling frame used for the rural component encompassed districts in the target states where sorghum production was judged to be important. So naturally, the scenarios of sorghum production and consumption derived from the rural studies exhibit a more optimistic picture of the crop and its role in rural livelihoods than might be expected by examining all-India statistics. While this may provide a rather skewed picture of sorghum in India, the results pertain in areas with a rural population of 60 million people and 20 million cattle and buffaloes. The urban populations add another 10 million people in these areas. This is a significant corpus of the world's poorest people. We believe these areas have stabilised as India's sorghum heartland, an area where sorghum will continue to be central to rural livelihoods.

The rural poorest are no longer farmers. The second point that emerges relates to the identity of the rural poor and the implication of

a commodity-focused approach to poverty alleviation. It is no longer valid — if it ever was — to consider the rural poorest in India as farmers. At best they are marginal farmers, at worst, and most frequently they are landless and reliant on agricultural employment. Numerically the poor are the dominant group in rural society. Their greatest concern continues to be access to food. If the poor have land, agricultural production contributes to their access to food, but never more than partially. More usually, the main contribution of agricultural production to their livelihoods is through the creation of employment opportunities. The best that agricultural development can offer them is cheap food and the means to access it.

Sorghum underpins the sustainability of the farming systems on which the poor depend for employment. Sorghum, and certainly the rainy-season crop, does provide the poor with cheap food. However it is farming systems — including sorghum production — that is the greatest means of accessing food via the employment opportunities it creates. The most important and rather intangible — and therefore underplayed — feature of sorghum is as an input into these farming systems. The relative importance of sorghum as a source of fodder for livestock is crucial to the same farming systems. It is the integrated nature of these crop-livestock systems that underpins the sustainability of the farming systems in the semi-arid tropics of India. Sorghum therefore underpins the system that is most important in allowing the poor access to employment and therefore food. This systemic importance, regardless of any other concern is a fundamental reason for sustaining the presence of sorghum in the cropping patterns of the semi-arid tropics.

Importance differences between the role and importance of rainy and postrainy seasons. Coming to more specific issues, quite distinct scenarios have emerged in the India sorghum sector for the postrainy-

and the rainy-season crops. Access of the poor to food in postrainy-season areas is predominately a productivity issue. Without a major breakthrough in yield in these production environments, the poor will continue to have difficulty in accessing their preferred food, either through their own production or through the availability of affordable sorghum grain in the market. The caveat to this suggested thrust is that productivity gains should not be at the expense of grain and fodder quality and quantity. Postrainy-season sorghum will continue to be needed for human food.

Rainy-season sorghum will be increasingly important for non-food uses. The rainy-season sorghum scenario is one in which productivity gains have already been relatively successful, and this has provided both the rural and urban poor with cheap food. Unfortunately this has often been at the expense of grain quality either in terms of taste, or because of its susceptibility to quality deterioration, both pre- and postharvest, as well as fodder quality. These two factors need to be given much closer attention in crop improvement programs. In part these quality factors have reduced the price of grain and this has aided the development of industrial demand for the commodity. There is clear segmentation of demand for both food and non-food uses for animal feeds, particularly poultry, but also grain alcohol and starch. This has developed a market for the lowest-priced and poorest-quality grains.

Implications for postharvest research focus.

While the systemic importance of sorghum has been highlighted, what are the likely mechanisms for maintaining the position of the crop in farming systems? Agricultural and trade policy reforms will at worst be neutral, and at best supportive to some extent. Increasing rural labour shortages will also tend to favour the crop due to its relatively low labour demands. Profitability will need continued support from demand at a

level at least equal to that at present if the competitive position is to be maintained. Rural household demand for grain will at best remain stable, and at worst show a steady decline. The same is also true for urban demand for food, with declines likely to be, if anything, more substantial. However, industrial utilisation of rainy-season sorghum is projected to grow very strongly. The target for postharvest research in rainy-season sorghum and its industrial utilisation. While postrainy-season sorghum should be given less importance, postharvest concerns should be should still be leveraged through postrainy-season sorghum crop improvement programs, particularly with respect to grain and fodder quality.

Of the three target industrial sectors identified as significant in the utilisation of sorghum, animal feeds (particularly poultry) and grain alcohol should be the targets. For the starch industry, sorghum has significant functional disadvantages compared to maize and cassava. The focus on the animal feeds sector should be on the technical and market and institutional issues discussed in detail below. For the grain alcohol sector constraints are more likely to be on the supply side, and therefore issues concerning marketing and vertical integration to link farmer with potential users are likely to be more important.

A postharvest focus on rainy-season sorghum for industrial utilisation needs to consider the following four elements.

Crop improvement for specific new industrial uses

Rainy-season sorghum is very clearly making the transition from a food crop to a crop used as an industrial raw material. While this does not mean that food quality should be given lower priority in crop improvement programs, variety traits for specific industrial applications need to be considered. This raises a number of institutional issues on the extent to which public good research should support industrial development in the private sector. While it would be useful to examine the streams of benefits that this technological trajectory would produce, if the systemic

importance of sorghum in farming systems is accepted, this approach would be consistent with supporting the livelihoods of the poor. However public/private sector institutional linkages in improvement programs will be critical if this research thrust is to be meaningful.

Technical constraints to increased utilisation

In the animal feeds sector a number of technical constraints to increased utilisation have been identified. These include; tannin levels of grain, mycotoxin contamination, and energy levels of different sorghum varieties. Long-term, bulk storage by industrial users needs much closer consideration, particularly as hybrid rainy-season sorghum is likely to be the predominant grain type. Similarly, long-term storage options need to be examined if sorghum is to be used in any further schemes of a decentralised public distribution system. Institutional arrangements for the scientific and technical support of these initiatives with the various stakeholder organisations involved will need to be carefully considered.

Market and policy constraints

Although initial assessment of the marketing system has indicated that it is relatively efficient and could cope with increased volumes, the levels of industrial utilisation predicted suggest that this needs much closer consideration. Market infrastructure, including storage and handling, and institutional factors need thorough examination. Understanding the reasons why closer integration of industrial users and sorghum producers has not occurred would be useful in this respect, as the process has important synergy and poverty implications. It would also be useful to examine in more detail the way in which trade and economic liberalisation is impacting on the functioning of grain markets, and the implications of this for sorghum utilisation. As a word of caution, the marketing system as a crucial link between production and a new source of demand for sorghum still has the potential to emerge as a rate-limiting step when

pushed beyond its current function. It therefore warrants much closer attention.

Institutional constraints to the uptake of postharvest technology

One of the key findings of this research is that increased utilisation of sorghum in the industrial sector has been despite any specific technical breakthrough, rather than because of it. In fact, many of the persistent perceptions of the poor industrial utility of sorghum are areas of research where considerable work has already been carried out in public-sector research institutions in India. There are many reasons for the divergence and weak linkages between private enterprise and public-sector research in India. However, what is clear is that further technical research on sorghum will only be worthwhile if it is undertaken within a project structure that bridges this institutional gap and provides a more interactive approach to problem solving. This is not because of the poor flows of existing knowledge to target sectors of economic activity. It is because there are no knowledge-creation processes that link science with these important clients. Addressing these institutional issues should be given priority. If these institutional constraints are allowed to persist postharvest research will become increasingly irrelevant, under-exploited, poorly adopted, and of little benefit to the poor of semi-arid tropical India.

Section 3

Research at National Research Centre for Sorghum

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The mandate of the National Research Centre for Sorghum (NRCS) is to conduct basic and strategic research that leads to the improved productivity of sorghum and its diversified utilisation, and to promote profitability from sorghum and sorghum-based cropping systems, to serve as a national repository of germplasm and as a national centre of training and consultancy on all aspects of sorghum production and utilisation, and to foster collaborative research with national and international agencies with a view to achieving these objectives.

All India Co-ordinated Sorghum Improvement Project (AICSIP)

Objectives

- Co-ordination and conduct of multilocational research at the national level to develop improved production technologies that aim to enhance productivity
- Evolution of superior hybrids and varieties that combine high yields and acceptable quality of grain and fodder, wide adaptability, and resistance to major pests and diseases
- Development of appropriate crop-management practices and formulation of efficient sorghum-based cropping systems enhance and stabilize productivity
- Conduct of investigations on known/potential pests and diseases including identification of sources of resistance leading to the development of integrated plant protection strategies.

Current research activities at NRCS

- Breeding high-yielding, post-rainy-season hybrids

- Development of early and medium-duration, rainy-season hybrids with increased resistance to grain moulds
- Collection, evaluation, documentation, and conservation of germplasm
- Studies on insect-host plant interactions
- Studies on host-plant resistance and management of major diseases
- Investigations on physiological and bio-chemical basis of seed vigour and viability
- Explorative studies on production of three-line and non-conventional two-line single-cross hybrids using A_2 germplasm
- Development of databases, economic analysis, and transfer of technology
- Production of somaclonal resistance to charcoal rot and grain moulds.

Cropping systems approaches to increasing productivity

Various studies at NRCS suggest that sorghum–pigeonpea intercropping increases productivity and profitability.

- In low rainfall areas: 2:1 row ratio using sorghum hybrid CSH 6
- In assured rainfall areas: 3:3 row ratio using sorghum hybrid CSH 9 and the pigeonpea varieties suitable for intercropping e.g., C 11 or BDN 2.

Meeting the challenges of erratic rainfall and pest attack

Since the rainfall pattern is erratic in nature, droughts are frequent, and pest attacks are prominent, NRCS has developed a contingency plan for both cropping seasons if the monsoon is delayed.

- During rainy season using a higher seed rate than normal and application of Furadon® or Phorate® granules in the seed rows at sowing to avoid shoot fly damage
- During the postrainy season under severe drought conditions, thinning out alternate rows of sorghum to ensure some grain yield.

Grain mould management

Grain mould following unseasonal rain is a serious problem particularly for hybrids.

Prophylactic measures

- Growing tolerant varieties or hybrids
- Harvesting at physiological maturity
- Applying Captan® + Dithane M-45® three times during the season, once at flowering and at two 2-day intervals in seed plots.

Postharvest techniques for mould control include pearling and treating mouldy grains with hydrochloride acid.

Sorghum competitiveness in India

Table 1 highlights the poor returns to sorghum cultivation that are an underlying cause of the declining area of its cultivation.

Table 1. Returns from sorghum and its competing crops during postrainy season

Crop	Average yield (kg ha ⁻¹)	Cost of production (Rs t ⁻¹)	Minimum price support (Rs t ⁻¹)	Expected returns (Rs ha ⁻¹)
Sorghum	1022	3410	3000	2349
Soybean	918	5920	6800	6242
Sunflower	611	6930	9500	5804
Groundnut	1042	7590	9000	9378
Cotton	262	8320	13500	3510
Mung bean	855	6760	8000	6840
Sugarcane	71099	258	425	30215

Some of the key findings in a study by TG Kelley, et al. (1994) on the competitiveness of sorghum in India indicate

- Expansion of irrigation favours irrigated crops
- Low producer prices of sorghum and price movements work in favour of competing crops
- Lagging productivity growth
- Sorghum is a non-commercial crop

Possible ways to enhance sorghum profitability

- Bridging the yield gaps
- Growing hybrids with high yield potential
- Adopting inter- and sequential cropping
- Reduction in cost of production per unit area
- Promoting industrial uses (encouraging sorghum substitution in various industries)

Alternate present and future uses of sorghum uses

Grain

- Human food bread, popped, parched, flakes, semolina, grits
- Livestock feed for poultry, farm animals, rabbits, ducks, pigs
- Starch, dextrine, dextrose, glue, liquid glucose, alcohols, plastics, textiles, paper board, 'U'-foam industries
- Alcohol: potable, industrial, fuel
- Malt: baby food, beer, beverages, malt syrup
- Glucose liquid/powder, HFS, DMH

Stems

- Syrup, jaggery, alcohols, sugar
- Baggase – used for fodder, paper, fuel, particle and corrugated boards

Glumes

- Natural colour

Factors Affecting the Production and Utilisation of Sorghum at the Farm Level

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Introduction

Sorghum is one of the main staples for the world's poorest and most food-insecure people. In India, it is the third most important cereal crop after rice and wheat, grown during both rainy and post-rainy seasons. The livelihood of millions of small and resource-poor farmers is dependent on sorghum, especially in Central and Peninsular India where the crop is grown on about 11.6 million ha annually producing 11.1 million tonnes of grain, 16% of the world's production. Rainy-season sorghum is 75% high-yielding varieties (HYV), but HYV adoption is very low in the post-rainy season. Both the level of production and level of consumption have shown an overall pattern of decline over the last 20 years.

Findings from a quantitative survey on production and utilisation of sorghum, which sought to quantify the changes taking place and their causal factors are reported. These included

- Changes in area of production
- Changes in household demand
- Competitiveness
- Determinants of change

The survey's overall hypothesis was: *Sorghum is still an important food for the poor, however the general trend in declining household demand has reduced its competitiveness compared to cash crops, hence the decline in sorghum's area of production.*

Sampling method

Initially 11 districts were chosen from the sorghum heartland by a random number selection process. Important sorghum-growing districts where sorghum represented more than 15% of the gross cropped area in either triennium 1980–82 or 1992–94 were identified. From each district, 6 taluks/mandals were randomly selected, and one village from each taluk/mandal was randomly selected. In each village 10–15 households were randomly selected for interview, resulting in 544 households interviewed in 42 villages.

Table 1. Districts sampled during the survey

Rainy	Postrainy	Both
Akola	Bijapur	Mahbubnagar
Amaravathi	Pune	
Buldhana	Raichur	
Mysore	Solapur	
Nanded		

1. The average land holdings were almost same in both districts (i.e., 4.76 ha rainy- season districts and 4.71 ha postrainy -season districts)

Key findings

Cash vs food

- Even in the traditional belts where sorghum is cultivated there has been a shift from subsistence to commercial farming
- With the introduction of HYVs and new technology yields have risen so the household demand for sorghum is met from a smaller cultivated area, this has led to a minimal allocation of land to just meet the household demand
- The rest of the land is devoted to commercial crops to meet increased cash needs

- This shift varies across wealth groups
- The shift from subsistence to commercial mode is more conspicuous among the rich in all situations surveyed
- In the postrainy season the area allocated to subsistence crops is 45% while that of commercial crops is about 67% of the total cropped area
- In the rainy season the proportion of sorghum to total cropped area is 28% among poor households and only 19% in rich households
- Limited by the extent of household demand for sorghum as food, the replacement of sorghum with cash crops has been proportionately greater in households with large land holdings.

Sorghum as food

- About 91% households in both postrainy- and rainy-season growing districts consumed on-farm the sorghum grain they produced
- On an average 52% of the total production was used for household consumption in postrainy-season districts and 47% in rainy-season districts
- Poor farmers keep more grain for domestic consumption than rich farmers
- Of the total cereal consumption, sorghum contributes more than half to the daily diet, forming the major staple food in all surveyed districts except Amaravathi
- In postrainy-season districts the proportion of sorghum consumption is slightly higher among rich households, and consumption of wheat or rice is slightly higher among the poor than the rich, because the superior quality of postrainy-season sorghum grain commands a premium price
- Presently the average per capita consumption of sorghum is 134 kg annum⁻¹ in postrainy-season, and 139 kg annum⁻¹ in rainy-season districts.

- As sorghum an important part of the daily diet, it is purchased whenever there is shortfall.

Changes in food consumption

- The decline in the per capita consumption of sorghum was highest (43%) in Mahbubnagar, followed by that in postrainy-season districts (16%)
- Several factors operating simultaneously produced the pattern of changes in consumption
 - Decreased production
 - Accessibility to the Public Distribution System (PDS)
 - Increased availability of rice/wheat through on-farm production were major factors that led to postrainy-season decline.
- In the rainy season change in tastes and accessibility to the PDS resulted in decreased consumption.
- In the postrainy situation the quantity of sorghum consumed bears a direct relationship to the size of the land holding.
- Small-scale farmers depend on PDS rice to a greater extent than large-scale farmers
- In rainy-season districts as the size of the holding decreases, the dependence on PDS rice increases.

Sorghum as feed

- Generally, sorghum stover is fed to draught bullocks, only in some cases is it also fed to milch animals, and sorghum grain is seldom fed to farm livestock.
- Sorghum contributes 96% of stover where it is grown in both seasons
- It contributes 96% in postrainy-season districts and 88% in rainy-season districts
- Its contribution is relatively less in Mahbubnagar where rice straw contributes substantially to the total fodder requirement

- Stover contribution does not vary across income classes in the postrainy season, but is higher among the poor in the rainy season
- Stover produced on-farm is almost totally fed to livestock leaving very little surplus for sale
- Poor households market more surplus stover than rich farmers
- The proportion of purchased sorghum stover in the total stover fed to livestock is higher among the poor
- Poor households gave equal importance for both the stover and grain in all three situations
- To rich households stover requirements are of paramount importance as they own higher proportions of draught animals than the poor.

Sorghum as income

- Sorghum contributes only 3% of the total income in rainy-season districts and 14% in postrainy-season districts
- Income from other crops contributes 73% of the total income in rainy-season districts and 40% in postrainy-season districts
- Low prices of sorghum relative to other crops and decrease in area and production are cited as reasons for plummeting income levels
- Increase in sorghum production, its marketable surplus, and use as wage payment are indicated as factors responsible for the increase in income in rainy-season situations.

Patterns of sorghum yield

- Average grain yield in the rainy-season growing districts is 1100 kg ha⁻¹ as against 600 kg ha⁻¹ in the postrainy situation
- Average highest grain price realised in the rainy-season situation was Rs 385, and the lowest Rs 284
- The average highest grain price realised in the postrainy situation was Rs 497, and the lowest Rs 393

- While 8% of the farmers discontinued growing sorghum in the rainy-season, 23% did so in the postrainy season.

Changes in sorghum area

- The area of sorghum production has been on the decline for the past 20 years
- Of districts surveyed decline was highest in Mahabubnager followed by rainy-season districts
- Rich households substituted sorghum for other crops more intensively than the poor, while the poor and medium farm households withdrew from sorghum cultivation in most of areas in Mahbubnagar district
- The decline in sorghum area (in the past 10 years) in rainy-season districts was at 65.8% and 48.5% in postrainy-season districts
- One reason is the availability of profitable alternatives, e.g., where irrigation facilities have been introduced
- In rainfed areas, there are few alternative crops that can thrive on residual soil moisture
- Among postrainy-season districts, the drop in area has been prominent at 63% in Bijapur district. The maximum area loss among the rainy-season districts is 88% in Akola.

Causes of change

- Crops that have replaced sorghum in postrainy-season districts are sugarcane, wheat, sunflower, groundnut, onion, and maize. In rainy-season districts, apart from cotton, farmers are cultivating mung bean and to some extent pigeonpea
- In Mahabubnagar groundnut, rice, castor, and cotton have replaced sorghum
- Crop replacement (mainly by rich households) is the most important factor for in decline in sorghum area, followed by division of land and its sale (mostly by poor farmers)

- About 93% of the farmers in postrainy-season districts and 91% of the sample in the rainy-season districts reduced their sorghum area to accommodate crops that yield better revenue e.g., cotton or soybean
- The number of samples recording increase in sorghum area was remarkably high at 40% (82) in the postrainy-season districts compared to 10% (30) in the rainy-season districts
- Decline in sorghum area occurred mainly by crop replacement where competing crops yielded better net returns
- Major factors responsible for declining competitiveness are profit motives and consumption-motivated factors
- Profit motivated factors included; introduction of irrigation, relatively attractive prices for the competing crops, and ceiling limits where competitiveness is not a criterion
- Consumption-motivated factors included; changes in tastes and preferences, decline in sorghum production, accessibility to PDS, and deterioration in grain quality.

Quality Changes in Farm-stored Sorghum Grain Grown in the Wet or Dry Season in South India : A Technical and Social Study

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Survey

- In the last 20 years there has been a steady decline in both the production and consumption of sorghum in parts of south India
- A survey of postharvest practices included sampling for grain quality in farmers' stores and a participatory rural appraisal (PRA) of the same farmers
- Twelve villages were surveyed in Maharashtra, Karnataka, and Andhra Pradesh
- Study areas were divided between those where sorghum is grown during the monsoon (rainy season) or in the postrainy season
- The first grain samples were taken from stores before the onset of the monsoon in June 1997. The second set of samples, from the same harvests and same stores, was taken after the monsoon in October 1997
- A third sample, of what remained of the postrainy season stocks, was taken in January 1998
- Grain samples were analysed for quality and tested for mycotoxin contamination.

Findings

- Nearly all postrainy-season farmers grew the improved variety Maldandi, and stored their grain in jute bags.

- Rainy-season farmers used a much wider range of storage techniques and grain varieties than postrainy-season farmers
- In June, the quality of rainy-season samples was considerably below that of postrainy-season grain due to mould damage attributable to preharvest damage
- No insect attack was evident in either harvest that both had mean moisture contents of about 8%
- After the monsoon, in October, the moisture content of the crops had risen to about 11% and insect attack was evident with the primary pests *Sitophilus oryzae* and *Rhyzopertha dominica* equally common on postrainy-season grain, but *R. dominica* particularly abundant on rainy-season grain
- Overall the quality of both crops had fallen substantially although grain weight losses were low, averaging only 1.7% for rainy-season and 0.88% for the postrainy-season crops
- Numerous fungal species were identified from the sorghum samples with eight species affecting 5% or more of grains. Fungal colonisation was more evident in the rainy-season crop
- Internal colonisation, as opposed to surface contamination with spores, was evident in the rainy-season grain due to *Fusarium monofiliforme*, *Alternaria alternata*, *Curvularia lunata* and *C. lunata* var. *aeria* while in the postrainy-season crop only *A. alternata* caused any significant internal colonisation
- Colonisation rates for typical field fungi appeared to drop between June and October, but the number of fungally infected grains actually rose in this period, so it is presumed that there was a rise in typical storage fungi that may not have been detected by the culture methods used in this study
- Mycotoxin contamination was observed in both crops, and included

aflatoxin B1, *Alternaria* toxins and *Fusarium* toxins, but all below limits likely to represent a hazard to human health

- *Fusarium* toxins were almost exclusively limited to the rainy-season crop, as expected by the high rate of internal colonisation by *F. monofiliforme*. This species is a typical field fungus and it is assumed that the accumulation of *Fusarium* toxins is linked to the pre-harvest grain blackening of the rainy-season crop
- Serious mycotoxicosis has been recorded from time to time in India due to the consumption of contaminated sorghum, and the current results should be interpreted with caution since there may be considerable year-to-year variation in the climatic factors affecting mycotoxin production
- Farmers indicated that while there were postharvest losses and quality deterioration, these were not a major concern, except for grain blackening due to unseasonal rainfall. The majority of farmers stored grain for a relatively short period (less than 6 months), due to the limited quantities produced by land-scarce households from the medium and poor wealth categories.

Conclusions

- Overall, the grain storage practices of farmers in South India do not appear to be a disincentive to sorghum cultivation
- Hybrid sorghum varieties suffered considerable quality decline in storage, but this is not an issue in current farm practice. This does not mean that these traits are not impacting on the wider sorghum economy (and therefore on farmers), but only that they are not impacting on the components of the sorghum production and utilisation system examined
- Storage by wholesale traders and industrial users may have shown a different picture — as been highlighted by related projects on sorghum utilisation and marketing

- This study has laid to rest many concerns relating to farm storage, but components of the utilisation chain where these factors now seem to be more critical remain to be studied in detail
- If farmers in the future wish to retain stocks between seasons, in order to market grain strategically, then their current practices are likely to be inappropriate since grain quality at the end of the storage season was poor.
- The current major issue facing sorghum grain is appear to be the preharvest mould damage sustained by the rainy-season crop.

The Role and Importance of Sorghum in the Livelihoods of the Urban Poor

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Survey

- Semi-structured interviews, group discussions, and questionnaires were carried out in five urban districts (Nanded, Akola, Solapur, Bijapur, and Mahbubnagar), representing: on a cross-section of three States (Andhra Pradesh, Karnataka, and Maharashtra), locations that grow crops in both seasons, areas with both declining and static consumption, and traditional and non-traditional sorghum heartlands.
- Urban sites within these districts were: selected close to the rural study sites so that data could be compared with that collected from Participatory Rural Appraisal (PRA) and market surveys.
- Proxy wealth indicators were used to elucidate the relationship between income and sorghum consumption, these included: the occupation of the head of household, type of house (pucca, semi-pucca, katcha or hut¹), possession of such electrical items such as a TV or radio, holder of a ration card² and the type of card (pink, white, red, or green) and the type of fuel used (gas, kerosene, electricity, or open fire – wood/coal/dung)
- The various wealth indicators were weighted and a socioeconomic value computed by adding the individual components

1. Pucca house is one built from brick/stone with a solid roof; semi-pucca is a stone-built house with a tin roof; katcha is a house built from tin or bamboo and/or that has fallen into a state of disrepair; hut describes a more temporary residence.

2. Pink ration cards are for people above the poverty line (annual income >Rs 6000); white ration cards are for people below the poverty line (annual income <Rs 6000), red and green ration cards are for the poorest sector.

Findings

- Sorghum plays an important role in the diets of the low-income urban consumer and is expected to continue to do so for the foreseeable future
- Sorghum has several attributes that make it the preferred staple food of the poor. These include the competitive price, taste, satiating qualities, familiarity or habit, and ready availability
- The introduction of rice and wheat has had some impact on the consumption pattern of urban consumers, although it is more noticeable in the wealthier groups and amongst the non-traditional sorghum consumers than in the very low income groups
- In districts where sorghum is not the main staple crop, for example in Hyderabad city, market availability and seasonal fluctuations are factors limiting consumption. Paradoxically, in these areas the high price commanded by sorghum, (generally regarded as a poor man's food, especially in relation to the cheap rice available through the Public Distribution Service (PDS) Scheme) means that sorghum becomes a luxury food for the urban poor rather than the cheap staple with which they are familiar
- Price is the overriding factor influencing the food choice of the urban poor. Generally, the cheapest cereal forms the bulk of their diet
- In the open market (apart from in Hyderabad city) sorghum is the cheapest and therefore the preferred grain. However, when PDS rice and wheat are available, these provide a cheaper alternative, but are not necessarily an alternative that the poorest can, or wish, to take advantage of for a number of reasons
- Most wage labourers are paid daily and therefore purchase food and other commodities on a daily or two-daily basis
- To take advantage of the PDS rice and wheat, the monthly ration must

be purchased in one transaction. This necessitates the availability of large amounts of cash (Rs 50 or 60) which is not always an option.

- Even when the resources are available to take advantage of the lower price, many individuals opt not to purchase the PDS cereals because of a combination of poor grain quality, unreliability of supply, and inefficiency of the system
- Cash-flow problems also mean that low-income urban consumers are unable to purchase food supplies in bulk quantities to take advantage of wholesale prices
- The impact of the PDS system on the consumption of sorghum varies greatly from state to state and within states at the district level. This is related to the efficiency of the system and also to the tradition of sorghum production and consumption in the area
- The most generous PDS scheme is in Andhra Pradesh where there is less reliance on sorghum as a staple food than in the other two states surveyed
- In the urban areas of Maharashtra and Karnataka the PDS system has had less impact on the consumption pattern of the poor urban consumer because the quality of grain offered is inferior to that available in the open market, and the supplies are erratic and unreliable. The poorest consumer often does not have a PDS ration card and so is unable to access the supplies. Even to those in possession of a card, access to ready cash and the time needed to purchase the PDS supplies make it impractical
- Lack of storage space is another factor limiting the ability of urban slum dwellers to purchase food in bulk. Housing in slum or low-income areas is overcrowded and often in areas that are prone to flooding
- There is evidence that the younger generation are consuming more wheat and rice and that they prefer these staples to sorghum

- Some consumers believe that sorghum is nutritionally inferior to wheat and rice and prefer to feed these two staples to their young children
- The older generation still prefer, out of habit and taste preference, to consume sorghum above all other staples
- As incomes increase wheat is becoming more popular, it is considered to be a high-status food of the wealthy and salaried, and a food to be reserved for festivals and special occasions
- There is limited peer pressure amongst labourers to consume wheat, although the majority of labourers claim to prefer sorghum
- For daily - wage labourers time is a premium, sorghum is viewed as an inconvenient food. Its preparation, milling, processing, and cooking are all more time-consuming than rice preparation. Linked to this is the requirement for large amounts of fuel to cook sufficient sorghum for the entire family
- The availability of kerosene through the PDS is an important consideration for the poor consumer choosing between sorghum and rice
- As incomes rise, poor consumers become more discerning about the quality of their diet. They prefer to move towards better quality, more nutritious types of cereal (either higher quality sorghum or wheat, depending upon age, habit, location, and taste preference).

Conclusions

- Although there is anecdotal evidence that the contribution of sorghum to the urban diet declines as incomes increase, there was no strong trend from the questionnaire survey to support this theory
- It is possible that the range of income groups surveyed (Rs 70 to 6500 per month) was not sufficiently diverse to give a noticeable difference and that for all low-income urban consumers, sorghum made a major contribution to the diet

- The lack of a strong trend between incomes and sorghum consumption suggests that factors other than income play a major role in determining food choice and preference
- Despite an increase in income, sorghum is valued in the diet of the urban poor for its taste, nutritional qualities, and out of habit
- Sorghum will continue to play a major role in the diet of the urban poor, especially in areas where it is a traditional staple food.

Marketing Postrainy-season and Rainy-season Sorghum in Andhra Pradesh, Karnataka, and Maharashtra

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Introduction

- A study to investigate marketing systems for sorghum grain and stover was undertaken over a 2-week period in February–March 1998. Subsequent field work was carried out in selected markets in Karnataka in April and May 1998
- The study aimed to describe current marketing systems and assess their performance.

Volumes

- During the 1980s, of all India's states Maharashtra accounted for by far the largest volume of sorghum arrivals at regulated markets: about 60% of recorded arrivals
- It was followed by Madhya Pradesh (14%), Karnataka (8%), and Andhra Pradesh, Tamil Nadu, and Uttar Pradesh all around 5%
- During the 1980s, marketed volume of sorghum in Madhya Pradesh was roughly on a par with that of Andhra Pradesh and considerably below that of Karnataka, whilst market arrivals in Maharashtra continue to outstrip every other state's.

Marketed surplus: unregulated channels

- There is scant data on unregulated marketed surplus. The study found an average level of marketed surplus in excess of 30%
- Given that official figures suggest 10% of sorghum is marketed

through regulated markets, it is estimated that two thirds of the surplus goes through unregulated channels

- The paucity of data on unregulated market transactions for sorghum suggests a clear need for further research on this issue
- The volume of unregulated market transactions needs to be established across the major sorghum-producing states, and this be compared to regulated volumes
- Unregulated market transactions may be more important than previously thought.

Trade on secondary market postrainy-season shipments

Food use

- To predominantly postrainy-season sorghum growing areas (for consumption by rural and urban low-income consumers)
- To non-sorghum growing areas (located in sorghum-growing states), (consumed by rural and urban low-income consumers)
- To big cities mainly in sorghum-growing states (urban low-income consumers)
- To meet seasonal shortages (deficits) in growing areas.

Non-food use

- Poultry feed, cattle feed, alcohol industry, starch manufacturing, pig feed, Both sorghum-growing and non-sorghum growing states (long distance)
- As seed for fodder (small quantities, but long distances).

Postrainy-season shipments

Food use

- To postrainy-season sorghum growing areas (consumed by middle and higher-income consumers)

- To big cities, large secondary and terminal markets in sorghum-growing states (consumed by urban middle-income consumers)
- Varied to meet requirements for preferred variety / quality
- As seed to meet shortages.

Market efficiency and future prospects

- The costs added to the price of sorghum on its journey from farmer to consumer are higher in relation to producer price than they were 20 years ago
- The only slight differences might be in terms of wholesaler and retailer margins
- Even if margins for these other crops were half those quoted, this would not make a great deal of difference to the position of sorghum relative to these crops
- In terms of its competitiveness as a food grain against other crops it is difficult to argue that the marketing system per se constitutes a constraint to utilisation of sorghum
- It is possible that the further marketing system will change due to the impact of increased industrial demand
- Existing marketing arrangements may not be able to meet the standards of quality, quantity, and price demanded by industry
- The possibility of a twin-track system developing, one for the foodgrain sector and one for the non-food sector should not be discounted.

Market efficiency and future prospects

- The high producer's share in the consumer's rupee for both postrainy - and rainy-season varieties indicates there are no major distortions in the regulated marketing chain
- Particular players are not making excessive profit to the detriment of either producer or consumer

- The marketing system per se does not put sorghum at a disadvantage in comparison with other crops or as a food grain.
- Marketing systems do not present a constraint to utilisation of the crop as a food grain. This conclusion is in line with earlier work
- Existing marketing arrangements may not be optimal for industrial users who do wish to go through the regulated channel, as they may be able to obtain sorghum more efficiently through new institutional arrangements that compress the marketing chain e.g., contract farming arrangements
- A two-track marketing system may develop. One track for foodgrains through which high-quality post-rainy-season sorghum and indifferent quality rainy-season sorghum will predominate, the other track for non-food system industrial users through which exclusively hybrid rainy-season sorghum will be traded
- Further work is necessary to investigate this.

Sorghum stover marketing

- Stover can be an important source of income for farmers. For some varieties, per hectare income from stover can be higher than that for grain
- Stover prices have risen faster than grain prices
- Grain yield alone is not a suitable criterion for selection of improved sorghum varieties/hybrids, selection should be based on total value of sorghum production i.e., grain + stover value
- Using prices and yields from the late 1970s, it was estimated that returns to the farmer from the sale of local rainy-season sorghum stover could be higher than returns from the sale of local rainy-season grain. Fodder value from the local yellow sorghum was 55% of the total market value of the crop, compared with only 24% for rainy-season hybrids

- Overall, the total grain and stover value for the local variety was comparable to the combined grain and stover value for the hybrids
- High returns from fodder of the local yellow varieties could be an important factor explaining why farmers continued to grow such varieties despite the availability of higher (grain) yielding hybrids
- High grain yields can be achieved at the cost of stover yield and quality, they are also accompanied by a decrease in grain quality and consequently grain price
- Considering the dual-purpose nature of sorghum, and farmer preference for both grain and stover yields, more careful thought is required in breeding new hybrids/varieties.

Industrial Utilisation of Sorghum in India

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Summary

Only rainy-season sorghum is used for industrial purposes. Postrainy-season sorghum is a highly valued foodgrain, and as such too expensive to be used as industrial raw material.

The main industries using sorghum in India include:

- Animal feed sector
- Alcohol distilleries
- Starch industries.

Animal feed

In terms of sorghum utilisation for animal feed in India, there is a need to distinguish between poultry and dairy production. Although the latter has a good foundation in the co-operative sector, the poultry industry appears to be more dynamic.

- According to poultry producers and feed millers, very little sorghum was used for poultry diets in 1998/99 due to the availability and price advantage of maize
- When maize is expensive, sorghum is used at an inclusion rate of up to 10% in the case of broilers, and up to 15% for layers
- Estimates of industrial demand are summarised in Table 1
- The demand for sorghum in poultry feed largely depends on the price of maize, the energy source preferred by poultry producers. According to industry sources, to make sorghum competitive, its price should be 20 – 30% lower than that of maize.

Table 1. Summary of industrial demand for sorghum in India (in '000 tonnes)

Industry	1998 ¹	2010 ²
Poultry feed		
Broilers	86 – 129	570 – 1 150
Layers	312 – 468	1 100 – 1 830
Others	20 – 30	156 – 234
Dairy feed	160 – 240	290 – 570
Alcohol	90 – 100	200 – 500
Starch	50	30 – 80
Brewing	0	?
Food industry	0	0
Exports	0	?
Total	718 - 1 017	2 346 - 4 364

1. These figures reflect average utilization of sorghum during the 1990s, based on past inclusion rates and current requirements on raw material, rather than or specific data for 1998 itself. The poultry and starch industries use sorghum only when maize is expensive or not readily available.

2. Projection.

Source: Kleih et al., 2000.

- Despite the recession of the Indian economy, the poultry sector is expected to grow at a relatively high rate, i.e., 8 – 10% per annum, for egg production, and about 15% per annum for broilers
- The resulting increased demand for poultry feed is expected to lead to a deficit in energy sources, in particular, because of the limited supply of maize. Maize imports are currently too expensive due to the lack of adequate port-handling infrastructure and transport facilities, so sorghum stands a chance as an alternative raw material in this sector, but will face competition from imports in the medium to long-term
- The limited inclusion of sorghum in poultry feed and its relatively low

status as a raw material are partly due to perceptions and misconceptions surrounding the crop, these include:

- Levels of tannin in Indian sorghum
- Level of mycotoxins in blackened i.e., moulded grain
- Energy value compared to maize
- Difficulties with processing
- Lack of carotenoids for yolk pigmentation
- The industry could benefit from the availability of more accurate information on the feed value of the grain, and better links with the sorghum research community
- The co-operative sector readily acknowledges the inclusion of sorghum in dairy livestock diets, although not all co-op feed mills use it
- Relatively little grain is used in dairy feed formulations, only about 10% depending on the type of feed
- It is estimated that in 1998 approximately 50% of the commercial dairy feed producers (4 million tonnes in total) used sorghum at an inclusion rate of up to 10%
- According to feed millers, the main criteria for the inclusion of sorghum in feed rations are cost, availability, and quality
- Storage of sorghum is a problem, in particular when the grain is used several months after harvest. Although ruminants are not very susceptible to partly damaged grain or the presence of tannin, private dairy feed millers in particular could benefit from more scientific information on the possibility of including sorghum in dairy feed rations. This should also give sorghum a higher status as a feed ingredient
- Aside from commercial feed manufacturing, substantial quantities of sorghum grain are likely to be consumed on-farm by small-scale dairy farmers, particularly in regions where the crop is grown

Alcohol

- Although the quantities of sorghum grain presently used are still comparatively low, the alcohol sector seems to be the most 'enthusiastic' user of the crop as an industrial raw material
- With the recent changes in government policies on licensing alcohol production and trade, the use of grains for the production of potable alcohol is being promoted
- This provides an opportunity for sorghum to gain greater acceptability as a raw material in the industry
- There are few complaints about sorghum as such, although some distillers indicated that varieties with a higher starch content and less protein would be preferred
- Distilleries have no difficulties with using severely blackened grain so long as the starch content is acceptable
- Distilleries purchase rainy-season sorghum through traders or brokers in the main producing centers
- Some distillers feel that brokers sometimes abuse their position and 'control' the market
- Contract farming may provide better links between producers and industrial users
- There is a sound technical knowledge of producing alcohol from sorghum, especially by Praj Industries Ltd, Pune.

Starch

- Some of India's main starch manufacturers, primarily based in Ahmedabad, have used up to 50,000 tonnes of sorghum per annum when maize was short in supply
- Starch producers have undertaken their own research into sorghum-based starch manufacturing technologies. Their conclusion was that

sorghum was not a preferred raw material and would only be used if there were no other alternatives.

- In order to improve the supply of maize, the starch and poultry industries have formed an association with maize research institutes called the Indian Maize Development Association (IMDA).

Other industries

- Although beer brewers are aware of sorghum-based beer production in Africa, they prefer barley malt as the principal raw material
- Broken rice or flaked maize are also used as adjuncts
- Hindustan Breweries in Mumbai expressed interest in undertaking trials using sorghum as an adjunct
- Export of sorghum does not appear to be a present option. Aside from the fact that at present Indian sorghum is not competitive on the international market, there are quotas for the export of coarse grains, that are usually taken up by maize.

Recommendations

Applied research and extension involving the private sector. A better link between sorghum research institutions and industries should improve the status and position of the crop. For example, on-farm feed trials with poultry farmers should lead to more accurate information on Indian sorghum varieties and make it more acceptable as a raw material.

Breeding and/or distribution of varieties more appropriate for industrial utilisation. The livestock feed industry would prefer varieties with higher levels of energy. Similarly, the alcohol industry would prefer a higher starch content. Many of the varieties encompassing these characteristics are likely to exist already and, as a result, more emphasis should be placed on their identification and distribution.

Extension of better storage techniques. The quality of sorghum stored

6 to 12 months after harvest appears to be a problem when the grain is used for industrial purposes.

Encouraging dairy and poultry production in sorghum-growing areas.

Given that sorghum has a place in the livestock feed industry, the extent to which the crop could be used by small-scale farmers for animal production is worthy of consideration. If the generation of cash is the primary objective, the respective marketing systems should be in place. The breeding of dual-purpose varieties for fodder and feed grain is an important element to be considered in this context.

Strengthening the link between farmers and industries. Although many members of the industry seem to be happy with the current sorghum marketing arrangements, there appears to be scope for certain forms of contract farming and farmer associations that could strengthen the link between sorghum producers and industrial users. Efforts to this end are already being undertaken by some members of the industry on the supply of maize.

Sorghum for Ethanol Production

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This paper mainly focussed on sorghum as raw material for ethanol production, and in ethanol process technology

Sorghum as raw material

- A coarse grain rich in starch
- Available in large quantities, without affecting food stocks
- Grown in rainfed areas in water-limited environments
- Grown both in rainy and postrainy seasons
- Rainy-season crop is mainly hybrids grown for fodder that also produce grain
- High productivity leads to surplus grain
- Unseasonal rains during rainy-season harvest lead to blackening of grain through fungal damage
- Damaged sorghum is no use for human consumption
 - Results in poor prices and low returns for farmers
 - Both normal and damaged sorghum can be used for ethanol production or as generates high protein animal feed
 - Ethanol production can fetch high and consistent returns for sorghum farmers.

Why sorghum?

- India produces 10–11 million tonnes annually
- Approximately 2–3 million tonnes are damaged by fungal infection, therefore large quantities are available for processing
- Sorghum contains the equivalent or more starch than maize
- Sorghum is easier and cheaper to grown than maize
- Sorghum gives high yields of ethanol (about 390–425 Lt⁻¹)

- Yields high-protein cattle feed (240–260 kg t⁻¹) as a by-product
- Sorghum conversion to ethanol is an environmentally clean technology, the plant does not produce toxic effluents
- Grain spirit has less sulphur and other impurities than other sources of spirit, so further processing is easy and safe
- Sorghum is a better feedstock for downstream applications as it is potable, and can be used as fuel, and in industry.

Why produce ethanol from sorghum ?

- Ethanol production can use large quantities of sorghum as raw material so can benefit sorghum producers on a large scale
- Other industrial products consume relatively small quantities of raw materials
- Using sorghum to produce glucose and high fructose syrups, cannot compete with large-scale sugarcane production.

Conclusions

- Sorghum can be used to produce ethanol
- Use of sorghum for ethanol production will benefit farmers with profitable returns
- Damaged sorghum can be used to produce high-value ethanol with cattle feed as a by-product
- Ethanol producing companies, research institutes, and the Government should co-ordinate with farmers to strategically develop value - added plans for the utilisation of sorghum.

Section 4

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Section 5

Publications and Databases

Semi-formal Project Reports

Outputs of the Department for International Development (DFID) Crop Post-Harvest Programme Project 'Sorghum Utilisation in India'

Socioeconomics and Policy Program (SEPP), ICRISAT, Patancheru 502 324, Andhra Pradesh, India. **Also WWW.ICRISAT.ORG**

Azam Ali, S. 1999. The role and importance of sorghum to the livelihoods of urban poor. 50 pp.

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Kleih, U., Bala Ravi S., and Dayakar Rao, B. 2000. Industrial utilisation of sorghum in India. Working Paper Series no. 4. 48 pp.

Marsland, N. and Parthasarathy, Rao, P. 1999. Marketing of rabi and kharif sorghum in Andhra Pradesh, Karnataka, and Maharashtra. Working Paper Series no. 1. 38 pp.

Navi, M., Bandyopadhyaya, R., Hall, A.J., and Bramel-Cox, P. 2000. An identification manual for species of grain mold infecting sorghum in India. Information Bulletin no 59. Patancheru 502 324, Andhra Pradesh, India : International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) 67 pp. Order code IBE 059

Available from Distribution Unit, ICRISAT.

Databases (unpublished)

Available from Director, National Research Centre for Sorghum (NRCS), Rajendranagar, Hyderabad 500 030, Andhra Pradesh, India.

1. National Sample Survey district-level data on the consumption of sorghum.
2. Farm-level sample survey data relating to production and consumption patterns of sorghum, including partial farm budget data collected in 11 districts in the states of Andhra Pradesh, Maharashtra, and Karnataka.



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