Case study 8

Minor millets in India: a neglected crop goes mainstream

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Background

In spite of several national nutritional intervention programmes, India faces huge nutrition challenges as the prevalence of micronutrient malnutrition continues to be a major public health problem with an associated economic cost of 0.8 to 2.4 per cent of the GDP. Most vulnerable segments of the population are children, adolescents, pregnant women and lactating mothers (Arlappa et al., 2010), with estimates from the most recent National Family Health Survey (IIPS, 2007) indicating that about 46 per cent of the children under five years of age, particularly those living in rural areas (Rajaram et al., 2007), are moderately to severely underweight (thin for age), 38 per cent are moderately to severely stunted (short for age), and approximately 19 per cent are moderately to severely wasted (thin for height) (Kanjilal et al., 2010).

The overdependence on a handful of species – rice, maize, wheat and potatoes – which provide over 50 per cent of the world's caloric intake (FAO, 2010), has seen hundreds of species and varieties of food plants marginalized and becoming increasingly irrelevant in national agricultural production systems and economies. Less attention by researchers on these so-called neglected and underutilized species (NUS) (Padulosi and Hoeschle-Zeledon, 2004) translates into missed nutrition and health opportunities (Smith, 1982; Frison et al., 2006; Chadha and Oluoch, 2007; Hawtin, 2007; Smith and Longvah, 2009), since many of them offer a broader range of macro and micronutrients than those available in major staple crops.

One such group of highly promising crops is that of minor millets. They are called 'minor' because of the lack of research investment they attract, and their limited commercial importance in terms of area, production and consumption patterns (Nagarajan and Smale, 2007). By no means are they considered 'minor' in terms of their nutritional and income generation opportunities, which is what this case study will attempt to demonstrate. Once widely consumed in India and playing a key role in household food security and dietary diversity, in the last two decades these millets have been supplanted by rice as the staple grain. However, over the last 10 years, there has been increasing recognition of their favourable nutritional properties and associated benefits, also thanks to several national and international projects tackling their valorization in India and elsewhere in South Asia (Padulosi et al., 2009). Furthermore, as well as gaining credit for their role as a staple crop in marginal agricultural regions, they are increasingly being appreciated as healthy foods for urban and middle-income groups, losing the stigma of 'poor people's food' that was associated with them up until recently (Bala Ravi et al., 2010).

The benefits of agricultural biodiversity: why, what

In India, this group of small-seeded cereals is represented by six species, namely, finger millet (*Eleusine coracana* (L.) Gaertner) (Figure C8.1), kodo millet (*Paspalum scrobiculatum* (L.)), foxtail millet (*Setaria italica* (L.) Pal.), little millet (*Panicum sumatrense* Roth *ex* Roemer & Schultes), proso millet (*Panicum miliaceum* (L.)) and barnyard millet (represented by two species: *Echinochloa crusgalli* and *E. colona* (L.) Link) (Bala Ravi, 2004; Padulosi et al., 2009). Millets are hardy crops and quite resilient to a variety of agro-climatic adversities, such as poor soil fertility and limited rainfall. In view of their superior adaptability (compared for instance with rice or maize), they play an important role in supporting marginal agriculture, such as that commonly practised in the hilly and semi-arid regions of India (Bala Ravi, 2004; Padulosi et al., 2009; Bhag Mal et al., 2010).

Minor millets are nutritionally comparable or even superior to staple cereals such as rice and wheat (Gopalan et al., 2004; Geervani and Eggum, 1989). Compared with rice, 100 g of cooked grain of foxtail millet contains

Figure C8.1 Farmer from Karnataka State in his finger millet field. Photo credit: Stefano Padulosi almost twice the amount of protein, finger millet over 38 times the amount of calcium, and little millet more than nine times the amount of iron (Gopalan et al., 2004) (Table C8.1). Millets are rich in vitamins, minerals (calcium and iron in particular), sulphur-containing amino acids and phytochemicals, and hence are often described as 'nutritious millets' (Bala Ravi, 2004) or 'nutri-cereals' (Choudhury, 2009). They also contain high proportions of non-starchy polysaccharides and dietary fibre. Their slow release of sugar on ingestion makes them ideal food for diabetic patients, whereas the lack of gluten in their grains makes them good food for coeliac-affected people (Kang et al., 2008). Recognizing the importance of minor millets, particularly local landraces, for food and nutritional security, a 10-year project was carried out from 2001 to 2010 to promote their conservation and sustainable utilization. The project, known as the IFAD NUS project, supported by the International Fund for Agricultural Development (IFAD) and coordinated by Bioversity International, aimed at enhancing the contribution of neglected and underutilized species (NUS) – minor millets among them – in strengthening food security and incomes for the poor (Rojas et al., 2009; Bhag Mal et al., 2010).

Using highly inter-connected, community-based conservation through-use interventions, as well as participatory methods and tools, the project targeted smallholder farmers who were socio-economically disadvantaged with respect to access to food and more so to nutritious food. Implemented in 31 villages across four Indian states (Tamil Nadu, Orissa, Karnataka and Uttarakhand), the project was estimated to have influenced, directly or indirectly, some 753 households (Padulosi et al., 2009).

The benefits of agricultural biodiversity: how

The IFAD NUS project used an eight-step approach to enhance the use of minor millets in India (Figure C8.2). Project objectives, explained in detail below, were pursued by promoting the conservation, improvement and utilization of local landraces, developing enhanced cultivation practices, raising awareness on the nutritional importance and strategic role of millets in food and nutritional security, promoting innovative value addition methods and empowering local communities to become self-sustainable producers of raw and processed food products that can compete with other well-established commodity crops.

1 Provision and conservation of genetic material

Surveys targeting the distribution of existing crop diversity were carried out to map the on-farm distribution of more common and endangered millet varieties. The establishment of village gene/seed-grain banks using culturally-acceptable approaches developed by the M.S. Swaminathan Research Foundation (MSSRF) allowed: i) the conservation of genetic diversity, ii) the creation of quality seed sources for cultivation purposes and iii) the accumulation of reasonable quantities of food grain stock to address food insecurity in most vulnerable households during lean income

Table C8.1 Nutrients in white rice and minor millets

Food (100 g)	*Energy (Kcal)*	*Protein (g)*	*Fat (g)*	*Fiber (g)*	*Carbohydrate (g)*	*Phosphorous (mg)*	*Calcium (mg)*	*Iron (mg)*
Rice (*Oryza sativa*)	346	6.4	0.4	0.2	79.0	143.0	9.0	1.0
Common millet (*Pennisetum glaucum,* "Bajra, Cambu")	361	11.6	5.0	1.2	67.5	296.0	42.0	8.0
Italian millet (*Setaria italica* "Thenai")	331	12.3	4.3	8.0	60.9	290.0	31.0	2.8
Proso millet (*Panicum miliaceum* "Pani-varagu")	341	12.5	1.1	2.2	70.4	206.0	14.0	0.8
Finger millet (*Eleusine coracana* "Ragi")	328	7.3	1.3	3.6	72.0	283.0	344.0	3.9
Little millet (*Panicum sumatrense* "Samai")	341	7.7	4.7	7.6	67.0	220.0	17.0	9.3
Kodo millet (*Paspalum scrobiculatum* "Varagu")	309	8.3	1.4	9.0	65.9	188.0	17.0	0.5

Source: Modified from Gopalan et al., 2004

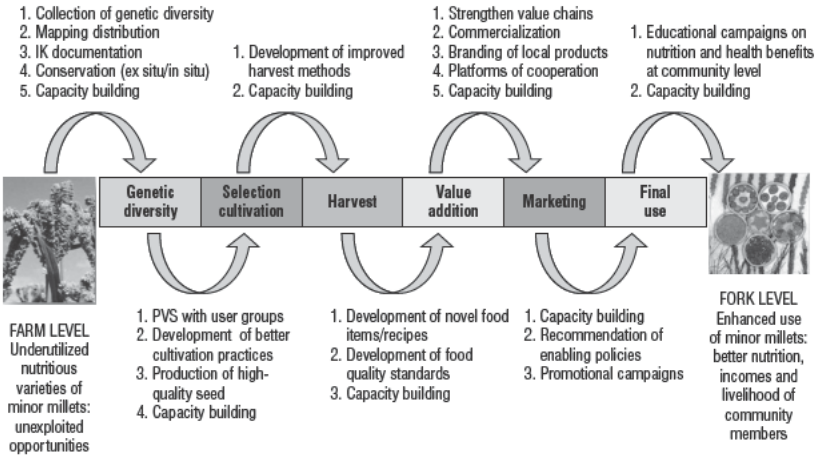

Figure C8.2 Holistic value chain approach applied to minor millets in India by the IFAD NUS project. Text boxes list main types of interventions carried out with the close involvement of community members in target villages across the states of Uttarakhand, Tamil Nadu, Orissa and Karnataka

periods. Surveys documenting existing traditional knowledge on the health and nutritional benefits of millets were also carried out.

2 Development of better varieties to promote use
Participatory variety selections (PVS) and participatory rural appraisals (PRA) carried out in project sites led to the selection of five varieties of little millet, foxtail millet and finger millet. Selected local and improved varieties were then tested for performance in farmers' trials based on visual and quantitative assessment, such as grain and fodder yield. The agronomic potential of varieties identified from PVS and PRA was demonstrated across project villages in all four states using farmer participatory trials. Results of these demonstrations showed that the mean grain yield of varieties selected from PVS were 40 to 60 per cent higher than their local counterparts (Bhag Mal et al., 2010). Upon identification of the best varieties, farmers were then engaged in participatory seed production programmes to produce enough quality seed to be widely disseminated to farmers in target villages and elsewhere through the seed networks and Self-Help Groups (SHGs) set up by the project.

3 Development of improved cultivation practices
Improved cultivation practices were developed by blending traditional farming approaches with scientific methods. These include the use of better quality seeds; the use of density-regulated row planting instead of traditional broadcasting with high seed rate; structured intercropping of millet and other traditional crops (i.e. mung bean, chickpea, pigeon pea, lablab bean, mustard and niger) instead of their broadcasting as multi-species seed mix; use of farmyard manure; and plant density control by

thinning /transplanting and weeding (Bala Ravi et al., 2010). Data gathered from 198 field demonstrations carried out in 2003 and 2004 revealed that the use of improved cultivation practices contributed to an increase of 39.8–62.8 per cent in grain yield and 34.1–47.3 per cent in fodder yield compared with traditional practices (Padulosi et al., 2009).

4 Development of more efficient processing technologies
The project successfully developed more efficient ways of grain threshing and milling, thus reducing drudgery normally associated with processing, a chore that has played a major role in the declining popularity of millets among traditional consumers (Bala Ravi et al., 2010). The provisioning of easy-to-use grain processing machines has effectively enhanced household consumption of minor millets as well as providing new livelihood options, particularly for women who are now able to complement their income by producing millet-based, locally-appropriate foods (Bala Ravi et al., 2010). Access to markets and micro-credit schemes was also supported to build long-term, economically viable and sustainable options (see also point 6).

5 Nutritional and industrial characterization of crops and products
New food-processing technologies were developed and tested to promote culturally-acceptable, millet-based products on the Indian food market. Traditional foods such as *paddu* (savoury pancakes) and novel foods such as biscuits, *laddus*, *chaklis* (popular sweet and savoury snacks), finger millet malt, finger millet flour and 'rice' of little millet and Italian millet were tested. A detailed cost-benefit analysis of product development showed that the highest benefits were associated with finger millet malt and little and Italian millet 'rice', for which a large market potential exists in India due to their importance in weaning and health foods (Bala Ravi et al., 2010). Malting of finger millet enhances the grain's energy value, making its protein, rich calcium and iron more bio-available, while enhancing the content of vitamins such as niacin and folic acid and its amino acid balance (Malleshi and Desikachar, 1986). Table C8.2 reports some of the novel foods developed by the project and their nutritive value assessed using the food composition tables of the nutritive value of Indian foods (Gopalan et al., 2004).

6 Build up of sustainable enterprises
Sustainability of activities beyond the project lifetime was achieved by establishing Self-Help Groups (SHGs) based on internal lending schemes and the creation of enterprises focusing on the cultivation, consumption, value addition and commercialization of end-products (Gruère et al., 2009). Since project inception in 2001, more than 35 SHGs were established with a total membership exceeding 386, of which 214 were women. To create market presence and promote demand for minor millet products, the MSSRF developed a branding strategy, which promoted the organic provenance and the conservation of millet genetic diversity as the products' added value. MSSRF also assisted SHGs in developing a booklet compiling traditional and novel recipes using minor millets (MSSRF, 2004), which was distributed as a part of the marketing efforts.

Table C8.2 Nutritive value of ethnic and novel foods

Parameters	*Rice*	*Millet*
Paddu – 100g		
Carbohydrates(g)	123.02	111.63
Protein(g)	19.03	20.85
Fat(g)	10.96	12.58
Ash(g)	2.02	4.75
Crude fibre(g)	0.75	12.42
Energy(kcal))	666.84	643.18
Calcium(mg)	68.86	94.08
Papad – 100g		
CHO(g)	81.82	78.51
Protein(g)	5.79	7.90
Fat(g)	3.06	4.06
Ash(g)	0.52	2.48
Crude fibre(g)	0.66	3.74
Energy(kcal)	377.98	382.18
Calcium(mg)	14.56	34.60
Biscuit – 100g		
CHO(g)	57.80	58.69
Protein(g)	4.78	4.35
Fat(g)	26.36	27.88
Ash(g)	0.28	4.55
Crude fibre(g)	0.12	0.92
Energy(kcal)	487.79	503.07
Calcium(mg)	60.40	90.16
Ladoo – 100g		
CHO(g)	64.46	63.97
Protein(g)	9.58	7.54
Fat(g)	18.91	18.39
Ash(g)	1.27	1.40
Crude fibre(g)	0.55	2.08
Energy(kcal)	500.00	483.34
Calcium(mg)	28.86	24.81
Chakli – 100g		
CHO(g)	45.48	39.13
Protein(g)	6.92	7.49
Fat(g)	32.33	32.12
Ash(g)	1.16	1.88
Crude fibre(g)	1.04	5.05
Energy(kcal)	501.33	475.58
Calcium(mg)	65.27	72.00

Source: Yenagi et al., 2010

7 Training of community members
At least 1,000 community members were trained in cultivation practices, value addition, marketing and nutrition during training efforts carried out by the IFAD NUS project in India. These training courses complemented the provision of novel technology and ranged from learning machinery operation to production of diverse value-added products suited for domestic consumption and commerce, standard codes of product quality, hygiene, packaging, labelling, marketing and account keeping. Capacity-building activities were mostly targeted at women, who are the main custodians of minor millet genetic diversity and the traditional knowledge associated with their production and consumption.

8 Raising public awareness
Numerous awareness-raising activities were organized on the nutritional importance of millets and their strategic role in providing food and nutritional security in certain agro-climatic regions. Targeting different stakeholders such as farmers (particularly women), urban housewives, government officials and rural development workers, primary and secondary school students and the wider public, activities included organizing poster sessions and millet-based product exhibitions during World Food Day, World Nutrition Day and World Diabetes Day, and during annual festivals in project villages. Similar exhibitions were organized by MSSRF during national and international conferences, as well as talks and lectures on the nutritional and health values of minor millets compared with more common cereal grains. During these events booklets and brochures were widely distributed, along with recipe books for these grains. Field demonstrations, farmers' fairs and exhibitions were also organized in project sites to promote high-yielding varieties, enhanced cultivation practices and improved processing technologies for finger millet. In addition, many TV and radio programmes promoting finger millet were organized, including a documentary in Kannada, the language of Karnataka, and English.

The benefits of agricultural biodiversity: health impacts

Investigations into the health impacts of minor millets showed promising results in a study carried out on school children from two millet-growing areas in Karnataka State. Using height and weight measurements and haemoglobin levels as measures of nutritional status, 60 school children between 11–14 years of age were monitored to assess the nutritional impact of replacing existing rice-based diets used in school feeding programmes with finger millet or foxtail millet rice. At baseline, the children, mostly from farming families, exhibited chronic energy deficiency (CED) with a BMI < 16.0, and haemoglobin levels below 12.0 g/100ml. Following a three-month intervention, research findings revealed a significant improvement with respect to weight and haemoglobin content in children fed on millets compared with the control group fed on rice (Table C8.3).

Table C8.3 Statistical analysis on the impact of millet-based food on school children

Parameter	*Control*				*Treatment*				
	Initial	*Final*	*Mean difference*	*'t' value*	*Initial*	*Final*	*Mean difference*	*'t' value*	*Paired 't' test*
Weight (kg)	24.58	25.25	0.67	5.12**	25.68	26.83	1.15	6.18**	2.23**
Height (cm)	133.50	134.3	0.80	9.96**	136.4	137.3	0.97	5.04**	1.51 NS
Haemoglobin (g/ml)	7.31	7.85	0.54	5.62*	7.78	10.46	2.68	14.10**	10.07**

* Significant, ** highly significant, NS not significant

Source: Annual Report 2010, MSSRF

Table C8.4 Nutrient composition of millet recipes per serving

	Finger millet (Ragi)		*Foxtail millet*	
Nutrient	*Rice and sambar /serving*	*Ragi Mudde and Sambar/ serving*	*Rice and sambar/ serving*	*Millet rice*
Protein (g)	15.77	16.52	17.06	25.31
Carbohydrate (g)	131.7	122.4	140.22	114.6
Fat (g)	15.0	16.2	7.18	12.88
Energy (Kcal)	691.25	773.75	696	675
Crude fibre (g)	0.67	5.77	1.1	12.8
Minerals (g)	1.77	4.92	2.18	6.23
Calcium (mg)	33.25	534.25	61.25	92.75
Phosphorous (mg)	316	500.5	358	553
Iron (mg)	1.72	6.52	2.56	5.71

Source: Yenagi et al. (not published)

In particular, haemoglobin levels of children eating millet-based school meals were significantly higher than the control group by 32.0–37.6 per cent.

Millet foods were considered very tasty and acceptable to more than 85 per cent of school children. The millet recipes developed and fed to the selected children were analysed for their nutrient composition. Results reported in Table C8.4 show that these products fulfil the nutritional standards indicated by the Supreme Court of India – which make it mandatory since 2001 to serve every child in all government schools mid-day meals containing at least 300 Kcal and 8–12 g protein a day for a minimum of 200 days (Supreme Court Order of November 28, 2001) – while providing additional amounts of micronutrients as compared with rice. Thus, millet foods represent a good source of micronutrients and have the potential to improve the nutritional status of school-going children and should therefore be recommended in the school mid-day meal programmes. These investigations were, however, limited in scale and in time and call for follow-up studies for further validation.

Policy impact

Concerted efforts to promote the nutritional and health benefits of minor millets successfully influenced public policy to include these grains in government-sponsored school feeding programmes and to subsidize public distribution systems including millets to target socio-economically and nutritionally-vulnerable populations. In 2006, Prof. M.S. Swaminathan urged the Government of India to include minor millet grains, sorghum and millet procurement and provision as part of the existing public distribution system to ensure nutritional security and sustainable production. This recommendation is now reflected in the policies of the Indian Government on 'nutri-cereals'. In his union budget speech for 2011–2012 the Finance Minister Pranab Mukherjee recognized the importance of minor millets and decreed that financial incentives would be made available to support millet farmers and 'promote higher production of these cereals, upgrade their processing technologies and create awareness regarding their health benefits'. The initiative is hoped to provide market linked production support to millet farmers in the arid and semi-arid regions of the country and to increase the nutritional security of about 25,000 villages.

Key lessons learned

The project was able to demonstrate that currently marginalized crops can be successfully used to create self-sustainable, agricultural-based enterprises that can support income generation in marginal areas of India while strengthening food and nutrition security through better use of culturally-adequate, nutritious crops. Furthermore, considering the high incidence of marginal land, poor soils and scarcity of water in many regions of India, the suitability of minor millets to grow in difficult edaphic and climatic conditions compared with other commodity crops make them ideal candidates to be used in climate change adaptation strategies in agriculture.

Barriers to their greater promotion are mostly of a policy nature, with heavy subsidies still being allocated to other commodity cereals, such as rice. Greater efforts are thus needed to convince policy makers to integrate minor millets in India's subsidized public distribution system (PDS). Such policies would not only move in the direction of enhanced food security, but would also support more resilient production systems in view of the global changes that are predicted to seriously affect the Indian continent in the coming decades (Padulosi et al., 2009).

Continued lobbying for the inclusion of minor millets in school-feeding programmes is also advocated as children could greatly benefit from the nutrients that are mobilized through a greater consumption of these crops and their products. Although the IFAD NUS project has been successful in demonstrating the value of certain interventions, more work is needed to scale-up approaches, methods and tools in wider areas of India. Greater government investment is also needed to continue developing superior varieties of minor millets as well as processing technologies that can satisfy increased demands for millet-based products across India, along with enabling policies to support their dissemination and adoption by consumers.

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